ADHD, delay aversion and waiting behaviour in preschool children: Family and cultural processes

Chan, Wendy

Awarding institution:
King's College London

ADHD, delay aversion and waiting behaviour in preschool children: Family and cultural processes.

Wendy WY Chan

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Department of Child and Adolescent Psychiatry
Institute of Psychiatry, Psychology and Neuroscience
King's College London, UK

Department of Psychology
Faculty of Social Sciences
The University of Hong Kong

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Abstract

The delay aversion hypothesis proposed by Sonuga-Barke (1994) views attention deficit/ hyperactivity disorder (ADHD) symptoms as a functional expression of delay aversion which enables them to escape from or avoid the delay rich situations that they find emotionally aversive (Sonuga-Barke et al., 1992a; 1992b; 2010). Further, according to the model, one way that this motivational orientation develops is through the conditioned paring of delay situations with the negative affective states arose from parental criticism and/or punishment for failures to wait or maintain attention. This second part of the delay aversion model has not been tested to date.

In this thesis, we aimed to explore this model of the social conditioning of delay aversion and ADHD by exploring the relationship between preschool children's ADHD symptoms, their sensitivity to delay (i.e., delay aversion) and their waiting behaviours in two communities known for their different attitudes to children's behaviour and self-regulation – Hong Kong and the United Kingdom – in four studies.

A community sample of 112 preschoolers (mean age = 46.22 months; 55 from UK, 57 from HK) completed a battery of three tasks measuring different waiting elements– *waiting for rewards*, *judging how long to wait* and *having to wait unexpectedly when task is interrupted* and another waiting task jointly with their parents. Children's and parents' behavioural and emotional responses were observed and coded during task performance. Actometers were also used to track children's task-related activity. Parents and teachers rated the children's ADHD symptoms and sensitivity to delay at T1 and T2 (12 to 18 months later).

There were several important findings to note. First, we found strong evidence that parents' perceptions and reports of ADHD-related behaviours are culturally determined, with HK parents appeared to have lower rating threshold than UK parents, that is, less waiting-related activity is required for HK parents before considering it as an ADHD symptom. Second, our findings showed that children's maladaptive waiting-related responses increased as a function of delay duration and significantly associated with their levels of ADHD symptoms. Moreover, children's frustration experienced during the waiting period affected their responses in a later post delay waiting period. Third, we found a strong positive correlation between children's maladaptive waiting-related responses and parental negative responses during delay at T1. Parents' negative behaviours and affect displayed during the joint waiting task at T1 significantly predicted the children's ADHD symptom and delay sensitivity level as rated by their teachers at T2, even after controlling for their symptoms level at T1. This pattern did not hold for parental negative response in non-waiting settings. Fourth, despite cultural differences found in parents' rating threshold and children's waiting-related responses, our findings suggested that the relationship between pre-schoolers' ADHD, delay aversion and waiting behaviours was not moderated by national group.

The differences between UK and HK communities in parents' rating thresholds and children's waiting behaviours reflected the value of including a cross-cultural comparison element in the research on the ADHD prevalence, assessment tool, parents' symptom endorsement and attributions. The cultural invariance in the relationship between ADHD, waiting and delay aversion provided insights for early intervention efforts that could be effective across cultures. Most importantly, longitudinal data highlighted the way parenting in relation to delay can increase the risk for delay aversion and ADHD-related difficulties. Intervention should not only focus on the children's tolerance and reactivity to waiting situations, but also help parents to understand the potential impact of their negative delay-related behavioural and emotional expressions.

Declaration of authorship

I hereby declare that this thesis represents my own work which has been done during my joint PhD degree at King's College London (KCL) and University of Hong Kong (HKU) between October 2017 and July 2023, and that it has not been previously included in a thesis, dissertation or report submitted to this University or any other institution for a degree, diploma, or other qualifications. The work was funded by the KCL Graduate School (King's-HKU Joint PhD Scholarship).

I conceptualised the work and formulated hypotheses under the supervision of Professor Sonuga-Barke and Dr. Kathy Shum. I also secured funding, designed and selected the tasks, recruited participants, administered testing sessions, collected and coded the data (with help from undergraduate and postgraduate students who were acknowledged in the relevant section), planned and conducted data analysis, interpreted the results and wrote drafts of chapters and revised them based on feedback from supervisors.

The T1 data collection in UK was completed by me between May and September 2019, whereas the T1 data collection HK was completed between June 2019 and Jan 2020 with the massive assistance of Ms Gigi Liu (postgraduate student in HKU). I originally planned to complete the T2 in-person testing in HK between Jun and Dec 2020 and have Ms Claire Ballard's assistance to conduct the T2 follow-up in UK. The in-person testing in both sites was however postponed and mostly suspended due to COVID-19. I only managed to conduct 12 testing sessions in May to July 2020 between phases of lockdowns and eventually completed the T2 follow-up through questionnaires in both UK and HK.

This is a thesis incorporating peer-reviewed published journal papers. The parts of thesis that have been published are noted as such in text.

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This journey of planning, executing and completing this research project has been wonderful and fulfilling, but at the same time it definitely was challenging and complicated. First and foremost, I would like to thank my supervisors, Professor Edmund Sonuga-Barke from King's College London, UK and Dr. Kathy Shum from the University of Hong Kong, HK for their continuous inspiration, support, advice and patience throughout all these years. It still felt like yesterday when I first read a paper in 2016 titled "Delay and reward choice in ADHD: an experimental test of the role of delay aversion" and got completely fascinated by the delay aversion model. Looking back, I feel so glad that I had gathered the courage of my life to contact Professor Sonuga-Barke who was the corresponding author of that paper. Professor Sonuga-Barke's knowledge and ideas were immense, and he was so willing to share all he knew with me and all his students. I have been very fortunate to have offered the King's-HKU Joint PhD Scholarship granted by the KCL graduate school. With the joint support from two outstanding universities, I am blessed to have my second supervisor, Dr. Kathy Shum equipped me with practical research and publication skills and given me the greatest encouragement. Everything worked like magic. Without my two supervisors' very constructive feedback and guidance, I would not have been able to accomplish my goals in designing new experimental tasks and conducting this cross-cultural longitudinal study.

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COVID-19 impact statement

The T1 data collection in UK and HK was completed in 2019. The original plan was to invite the parent and child participants to complete another in-person testing session with the same set of tasks administered 12 months later, i.e. between May and December 2020. I flew to HK in October 2019 to prepare for T2 data collection with HK children. Unfortunately, due to COVID-19 school closures and lockdowns, the scheduled in-person testing sessions had been postponed again and again, and eventually most of them were cancelled. Similar situations arose in England and the originally planned T2 testing in London was also terminated. The T2 follow up data was eventually obtained using parent and teacher questionnaires, which still provided us valuable information to test the main hypotheses in understanding the relationship between preschool children's ADHD symptoms, delay aversion and waiting behaviours in a cross-cultural context over time.

Contacting parents and teachers during the pandemic was particularly challenging and a large number of parents and teachers, especially those in the UK, needed additional time to complete the questionnaires due to the extra childcare and online teaching support in that period. The UK and HK children's age at T1 testing was not statistically different, yet UK children's average age at T2 when their parents and teachers completed the questionnaire was greater than that of HK children due to the additional time needed to complete the questionnaires.

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List of abbreviations

ADHD	Attention deficit/ hyperactivity disorder
ADHD-RS-IV-P	ADHD-Rating Scale IV Preschool Version
ANOVA	Analysis of variance
BDT	Bee Delay Task
BIP	Basic information processing
CD	Conduct disorder
CDT	Cookie Delay Task
CFI	Comparative Fit Index
DA	Delay aversion
DD	Delay discounting
DSM	Diagnostic and Statistical Manual of Mental Disorders
EF	Executive functioning
fMRI	Functional magnetic resonance imaging
ICC	Intraclass correlation coefficient
ICD-11	International Classification of Diseases 11th Revision
IQ	Intelligence quotient
LL	Large but later rewards
ODD	Oppositional defiant disorder
PARCHISY	Parent-Child Interaction System
P-DeFT	Preschool Delay Frustration Task
PC-DeFT	Parent-Child Delay Frustration Task
PERCI	Parental Emotional Response to Children Index
PSDQ-SF	Parenting Styles and Dimensions Questionnaire – Short Form

PSI-4-SF	Parenting Stress Index 4 – Short Form
QDQ	Quick Delay Questionnaire
SDQ	Strengths and Difficulties Questionnaire
SRD	Stage regulation deficits
SS	Small but sooner rewards
T1; T2	Time-point 1; 2
VNTR	Variable number tandem repeat
WPPSI	Wechsler Preschool and Primary Scale of Intelligence

Chapter 1 Introduction

In this chapter we provide the reader with an overview of the ADHD literature, structured to highlight the elements relevant to the delay aversion hypothesis. To this end there are three major sections. First, we review the basis of ADHD, including its characteristics, prevalence, related impairments and interventions. We also discuss ADHD as a continuum and a condition applicable to the preschool population. Second, we introduce the neuro-psychological nature and the causal origins of ADHD, with a particular focus on the hypotheses stemming from the delay aversion model, beginning with understanding ADHD as a functional expression of delay aversion and then its socio-developmental processes. Third, we present the literature on cross-cultural differences in perceptions of ADHD-related behaviours, as well as children's expression and development of ADHD.

1.1 ADHD

1.1.1 Clinical characteristics of ADHD

Children vary in their levels of attention, activity and self-control with some children showing difficulties. When these problems are pervasive and impair functioning, they lead to a diagnosis of attention deficit/ hyperactivity disorder (ADHD). The American Psychiatric Association (2022) defines ADHD as a life span neurodevelopmental condition characterized by age-inappropriate, persistent and impairing levels of hyperactivity, attentional difficulties and impulse control problems to an extent that functioning at home and at school are interfered (as in Diagnostic and Statistical Manual of Mental Disorders).

The two most commonly used diagnostic systems for ADHD are the Diagnostic and Statistical Manual of Mental Disorders (DSM-5-TR; American Psychiatric Association, 2022) and International Classification of Disease (ICD-11; World Health Organization, 2019). Both systems highlight the multiple-setting criteria (i.e. symptoms were present in two or more contexts), persistence of symptoms (i.e. lasted for at least six months), the age of onset (i.e. symptoms appeared before the age of 12) and the significant impact of the symptoms on one's social, learning or work functioning. In both, the list of symptoms was grouped in two clusters: (a) Inattention and (b) Hyperactivity and Impulsivity. Examples of symptoms include:

> Inattention:
> Often does not seem to listen when spoken to directly (e.g., mind seems elsewhere, even in the absence of any obvious distraction);
> Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (e.g., loses focus, side-tracked);
>
> Often has difficulty organizing tasks and activities;
> Easily distracted by extraneous stimuli or thoughts not related to the task at hand;
> Is often forgetful in daily activities.
>
> Hyperactivity/ impulsivity:
> Often fidgets with or taps hands or feet, or squirms in seat;
> Often runs about or climbs in situations where it is not appropriate (adolescents or adults may be limited to feeling restless);
> Often talks excessively;
> Often blurts out answers before a question has been completed (e.g. cannot wait for turn in conversation);
> Interrupts or intrudes on other's conversations or games.

DSM classified ADHD into three presentations based on the symptoms profile: combined type, predominantly inattentive type, and predominantly hyperactive/ impulsive type; six out of the nine symptoms listed in that cluster are needed for the diagnosis of the particular subtype (both clusters for combined type). The assessment of ADHD typically involves multiple methods such as behavioural rating scales, interviews and clinical observations using multiple informants such as parents, teachers and the children (Sattler & Hoge, 2006; Sharma & Couture, 2014).

Studies exploring the comorbidity of ADHD estimated that at least half of the children with ADHD have at least one other co-existing neurodevelopmental disorders (Gillberg, 1983; Gillberg et al., 1997, 2004; Root & Resnick, 2003). Externalizing disorders such as oppositional defiant disorder (ODD) and conduct disorder (CD) are the most common comorbid disorders, with around 30-50% children with ADHD also meeting the diagnostic criteria for ODD or CD (August et al., 1983; Gillberg et al., 2004; Gnanavel et al., 2019; Pliszka, 1998). Internalizing disorders such as depressive disorder and anxiety disorders are also common in children with ADHD (Angold et al., 1999; Gnanavel et al., 2019; Jarrett et al., 2016; Wilens et al. 2002).

1.1.2 Prevalence

ADHD is one of the most common neurodevelopmental disorders. In the '90s, it was once questioned whether ADHD was a phenomenon unique in western culture (Anderson, 1996; Timimi & Taylor, 2004), but a worldwide prevalence study conducted by Polanczyk et al (2007) systematically reviewed 102 studies and estimated the global pooled prevalence of ADHD as 5.29%. Variability of the prevalence rates was related to the choice of diagnostic tools, source of information and geographic location of the studies. Once methodological variations were accounted for, there were significant differences only in the estimates between western (North America/ Europe) and some non-western (Middle East/ Africa) cultures; the differences in prevalence rates between America, Europe, Oceania and Asia were not significant.

Sex/gender difference in prevalence rates is considerable, with boys being diagnosed to have ADHD three times more than girls (Barkley, 2006; Gaub & Carlson, 1997). It was suggested that girls with ADHD present the same kind of symptoms as boys with ADHD, but are in general less marked/ obvious, i.e., exhibiting more inattentive symptoms than hyperactive/

impulsive symptoms (Gershon, 2002; Root & Resnick, 2003; Skogli et al., 2013). This may lead to girls being under-identified and not getting the appropriate support in time (Rucklidge, 2010).

1.1.3 Dichotomous vs continuous

The diagnostic systems for ADHD like DSM and ICD use a categorical approach to characterise the 'disorder'. Such a system has received criticism as numerous taxometric investigations applying advanced statistics found no evidence for discrete groups demarcated by clear boundaries (Coghill & Sonuga-Barke, 2012; Greven et al., 2016). It was therefore argued that ADHD should be modelled as a continuum, as a trait normally distributed in a bell curve.

A growing number of studies have supported the continuum model. Based on the data from a large population-based sample, Mous et al. (2014) found a significant relationship between cortical thinning and ADHD symptom severity, which was consistent with Shaw et al.'s (2011) study that found that cortical thinness was also observed in children with subclinical ADHD symptoms. In another neuropsychological research, Salum et al. (2014) noted that a poor performance in tasks assessing basic information processing (BIP) was found across the full ADHD symptoms spectrum, and the association between BIP performance and two domains of ADHD symptoms (inattention and hyperactivity-impulsivity) was linear in nature.

Another important implication of considering ADHD as a continuum is that researchers may draw insightful results by examining and comparing the low and moderate symptoms group. Instead of looking at "Non-ADHD" population as a whole, the dimensional model of ADHD allows researchers to explore what factors may contribute or relate to low or moderate levels of ADHD symptoms, and whether there are potential preventive strategies that can target those risk factors.

1.1.4 Impact and other areas of impairment

Although the pattern of difficulties experienced by children with ADHD may change over time, for instance, the levels of hyperactivity lessen while symptoms of inattention become more common, relatively speaking (Harvey et al., 2015), the impact of ADHD on an individual's functioning and wellbeing persists over different life stages (Biederman et al., 2010). A longitudinal study comparing 22-year-old adult participants who were diagnosed with ADHD at or before the age of seven against age-matched subjects without ADHD, found that 58% of participants with ADHD had poor long-term outcomes persist into adulthood, including the diagnosis of other psychiatric disorders, higher rate of criminal offense and lower educational level. Analyses also showed significant group differences, with only 13% subjects in the control group had comparable outcomes (Rasmussen & Gillberg, 2000). Many other studies on the impact of ADHD also found related impairments in school performance (Frazier et al., 2007), emotional regulation (Graziano & Garcia, 2016), social functioning (Nijmeijer et al., 2008), employment and earnings (Fletcher, 2014) and substance abuse (Lee et al., 2011).

It was also noted that ADHD did not only have an impact on individual outcomes, but also on family life and general classroom functioning. For instance, parents of children with ADHD reported higher level of parenting stress (Podolski & Nigg, 2001), lower marital satisfaction (Ben-Naim et al., 2019) and elevated parent-child conflict (Johnston & Mash, 2001); sibling relationship in these families was also found to be more negative and problematic (Harpin, 2005). At school, children with ADHD experienced difficulty in sustaining attention in academic tasks and were more likely to leave their seat without permission, disturb the teacher or classmates and speak out of turn, disrupting the classroom routines and affecting teacher-student interactions in general (Bender & Mathes, 1995; Gaastra et al., 2016).

1.1.5 Preschool ADHD

It is commonly agreed that ADHD-related behaviours become more apparent when children start formal education as the demand for impulse control and sustained attention significantly increases in classroom settings (Sattler & Hoge, 2006). For this reason, most ADHD cases are not typically diagnosed until at least the age of six, however, it has been found that children with attention, activity and impulse-control difficulties can be identified as early as 15 months of age and these early manifestations appear to show persistence over age (Arnett et al., 2013; Lahey et al., 2004; O'Neill et al., 2017). The factor structures of ADHD symptoms in preschool and school-age populations are comparable; the associated deficits and impact of preschool ADHD on toddlers' functioning and wellbeing are also similar to that of ADHD found in school age (Biederman et al., 2010; Fantuzzo et al., 2001; Sonuga-Barke et al., 1997, 2003, 2005).

One of the reasons why there has been more studies on preschool ADHD is that teachers nowadays in general expect pre-schoolers to exhibit certain levels of attentional and behavioural control, as well as ability to cope with waiting situations (Blair, 2002; Eisenberg et al., 2010; Ursache et al., 2012). It has been found that typically developed children as young as two years old could understand and manage to suppress their natural tendency to respond immediately and wait for their desired outcomes (Golden et al., 1977; Kochanska et al., 1996; Kochanska et al., 2000; Pauli-Pott & Becker, 2011).

As mentioned above, the early behavioural makers of ADHD have been noted to be associated with poor individual and familial outcomes - without sufficient intervention, even hyperactive children with normal cognitive abilities were found to struggle at school and have difficulties interacting with peers (Cole et al., 2011; Graziano et al., 2007; Ryan-Krause, 2017; Smith et al., 2017). However, most of the children with early signs of ADHD did not receive timely support (Glozman & Shevchenko, 2014). Early childhood is a critical period in the development of attentional control, behavioural and emotional regulation where changes in these aspects can be enormous; early identification and intervention are thus commonly agreed to be very important (Campbell, 2002; Ruff et al., 1998; Smith et al., 2017).

1.1.6 Intervention

In many countries, stimulant medications such as methylphenidate and amphetamine have been one of the most common treatments for school-age children with ADHD (Connolly et al., 2015). The effectiveness of pharmacological intervention for ADHD is well-documented, with around 70-80% of children with ADHD responded positively to psychostimulants, showing a diminished severity in symptom levels and improved academic performance (Banaschewski et al., 2006; Barbaresi et al., 2006; Barkley, 2006; Faraone et al., 2006; Hawk et al., 2018; Simeon & Wiggins, 1993). Like any other medications, the psychostimulants come with side effects and the most common ones are interference with growth rate, weight loss, sleep disturbance and fatigue, etc (Barkley, 2006; Sattler & Hoge, 2006; Sharma & Couture, 2014; Vaughan et al., 2012). A considerable proportion of parents have strong hesitation or feelings of ambivalence about prescription as they worry about the labelling and possible side effects (Hansen & Hansen, 2006; Leung et al., 1996; Wan et al., 2016). Moreover, the use of psychostimulants is a lot less popular among pre-schoolers and relevant efficacy research is limited (Greenhill et al., 2006; Mulqueen et al., 2015). Alternative interventions are thus recommended for children with ADHD under five years as first-line treatment (American Academy of Pediatrics, 2011; NICE, 2008).

The most common non-pharmacological treatment options are evidence-based behavioural and/or cognitive interventions, and parental interventions. Behavioural therapy is based on learning theory and principles of classical and operant conditioning which try to modify children's responses and behaviours using modelling, shaping, reinforcement and consequences, etc. (Sattler & Hoge, 2006). A meta-analysis of 114 studies on behavioural treatments for ADHD showed that the intervention had significant improvement on children's functioning, with overall effect sizes ranged from .70 to 3.78 in magnitude (Fabiano et al., 2009). Cognitive behavioural interventions such as the use of self-directed speech and self-monitoring were also found to be effective in the improvement of adolescent and adult ADHD symptoms (Antshel & Olszewski, 2014; Sprich et al., 2015).

Parent based interventions are recommended as they could be used for children at risk of developing ADHD and/or awaiting formal diagnosis (American Academy of Pediatrics, 2011). Manual-based parent training interventions such as the new forest parent training programme (NFPP), Triple P–Positive Parenting Program, and Incredible Years parent training programme aim to equip parents with behavioural management strategies, expectation management, positive parent-child communication skills and the planning of daily routines, etc (Daley et al., 2009). Systematic review showed that parent training was cost-effective in reducing ADHD symptoms and enhancing parental well-being (Charach et al., 2013; Sonuga-Barke et al., 2001, 2018). Similarly, classroom-based interventions such as Head Start were also found to be effective in reducing disruptive classroom behaviours in children with ADHD (American Academy of Pediatrics, 2011; Chronis et al. 2006; Feil et al., 2016; Gaastra et al., 2016).

Consistency in the behavioural management approach across home and school settings was noted to be the key to intervention success (Raggi & Chronis, 2006).

The efficacy of other nonpharmacological treatments such as dietary supplementation and artificial food colour exclusion was explored but further research is needed to test the clinical significance of these (Sonuga-Barke et al., 2013). In general, meta-analyses suggested that there was no single method that was found to be consistently effective in treating ADHD across time and cultures; the effect of a combination of pharmacological and behavioural interventions was noted to be stronger than sole approach (Coates et al., 2015; Hodgson et al., 2014; Sonuga-Barke, et al., 2013).

1.2 Delay Aversion Model

The neuro-psychological nature and the causal origins of ADHD have been theorised in a number of different ways. In this, we are going to focus on the explanatory power of the delay aversion hypothesis – first in terms the psychological significance of symptoms and their underlying cognitive or motivational mechanisms, second in terms of their developmental causes and/or processes. Therefore, this introduction will be structured around these two elements.

1.2.1 Part I – Delay aversion as a neuropsychological explanation of ADHD

The delay aversion hypothesis was first formulated as a behavioural economic model of ADHD in 1992 (Sonuga-Barke et al., 1992a, 1992b) – it was a novel approach in understanding the patterns of ADHD-related behaviours like hyperactivity and impulsiveness as a realization of economic functions (maximizing reward and minimizing delay). Since then, the formation has evolved with a stronger focus on the affective quality of the concept that ADHD may serve as a function to reduce the delay-associated aversive negative affective states. It was suggested that children with the attention, activity and impulse-control difficulties constellation, including those with full blown ADHD, find the experience of delay especially aversive and have a motivational drive to avoid or escape potential delay-rich situations (i.e., any conditions involving free or enforced waiting during tasks or for outcomes) (Sonuga-Barke, 1994; Sonuga-Barke et al., 1992a; Sonuga-Barke et al., 1992b). The children's apparent maladaptive responses in delay-rich situations such as terminating waiting time prematurely or choosing more immediate outcomes in choice situations (impulsivity), losing concentration, distracting themselves (inattention), creating stimulation and acting up when feeling bored (hyperactivity) are considered as means to reduce their subjective experience of delay and speed up passage of time where delay cannot actually be reduced (Lambek et al., 2011; Sonuga-Barke, 2002; Zakay, 1992; Zakay & Tsal, 1989). In sum, the delay aversion model perceives ADHD (inattentive and hyperactive behaviours) as a functional expression of delay aversion which are context-dependent, i.e. their variation in levels depends on how much delay was involved in the specific contexts.

1.2.1.1 Evidence: brain structure and functions

The delay aversion model highlights the dynamic and developmental nature of ADHD which is related to the fundamental alterations in the processes governing responses to incentives, especially when delivery of the rewards is delayed in time (Barkley et al., 2001; Sagvolden et al., 1998). Sonuga-Barke (2003) suggested that these alterations stemmed from impaired neural singling of delayed rewards associated with cortio-striatal circuits through orbito-frontal regions and the ventral striatum modulated by dopamine and other catecholamines.

In a study with rats, it was found that medication that activates dopamine receptors (D2 antagonist raclopride (40, 80, and 120 micrograms/kg) significantly reduced the rats' impulsivity and lengthened their pre-reward waiting time (Wade et al., 2000). In another animal study, it was found that the activity of dopamine neurons varied as a function of reward size (more activation in more valuable choice) and the amount of delay (less activation in longer delay) (Roesch et al., 2007). A functional magnetic resonance imaging (fMRI) study conducted with healthy human subjects also found that ventral striatum was highly sensitive to even slight change in the magnitude of delay on reward discounting tasks (Gregorios-Pippas et al., 2009).

In a direct comparison between adolescents with and without ADHD, another fMRI study showed that the ADHD group had less ventral striatal activation during the waiting period prior to reward presentation and the reduction in ventral striatum activation was correlated with the participants' ADHD symptom levels across the entire sample (Scheres et al., 2007). An EEG study examined the spontaneous brain activity of children with and without ADHD during resting and waiting found that increased activity during waiting (particularly in temporal regions) was only shown in children with ADHD and the activity level was associated with parent ratings of delay aversion (Hsu et al., 2015).

The strongest direct evidence for delay aversion in ADHD comes from brain imaging studies showing that the anticipation of delay was differentially associated with hyperactivation of brain regions that responded to negative emotions and aversive events such as frustration and punishment (e.g., amygdala and insula); and this hyperactivation was found to significantly mediate the relationship between ADHD and an increase in general delay sensitivity (Plichta et al., 2009; Van Dessel et al., 2018). In a study with relatively small sample size, imaging results showed qualitative difference in amygdala activation in adults with and without ADHD, with longer delays associated with decreased amygdala activity in controls and increased activity in ADHD group; physiological data collected using skin conductance and finger pulse rate also supported the relationship between symptom levels and emotional arousal (Wilbertz et al., 2013).

1.2.1.2 Evidence: experimental findings

Support for the delay aversion hypothesis comes from research findings using a variety of delay-involved tasks, including inhibition during waiting, choice delay, delay discounting and delay frustration tasks.

Inhibition: It has been consistently found that children with ADHD, relative to typically developing peers, exhibit greater difficulty in inhibiting their impulse when asked to wait for a 'forbidden' reward. Using multiple inhibition tasks with varied duration of delay and requirement of alternative responses, Bitsakou et al. (2008) found that children and adolescents with ADHD performed less well in all of them than non-ADHD controls and these effects were independent of IQ. Similar results were found in the preschool population. Performance in age-appropriate inhibition measures such as snack delay task (waiting for a signal before retrieval for the reward) and gift wrap task (waiting before opening a present) could discriminate between pre-schoolers with and without ADHD and the impulsivity scores were found to predict ADHD diagnosis in later years (Breaux et al., 2016; Pauli-Pott & Becker, 2021).

Choice delay: In a typical choice delay task, participants choose between small-immediate and larger-delayed rewards. A meta-analysis of 26 studies examining the relationship between ADHD and reward-delay choice impulsivity (i.e. choice of immediate over delayed rewards) found significant group differences (N_{ADHD} = 2,360 and N_{Control} = 1,960) (Patros et al., 2016). The preference for immediacy over delay was found to have discriminative validity between children with and without ADHD, with medium-to-strong pooled effect sizes ranging from .57 to .71 (Dalen et al., 2004; Marx et al., 2021; Schweitzer & Sulzer-Azaroff, 1995; Sonuga-Barke et al., 1994; Tripp & Alsop, 2001; Willcutt et al., 2008). One limitation of the traditional choice delay tasks is its inability to differentiate between an individual's inability to inhibit their impulses and their motivational drive to reduce waiting time.

Sonuga-Barke et al. (1992b) introduced the addition of post-reward delay in choice-delay tasks to equalise the amount of overall delay across response alternatives (i.e. next trial will appear immediately with no post-reward delay if participant chooses the larger-delayed reward whereas for the choice of small-immediate reward, a post-reward delay will be added before the next trial appears). With the new task, it was found that both ADHD and non-ADHD groups showed an increase in preference for the larger delayed reward, suggesting children with ADHD were not necessarily impulsive. To show that children with ADHD were delay minimiser rather than reward maximiser, Sonuga-Barke et al. (1992b) added the two conditions: time-constraint (participants were given ten minutes to make as many choices as possible) and trials-constraint (participants only had 20 choices to make) and found that relative to controls, children with ADHD showed similar preference for immediate rewards in the time-constraint condition but made less choices on large delayed rewards in the trials-constraint condition, resulting in an overall weaker performance in terms of reward but also a cutback in delay period.

It was suggested that in choice-delay tasks with conditions altering in the presentation of post-reward delay (e.g. The Maudsley Index of Delay Aversion—MIDA), children who were delay aversive would show higher preference for the small-immediate reward in the no-post-reward-delay condition than in the post-reward-delay condition. Indeed, research findings supported that the number of impulsive choices made by people with ADHD was greater when the choices are associated with overall delay reduction than when they were not (Antrop et al., 2006; Marco et al., 2009; Solanto et al., 2001; Sonuga-Barke et al., 2003). Moreover, in a varied version of the choice delay task in which errors or impulsiveness were punished with extra delay, even children with elevated ADHD symptoms were willing to invest more time in tasks and make more delayed choices (Sonuga-Barke, et al., 1996).

Delay discounting/ delay sensitivity: The delay aversion hypothesis suggests that children with ADHD are extra-sensitive to delay. Sonuga-Barke et al. (2004) used the dot-probe conditioning paradigm to pair colour patches shown on screen with three different delay-related cues (no delay, 3-sec delay or 9-sec delay) and found that children with ADHD presented stronger attentional bias towards delay-related cues, especially the ones signalling longer delays, over neutral cues.

An individual's sensitivity to delay can also be examined using tasks that include trials with varied delay duration or temporal discounting tasks with rewards varied along a continuum of waiting period. It was found that levels of inattention and hyperactivity in children with ADHD increased with the length of delay exposure (Bitsakou et al., 2006; Marx et al., 2021; Mies et al., 2018; Schwarz et al., 1983). Further, participants with ADHD were shown to discount future rewards and have steeper delay discounting curves than controls, i.e. subjective value of the delayed reward decreases with the length of the delay (Barkley et al., 2001; Marx et al., 2021; Mies et al., 2018; Patros et al., 2016; Sagvolden et al., 2005; Scheres et al., 2008; Thorell et al., 2017). However, some other delay discounting studies found no significant between-group differences (Patros et al., 2018; Scheres et al., 2006) and the fact that most delay discounting tasks were hypothetical-based with large difference in reward size and waiting interval up to year(s) might limit their application in testing pre-schoolers and younger children (Sjöwall et al., 2013).

Delay frustration: In the typical choice delay and delay discounting tasks, the "need to wait" was pre-announced and participants were given the options to avoid or reduce the amount of delay. More recent studies were conducted to explore individuals' responses in non-choice situations where pre-reward waiting periods was imposed; findings showed that children with ADHD were more reactive, frustrated and stimulation-seeking during the inescapable delay (Bitsakou et al., 2006; Bitsakou et al., 2009; Chronaki et al., 2019; Mies et al., 2018; Van Dessel et al., 2018). An innovative Delay Frustration Task (DeFT) was designed by Bitsakou et al. (2006) to explore adults' reactions in face of unexpected and inescapable delay; results showed that participants with elevated ADHD symptoms showed more intense reactions and took more actions to try terminating the delay. To our knowledge, no task of this sort has been designed for the preschool population.

Simulation in delay context: In randomized control trials, children with and without ADHD were assigned randomly in waiting situations with and without extra stimulation; observation results showed that children with ADHD exhibited significantly higher levels of physical activity such as running around and touching objects than the controls in the waiting situations without extra stimulation, whereas in the waiting condition with additional stimulation, both groups displayed less lower physical movement and the between-group differences narrowed (Antrop et al., 2000, 2006). These findings are consistent with the delay aversion hypothesis that individuals with ADHD have the motivational drive to avoid delay situations, and if not possible, would attempt to maximize their attention to non-temporal stimulation and/or create stimulation for themselves so as to reduce the subjective passage of the waiting time (Sonuga-Barke et al., 1992b; Sonuga-Barke, 2003). However, most of these studies assessed participants' behavioural responses during the waiting period only. Measures that can tap participants' waiting-related emotional responses may provide additional support to the delay aversion model.

1.2.1.3 Alternative neuropsychological models to delay

There has been a range of other neuropsychological models proposed to explain the complexity of ADHD, including the executive functioning deficits (EF; Barkley, 1997), state regulation deficits (SRD; Sergeant, 2000), basic information processing deficits (BIP; Salum et al., 2014) and temporal information processing deficits (Toplak et al., 2006).

While the delay aversion model highlights the patterns of behaviours and cognitive performance in children with ADHD varied from context to context (Castellanos et al., 2006), it was once argued in the 1990's that ADHD was a consequence of individual's deficit in executive functioning. The executive functioning model highlights the role of fixed and core deficits with the top-down cognitive processing that comprises goal-driven inhibitory control, selective attention, working memory, organization, planning and problem solving (Barkley, 1997; Castellanos & Tannock 2002). The behavioural manifestations of difficulties in executive functioning includes the inability to hold one's drive and act before thinking, the difficulty to consider long-term consequences or reward rather than focusing on more immediate ones, the display of excessive activity and lack of attention or persistence during tasks that require mental effort, and the difficulty to remember instructions and steps, etc. It was suggested that executive functioning was related to the dysfunction in neural pathways between frontal lobes and subcortical structures, basal ganglia in particular, which are modulated by catecholamine-based neurotransmitters such as dopamine and norepinephrine (Durston et al., 2011; Logue & Gould, 2014; Sediman, 2006).

At a neurobiological level, neuroimaging studies provided evidence supporting the executive functioning deficit model, for instance, USA- and UK-based research found that individuals with ADHD had smaller volume and reduced activation in the frontal and basal ganglia regions compared to control (Aylward et al., 1996; Castellanos et al., 1996; Cubillo et al., 2010; Swanson et al., 1998). Similar results were found in a fMRI study conducted in China (Cao et al., 2008). A more recent meta-analysis of 55 fMRI studies showed that for both adults and children with ADHD, relative to controls, had reduced activity in the frontoparietal system, with adults in addition showing hyperactivation in visual and dorsal attention systems (Cortese et al., 2012).

The relationship between ADHD and executive functioning deficits was also supported by experimental findings with the use of a large variety of assessment tools and tests developed to measure the multiple elements of executive functioning, such as go/no-go task tapping inhibitory control, Stroop test tapping selective attention, backward digit span tapping working memory and tower of London tapping planning, etc (Nigg, 2005). A systematic review of 83 studies examining the relationship between executive functioning impairment and ADHD found significant group differences (N_{ADHD} = 3,374 and N_{Control} = 2,969) in all the 13 measures, with tasks on response inhibition, working memory and planning as the most discriminating and consistent ones (Willcutt et al., 2005). The weaker performance in executive functioning tasks were found in both clinically diagnosed and community samples with raised ADHD symptoms, even when IQ and comorbid disorders were taken into account. In a more recent meta-analysis of 34 studies, similar significant group differences in executive functioning were found with a medium-sized pooled effect (.45); higher effect sizes (over .50) were observed for measures tapping response inhibition, working memory and reaction time (Pievsky & McGrath, 2018).

1.2.1.4 Neuropsychological heterogeneity and the dual and triple pathway models

In recent years, the limitations of the account that executive functioning impairment is a fixed and core deficit of children with ADHD have been highlighted. For instance, Salum et al. (2014) found that the associations between inhibitory-based executive function and ADHD were not significant. Moreover, the meta-analysis conducted by Willcutt et al. (2005) showed that a large proportion of individuals with ADHD, even for those in the extreme of the continuum and had a full diagnosis of ADHD, did not display significant weaknesses in the executive functioning measures. If performance in executive functioning tests was to be used as an identification measure, it was found that only around half of the children with ADHD were being reasonably classified suggesting that executive function deficit is not a single necessary, universal or sufficient condition for ADHD (Nigg et al., 2005; Willcutt et al., 2005; Willcutt et al., 2008). In a similar way, it was found that delay aversion alone could not discriminate ADHD groups from typically developed control groups (Bitsakou et al., 2009; Nigg et al., 2005). It is therefore now widely accepted that people with attention, activity and impulse-control difficulties are a neuropsychologically heterogeneous group with no one, single pattern of impairment accounting for all cases. There is a paradigm shift from understanding ADHD as a single core deficit to a highly complex and heterogeneous condition.

In 2003, Sonuga-Barke proposed a dual pathway model that both the impaired executive and reward circuits contribute to the presence of ADHD symptoms. The role of dopamine was critical in both circuits but via unique and distinctive pathophysiology pathways. The dual pathway model was supported by a number of studies that showed children with ADHD appeared to display difficulties in response inhibition as well as hypersensitivity to delay (Kuntsi et al., 2001; Solanto et al., 2001). A large-scale community study showed that children's ADHD symptoms correlated with both impulsive choices and delay aversion scores (Paloyelis et al., 2009).

Further studies directly compared the association between ADHD and the two pathways showed that although the outcomes of response inhibition and delay aversion tasks were not correlated with each other, they independently contributed to the same behavioural manifestations of ADHD (Bitsakou et al., 2009; Solanto et al., 2001). Systematic review conducted by Sonuga-Barke et al. (2008) also compared the role of executive functioning and delay aversion in ADHD diagnosis and concluded that neither of the models could solely explain the development of ADHD. In sum, an individual with inhibitory deficit may not necessarily be delay aversive and delay aversive does not necessarily mean impulsive as well, yet, both the two factors were shown to be strongly associated with ADHD and the combination of two could identify almost 90% of children with ADHD (Solanto et al., 2001).

The dual pathway model is also applicable in the preschool population. A preschool study employing three executive functioning tasks (working memory, set shifting, planning) and two delay tasks (delay of gratification and choice delay) showed that the measures within a domain were intercorrelated but the correlation between domains was not significant (Sonuga-Barke et al., 2003). Each of the executive functioning and delay aversion factors independently predicted ADHD symptoms even when other factors such as age and IQ were controlled for (Sonuga-Barke et al., 2003, see also Dalen et al., 2004, Pauli-Pott et al., 2013; Thorell & Wahlstedt, 2006). A meta-analysis of 25 studies with pre-schoolers aged between 3 and 6 showed that effect sizes for response inhibition tasks in association with ADHD was .64 while choice-impulsive decision had a larger effect size of .80; between-group differences were larger in younger than older children (Pauli-Pott & Becker, 2011).

Further, a triple pathway model was supported by the evidence that there was only a small overlap between the domains of inhibitory deficits, delay aversion and temporal deficits in the ADHD sample and there was a substantial number of individuals with ADHD showing difficulties in only one of the three domains, resulting in different neuropsychological subgroupings (Sonuga-Barke et al., 2010a). The fact that no single deficit is universally found in children with ADHD supported that this disorder is heterogeneous and can be developed in multiple paths (cognitive pathway, motivational pathway and/or temporal pathway). Between subjects, children with the same diagnosis may show different specific types of difficulties and within subjects, the difficulties experienced can change across different stages of life.

1.2.2 Part II – Delay aversion as an acquired characteristic

It was still not clear what the exact causes of ADHD are, and many factors were found to be associated with ADHD (Thapar et al. 2013). In 2005, Sonuga-Barke expanded the delay aversion model to explore the origins of the adverse emotional response to delay in some individuals with ADHD. He focused on delay aversion as an acquired characteristic that arises in individuals who are predisposed to struggle with waiting in delay-rich social contexts. This hypothesis is quite different from the existing causal models of ADHD that typically focus on its bio-genetic origins (Faraone & Larsson, 2019; Faraone et al., 2005) and its association with genetic alterations (Banaschewski et al., 2010; Faraone & Mick, 2010). While pre- and perinatal factors have also been implicated in the causes of ADHD pathways and trajectories, such bio-genetic pathways are considered impervious to post-natal social environmental influences. The impact of environmental factors has largely been dismissed. In the following, we first discuss the different causal models of ADHD, especially the role of genetic and environmental factors, then discuss how these factors are associated and implicated in the delay aversion model.

1.2.2.1 Bio-genetic causes of ADHD

Research in the past decades has shown that ADHD tends to run in families and is highly heritable. Systematic review of twin studies estimated high heritability rates of ADHD to be 70-80% (Faraone & Larsson, 2019; Faraone et al., 2005) and consistently found that identical (monozygotic) twins had higher chance to share the same disorder than fraternal (dizygotic) twins (Stevenson et al., 1993; Willcut et al., 2000). Taking into account the factor of shared family environmental, adoption studies compared the reporting rates of ADHD in different families and found that reporting rates were highest in biological relatives of adopted children with ADHD, followed by adoptive relatives of adopted children with ADHD and least in the relatives of children in control group, supporting that genetic factors underlie the causation of ADHD (Faraone & Larsson, 2019; Thapar et al., 2013). Molecular genetic studies tried identifying common gene variants among individuals with ADHD but results were mixed, with very small effect sizes of individual genomic loci found (e.g. D4 dopamine receptor gene (DRD4) and human dopamine transporter gene (DAT1/SLC6A3); Banaschewski et al., 2010; Nigg et al., 2020). It is thus commonly accepted now that the "genetic architecture" for ADHD is complex - ADHD is related to alterations in clusters of genes and no particular "risk genes" are necessary and sufficient to cause ADHD (Faraone et al., 2005; Faraone & Larsson, 2019; Faraone & Mick, 2010; Thapar, 2018).

Apart from genetic factors, neuroimaging techniques also found ADHD to be associated with complex abnormalities in brain structures, such as reduced grey matter volume, delayed cortical development, deficiency in one or more neurotransmitters, and lowered dopamine receptor density which are consistent with the executive functioning and delay aversion models (Sharma & Couture, 2014; Tarver et al., 2014). The effectiveness of stimulant medications in alleviating ADHD symptoms is considered supporting evidence of the solid linkage between reduced dopamine function and ADHD (Sharma & Couture, 2014).

1.2.2.2 Environmental causes of ADHD

Despite the high heritability rates of ADHD, a number of pre- and perinatal environmental risk factors have also been identified to be associated with ADHD (Sharma & Couture, 2014; Tarver et al., 2014; Thapar, 2018). A large amount of longitudinal and quasi-experimental research has been conducted to explore the environmental risk factors associated with ADHD and the most widely studied ones are: pre- and perinatal factors, environmental toxins and family environment (Thapar et al. 2013).

Examples of pre-natal risk factors include maternal smoking, stress, alcohol and drug misuse during pregnancy (Tarver et al., 2014). A systematic review showed that the risk for ADHD diagnosis in children whose mothers smoked before their birth was more than twice as much as those whose mothers did not, and the dose of cigarette smoking was also positively correlated with level of risks (Langley et al., 2005). The findings regarding the impact of alcohol and substance use during pregnancy were less consistent with insufficient statistical power (Linnet et al., 2003). Common perinatal risk factors for ADHD are prematurity and low birthweight (Tarver et al., 2014; Thapar et al. 2013), with estimated odds ratio of 4.3 and 10.5 for ADHD and ADHD predominantly inattentive type respectively (Johnson et al., 2010). The exposure of environmental toxins like lead and pesticides in both pre- and perinatal life, as well as dietary factors such as nutrition deficiency and consumption of food colouring and sugar were found to be associated with ADHD (Tarver et al., 2014).

A number of familial factors including psychosocial adversity or disadvantage, parental characteristics, parenting style and parent-child relationship were considered as risk factors for ADHD (Nigg et al., 2020; Thapar et al. 2013). Children who experienced deprivation and neglect in the early years were found to have higher level of ADHD-related behaviours, despite having a more stable familial environment in later years (Kreppner et al., 2001). The levels of maternal stress before and after pregnancy was positively correlated with the severity of children's ADHD symptoms (Glover, 2011; Grizenko et al., 2008).

The relationship between parenting style/ practices and ADHD has been one of the most popular focuses in the research on ADHD risk factors. A meta-analysis that includes 59 longitudinal studies showed that parenting interaction quality predicted later ADHD symptom levels and diagnosis, but the pooled effect sizes were small (e.g. .19 for harsh disciple and .17 for intrusive interaction) (Claussen et al., 2022). Parents of children with ADHD were found to be more controlling, less rewarding and responsive and had more frequent of punishment and lower level of warmth, however, again the magnitude of these associations was small (Modesto-Lowe et al., 2008; Pauli-Pott et al., 2018; Teixeira et al., 2015). Moreover, despite recent research effort in exploring the direction of the relationship between parenting and ADHD, it remains unclear whether the more negative parenting practices lead to an escalated level of ADHD-related behaviours, or the less optimal parenting style is primarily just a pattern of reactions provoked by the ADHD-related behaviours (Tarver et al., 2014). It has been observed that children with ADHD exhibited more disruptive behaviours at home, had higher incidence of fighting with siblings, answering back and ignoring parents' instructions (Johnston & Mash, 2001), and the ADHD-related behaviours was found to predict an increase in parental distress and mental well-being concerns (Modesto-Lowe et al., 2008; Theule et al., 2013).

1.2.2.3 Development of delay aversion and exacerbation of ADHD symptoms

Challenging the dominant view that bio-genetic pathways are impervious to post-natal social environmental influences, the delay aversion model proposed an alternative socio-motivational hypothesis of ADHD development (Marco et al., 2009; Sonuga-Barke, 1994, 2005; Sonuga-Barke et al., 1992, 2010b). It concerned the developmental origins of delay aversion and its potentially exacerbating effect on ADHD symptoms through a transactional process (Marco et al., 2009; Sonuga-Barke, 1994, 2005; Sonuga-Barke et al., 1992, 2010b). Sonuga-Barke (2005) suggested that delay aversion could develop overtime through a process of social conditioning and that this could exacerbate ADHD symptoms.

In this, it was suggested that children's challenging and maladaptive behaviours in that delay-rich settings would elicit punitive responses and rejection from parents and significant others like teachers and peers, which over time, could exacerbate their conditioned avoidance of waiting situations and consequently lead to an increase in ADHD-like symptoms (which are considered as behavioural manifestations of delay escape or reduction) (Lambek et al., 2014; Sonuga-Barke, 2002). This is a behavioural phenomenon that can be explained by classical conditioning – the original neutral waiting environment comes to be paired with the negative affect induced by the unfavourable feedback from others as well as the internal feelings of failure/shame; the conditioned waiting situation then promotes a conditioned avoidance of delay exhibited through an increase in impulsive and inattentive behaviours from children and further adverse feedback from others, resulting in a coercive cycle of negative reinforcement (Cartwright et al., 2011; Sonuga-Barke et al., 2005). An alternative learning mechanism is operant conditioning, which suggests that children who are punished for their impulsive behaviours during waiting may learn to be more inhibited to avoid future punishment; yet empirical evidence (see next sections) favours the classical conditioning explanation.

The hypothesis that children's development of delay aversion is associated with adults' responses during waiting situations has not been tested. As described in the previous section, there has been research evidence showing a relationship between ADHD symptoms and general negative parenting behaviours like punishment and negative affect, but the magnitude of the associations was small (Belsky et al., 1996; Rochelle & Cheng, 2016; Hutchison et al., 2016; Rothbaum & Weisz, 1994; Stevens et al., 2019), According to the developmental delay aversion hypothesis, parental negative responses during the delay is a key to the development of a conditioned avoidance of waiting situations and which over time exacerbates ADHD-related behaviours. The relatively small effects found in the existing parenting studies on ADHD may be related to the fact that they have not differentiated the effect of the context in the parent-child interactions and their associations with children's ADHD symptoms. General parenting style may have an effect on ADHD symptoms, but parental response in specific situations (waiting versus non-waiting) can have qualitatively and/or quantitatively different associations with ADHD.

1.2.2.4 Gene-environment interactions

Although genetic factors of ADHD have been well-documented, the environmental factors also are shown to have direct or indirect effects on ADHD diagnosis and severity via the gene-environment interactions (Faraone & Larsson, 2019; Faraone & Mick, 2010; Faraone et al., 2021). Bio-genetic and environment factors were not independent, rather, they overlap and have shared effects on children's development - the interplay of them could explain the differences in ADHD diagnosis among children under the exposure of similar levels of genetic or environmental risk factors (Thapar et al. 2013; Thapar & Stergiakouli, 2008). Take parenting as an example, the heritability of ADHD would mean that parents of children who are delay aversive may also have difficulties managing delay and their condition may have an impact on their parenting style and practices, and perhaps have a particular effect on their interaction style and responses to children in delay-rich settings (Tarver et al., 2014). The genetic risks may affect how sensitive one is to be affected by the environmental risk or protective factors; and altering the environmental factors may modify how ADHD-related behaviours are expressed and their levels of severity (Faraone & Larsson, 2019; Thapar & Stergiakouli, 2008).

1.3 Cross-cultural differences in ADHD

1.3.1 Prevalence

ADHD is generally considered to be manifest in similar ways and to similar degrees in different cultures (Bauermeister et al., 2010; Davis et al., 2011). Indeed, meta-analyses have shown that ADHD prevalence is similar across a wide range of cultural contexts and national groupings once methodological factors are taken into account, and a global pooled prevalence of ADHD was estimated to be 5.29% (Polanczyk et al., 2007, 2015). In the United Kingdom (UK), the range of prevalence rates was found to be between 1.5% (clinically recorded prevalence) and 8% (community prevalence), depending on what diagnostic tools were used and which informants were involved (ADHD Project Subgroup CAMHS Advisory Group, 2018; Alloway et al., 2010; Russell et al., 2014). The first prevalence study conducted in Hong Kong (Leung et al., 1996) found a prevalence rate of ADHD similar to the western prevalence in a local community sample. Similar rates were reported in other Asian societies like China (6.5%) and Taiwan (4.2%) (Liu et al., 2018). Specifically for the school-age population, the estimated prevalence in HK was 3-5% (Child Assessment Service, Department of Health, HKSAR, 2007).

1.3.2 Perceptions and report of ADHD-related behaviours

Although there are a variety of tools to assess ADHD, in real practice, the diagnosis usually depends on subjective reports and informants' (i.e., parents and teachers) interpretations of children's behaviours – whether the behaviours are considered as exceeding typical level and to a sufficient degree that they will be endorsed as an ADHD symptom (Canino & Alegria, 2008; MacDonald et al., 2019; Reid & Maag, 1994). It was found that these individual interpretations of hyperactive, inattentive and impulsive behaviours were strongly linked to cultural bias. For example, considering one of the DSM-5-TR diagnostic criteria—"often talks excessively", a child being interpreted as too talkative in one culture may be perceived as sociable and out-going in another (Sattler & Hoge, 2006; Sonuga-Barke et al., 1993). In a US-based study, it was found that children of Hispanic/Latino background were rated lower in ADHD symptom frequency by both teachers and parents than non-Hispanic children (DuPaul et al., 2016). In another, it was found that African American parents, compared to Caucasian parents, tended to perceive ADHD-related behaviours as a relatively short-term behavioural problem rather than a medical condition and had greater concerns about the corresponding treatment (Miller et al., 2009). Similar cross-cultural differences were indicated in a study that involved showing mothers from different ethnic background taped vignettes of children exhibiting behaviours that matched the ADHD diagnosis in DSM-IV; that Latino mothers showed greater concerns about the children's behaviours and were more likely to discuss the behaviours with medical practitioners than Anglo mothers (Gidwani et al., 2006).

Weisz et al. (1988) proposed that social norms regarding children's conduct and child-rearing practices had an impact on the level of stress experienced by parents when their children misbehaved which in turn would affect their endorsement thresholds for ADHD-related behaviours (Canino & Alegria, 2008; Gomez & Vance, 2008; Hillemeier et al., 2007; Porter et al., 2005; Thompson et al., 2017; Weisz et al., 1988). The cultural bias in perceptions of hyperactivity and inattention may lead to children diagnosed with ADHD in two different cultures showing different levels of actual behaviours.

Most of the existing comparisons of ADHD rating threshold across cultures were not direct, relying instead on data that were collected at different times and often for different purposes. For instance, Ho et al. (1996) found that HK boys were rated as having twice the levels of ADHD symptoms compared to UK children on Rutter's questionnaires items —"restless", "fidgety", "can't settle" (Rutter et al., 1970). A more recent study found similar results for teacher ratings (Lai et al., 2010; Meltzer et al., 2000). Despite these rating scale findings, studies of actual behaviour tend to suggest that HK children are less active than their UK counterparts. Luk et al. (2002) compared a HK epidemiological study of hyperactivity (Leung et al., 1996) against a separate but similar British study (Taylor et al., 1991) and found that the measured activity level was significantly lower in HK than UK children. These differences found in ratings and behaviours could be related to the cultural expectations between UK and HK parents on their children's behaviours when it comes to conformity to rules (Chao, 1994; Chen, 2005; Lam & Ho, 2010; Thompson et al., 2017). In Chinese culture, social norms require individuals to exercise self-control and compliance to avoid creating trouble or inconvenience for others (Chao, 1995), evident by cross-cultural comparison studies that showed Chinese parents had particular emphasis on children's hyperactive behaviours and had more extreme ratings in the hyperactivity domain on behavioural scales (Mann et al., 1992; Norvilitis & Fang, 2005).

In general, Asian parents also have high expectations for children's academic excellence and discipline, and are less tolerant of problematic behaviours and failures (Chao, 1994; Chen, 2005;

Lam & Ho, 2010; Thompson et al., 2017). When children behave in ways that breach these social standards, Asian parents tended to attribute the negative behaviours to internal characteristics and had higher levels of self-blame and reported parenting stress (Chiang et al., 2000; Leung et al., 2005). Whereas in western culture, parents are more likely to adopt a more child-centred approach, with more freedom given to children to choose what they want to do and how they want to channel their energy (Chen et al., 2003).

The advocacy and demand for self-regulation does not only exist within the household, but also in classroom settings. In HK, the most commonly used phrases for teachers to praise students are "gwaai" (乖, meaning well behaved) and "teng-waa" (聽話, meaning obedient and compliant); children who are quiet and do not act in a lively way are considered as good children; whereas for children who exhibit occasional undisciplined behaviours are more likely to be labelled as hyperactive (Leung et al., 1996; Porter et al., 2005; Taylor, 1998). In a UK-based study, Sonuga-Barke et al. (1993) found that teachers appeared to rate Asian children as more hyperactive than their English classmates, but the observed hyperactive behaviours and activity level of Asian children were actually lower than their English classmates who have matched levels of rated hyperactivity. Further, in a study using taped vignettes of target child exhibiting ADHD-related behaviours, it was found that teachers in China and HK rated the same pattern of behaviours as more hyperactive, inattentive, and impulsive than teachers in the UK (Alban-Metcalfe et al., 2002), again supporting the cultural differences in adults' perceptions and report of ADHD symptoms.

1.3.3 Expression of ADHD

1.3.3.1 Executive functioning

Cultural differences between the East and West were found in the studies of self-regulation (Canino & Alegría, 2008; Thompson et al., 2017; Weisz et al., 1988). Asian children appeared to outperform their Western same-age peers on executive functioning tasks (Chen et al., 1998; Lan et al., 2011; Fujita et al., 2022; Oh & Lewis, 2008; Schirmbeck et al., 2020; Schmitt et al., 2019; Wang et al., 2016). A Chinese versus American comparison found that Chinese pre-schoolers scored better their American counterparts in all the seven tasks that tapped different executive functioning skills while the two groups showed no significant differences in verbal ability and social functioning (Sabbagh et al., 2006).

Xu et al. (2020) found that the Asian's advancement in executive functioning in their years extended into the adolescent years. In a cross-cultural comparison of HK and UK adolescents' performance on a battery of tasks measuring inhibition (stop-signal task), working memory (spatial span task), set-shifting (figure-matching task) and planning (tower of Hanoi task), results showed a significant group difference, with 10-year-old HK children on average performed as well as UK children at age 12 (Ellefson et al., 2017). Interestingly, Chinese parents still rated their children as having worse executive functioning and poorer inhibition than parents in Western countries (Schirmbeck et al., 2020; Thorell et al., 2013).

Regarding the relationship between executive functioning deficits and ADHD, it appears to be established consistently across different Western countries, such as Canada, the United States, Germany, and Norway (Arora et al., 2020). Meta-analyses of western-based studies reported medium to large between-group effect sizes, supporting a positive association between ADHD status and EF impairments across cultures (Martinussen et al., 2005; Willcutt et al., 2005). Indirect comparisons of studies conducted in Eastern and Western nations supports the cultural invariance in ADHD neuropsychological correlates. Studies conducted in Asia also showed that children with ADHD performed less well than controls in working memory, self-control, planning and attention shifts tasks (Chan et al., 2006; Gau et al., 2009; Li et al., 2005; Yang et al., 2011). However, this assumption of cultural invariance has rarely been tested through direct cross-cultural comparison.

1.3.3.2 Waiting behaviours

Waiting-related responses and abilities are also likely to be shaped by cultural factors (Göllner et al., 2018; Mischel & Metzner, 1962; Silverman, 2003). For instance, motivated by Confucianism and collectivist ideology, self-regulation and patience during waiting situations are highly valued in Eastern cultures (Chao, 1994; Chao, 1995; Leung et al., 2005). Children are trained to exercise self-discipline appropriately during waiting and situations where their desires cannot be met immediately (e.g. classroom) (Eisenberg et al., 2010; Hue, 2007; Lan et al., 2011; Ng & Rao, 2008; Phelps, 2005; Sun, 2015). In contrast, in Western cultures, adults are generally more relaxed about their children and show more understanding of their frustration during these situations as well as higher level of acceptance of a broader range of behaviours (Chen et al., 1998; Chen et al., 2003).

Apart from waiting-related behaviours, children may also differ in their emotional expressions during the waiting situations. This is an area that has not been examined in any Asian cultures, but there are reasons to estimate that children in the Chinese culture would appear calmer than those in Western cultures, as it is a cultural expectation to suppress individual feelings and emotions regardless of context (Chan et al., 2021). Contrastingly, there is also a chance that

HK children may display more intense reactions during waiting than those in the West, as the culture in HK values efficiency and pragmatism; people there in general dislike waiting and live a fast-paced lifestyle (Hairon et al., 2018). The result-orientated tradition in the education system in HK may have also cultivated parents and children to emphasise productivity in tasks completion and any interruption or delay may trigger higher level of negativity (Young, 2012).

To the best of our knowledge, there has been only one cross-cultural study directly and specifically comparing children's waiting-related behaviours in Western and Eastern cultures - Ding et al. (2021) found that Chinese children were more able/willing to wait for larger-but-delayed rewards compared to British children. Indirect comparisons also showed that the correlations between ADHD symptoms and waiting-related responses were similar in HK and UK (e.g., Shum et al., 2021; Sonuga-Barke et al., 2003).

1.3.4 Process underpinning the development of ADHD

1.3.4.1 Bio-genetic factors and ADHD

The meta-analyses of 30 western-based studies found that the increased prevalence of 7-repeat (7R) allele of the exon 3 variable number tandem repeat (VNTR) of the DRD4 was associated to the risk for ADHD (Faraone et al., 2001). A HK-based genetic study found that the HK ADHD sample was associated with an increase of the 2-repeat (2R) allele instead (Leung et al., 2017). The lack of increased prevalence of the 7R allele in the HK sample appeared to be different from those identified in other European studies; however, they found that in Asian samples, the 2R allele functioned biochemically the same as the 7R allele, suggesting a mutation in the exon 3 VNTR of the DRD4 was a cross-culturally common risk factor for ADHD.

1.3.4.2 Familial risk factors and ADHD

In both UK and HK-based studies, parents' harsh parenting and negative parent-child relationship were found to be associated with increased rates of ADHD (Morrell & Murray, 2003; Lifford et al., 2008; Lifford et al., 2009). However, it was found that Chinese parents were more likely to adopt authoritarian parenting style (Chao, 1994; Gomez & Vance, 2008). If parental negativity and use of punishment is truly a risk factor for ADHD, logically it can be inferred that the incidence of ADHD should be higher in HK than UK, yet, prevalence studies did not show significant differences between the rates in these two nations (section 1.3.1). It remains a question whether parenting factor associate with ADHD to a different extent in different cultures.

Another issue that may lead to potential cross-cultural differences in the relationship between parenting and ADHD is the role of child's primary caregiver. It has been found that paternal and maternal parenting behaviours have qualitative differences in their prediction of children's ADHD symptoms, for instance, levels of children's inattentiveness positively correlated with maternal hostility but negatively correlated with paternal involvement (Keown, 2012). Instead of having mothers or fathers as the primary caregivers, a considerable proportion (appropriately one in four families) of children in some Asian cities like HK and Singapore were taken care of by full time live-in foreign domestic helpers (Cheung, 2021; Lam et al., 2006). These foreign domestic helpers are not only responsible for household tasks like cooking and cleaning, but they also take up a major childcare role (Cheung, 2014; Leung & Shek, 2018). Previous studies suggested that children perceived their domestic helpers as "substitute parents" and established a close relationship with them (Lee & Yelland, 2017; Leung & Shek, 2018). Ip et al. (2008) also found that mothers with domestic helpers expressed that they felt guilty about the lack of involvement in childcare and the domestic helpers rated themselves as having higher warmth than the mothers. How this phenomenon affects children's behaviours is not clear. While it was suggested that domestic helpers regarded the children they looked after in the household as one of their 'bosses' and thus were more reluctant to discipline the children and likely to adopt a permissive childrearing style (Ip et al., 2008, Yeoh et al., 1999), others noted that the hiring of domestic helpers may have a positive impact on parent-child relationship as the domestic outsourcing can allow parents to spend more quality time with their children after work hours (Chan, 2005; Cheo & Quah, 2005). There has been only one study so far that includes the caregiver role in the study of children's ADHD symptoms - a Singapore-based study found that families with and without children with ADHD did not have significant differences in their childcare arrangement and that the children's behaviours did not differ as a function of caregivers (Nomanbhoy & Hawkins, 2018). In general, there are a large number of between-nation differences in familial characteristics and parenting practices, it is therefore essential to examine the development of ADHD and its correlates in a cultural context.

1.4 Aims of the current research

The overall aim of this work is to fill the literature gap in the understanding of preschool ADHD symptoms in relation to delay aversion and waiting behaviours in a cultural and familial context. How the interaction between children's and parents' responses during waiting associate with the development of preschool ADHD symptoms over time have not been explored. We conducted four studies to examine ADHD symptom rating threshold, relationship between waiting-related responses, delay sensitivity and ADHD, as well as the socio-developmental origins of delay aversion and ADHD in two cultures known to have very different expectations on children's behaviours.

To do this, we first developed a new task. The first objective of this research study was to introduce the development and application of a new task that measures preschool children's waiting-related behavioural and emotional expressions - the Preschool Delay Frustration Task (P-DeFT) (presented in Chapter 3). As mentioned, there has been a lack of testing tool in exploring pre-schoolers' behaviours and frustration in situations when waiting is enforced unexpectedly. The P-DeFT allows us to measure children's behavioural agitation and negative affect during and after the delay. This study also examined how children in HK and UK differ in their behavioural and emotional frustrations during unexpected delay situations; information on pre-schoolers' waiting-related frustrations in the HK context is particularly lacking.

Another major aim of the research is to examine ADHD in a cultural context by comparing how parents in HK and UK adopt different thresholds when rating ADHD symptoms and how these ratings associate with pre-schoolers' waiting-related abilities and responses. With regard to the cultural differences in parents' perceptions and report of ADHD-related behaviours, the second objective (presented in Chapter 4) was to test the relationship between parent-rated ADHD symptom levels and pre-schoolers' objectively measured activity level in HK and UK and explore what factors may contribute to the differences in ADHD symptom endorsement thresholds between the two cultures.

As an extension of the second objective, the third objective (presented in Chapter 5) was to test the delay aversion hypothesis by examining the linkage between parent-rated ADHD symptoms and children's waiting-related performance and reactions. To fill the literature gap in understanding such relationship in a cultural context, we explored the cultural differences through a direct comparison of pre-schoolers in HK and the UK.

The fourth objective (presented in Chapter 6) was to test the socio-developmental origins of delay aversion and its effect on ADHD symptom levels over time, that is, to explore how parental reactions during waiting at one point could affect children's delay aversion and ADHD symptom levels after a period of time. We also examined if parents from different cultures who vary in their parental expectation and perceptions of ADHD-related behaviours would differ in their reactions during waiting and whether there would be cultural invariance in its relationship to children's development of delay aversion and ADHD. This study is the first to employ a longitudinal and cross-cultural design in exploring how parents and children shape each other in their waiting-related behaviours.

In each of the empirical chapters, research questions and hypotheses are presented in detail, following by the findings in relation to the study objectives. Chapter 7 summarises the interpretation and discussions of the results, as well as the implications, strengths, limitations and future directions of the work presented.

Chapter 2 General Methodology

Chapters 3-6 are all based on data collected for this work. The participants and measures are common in these chapters, but specific methodical features and data analysis plans are provided in detail in the relevant chapters.

2.1 Funding and Ethical Approval

This work was funded by the Centre for Doctoral Studies at King's College London and received ethical approval from the Research Ethics Committees at King's College London (KCL; reference: HR-18/19-8506) and the University of Hong Kong (HKU; reference: EA1812027) in 2019.

2.2 Study Design

This study adopts a longitudinal cross-cultural design. Participants were pre-schoolers and their parents recruited from communities in London, United Kingdom and Hong Kong. The original plan was to use the same sets of measures, which included parent and teacher questionnaires, interviews with parents and in-person testing at the university at both T1 (2019) and T2 (2020, 12 months later). However, due to the COVID-19 pandemic, in-person testing was suspended for most of 2020 and only 12 in-person testing sessions were successfully completed between phases of lockdowns from May to July 2020. Due to the small number of available data, these were not included in the main analyses of this thesis but were used to establish test-retest reliability for the waiting tasks. The T2 follow-up, which aimed to measure the development of children's ADHD symptoms and delay aversion over time, was eventually carried out using parent and teacher questionnaires. Full sets of data were collected at T1 between May 2019 and Jan 2020 (children aged 3-5 years) and follow-up questionnaires were completed at T2 between Aug 2019 and Jul 2021 (children aged 4-6 years).

2.3 Participants

The sampling procedure is outlined in **Figure 2-1**. Participants in this study were recruited via local nurseries, preschools and online parent groups using social media adverts in London, UK, and Hong Kong. One-hundred-and-eighty-nine preschool children and their parents gave their consent to participate in the initial screening (UK: n=68, 51 % male; HK: n=121, 58 % male).

The screening questionnaires completed by teachers and parents provided basic demographic information of the child participants, whether the child had a diagnosis of special educational needs and/or pervasive developmental disorders (e.g., autism spectrum disorder), and their primary language spoken at home and at school. Thirty children (n^{UK}=13 and n^{HK}=17) were excluded on the following criteria — outside the age range; existing diagnosis; age-inappropriate level of comprehension abilities of spoken English (UK) or Cantonese (HK); teacher non-engagement; family not able to attend testing sessions. No children had been formally diagnosed with ADHD and none were taking ADHD medications.

To ensure we include child participants with a range of levels of activity and attention problems and compare like with like across cultures, children were screened for their level of ADHD symptoms using the five-item hyperactivity/inattention subscale of the Strengths and Difficulties Questionnaire completed by parents and teachers (SDQ, version T2-4). We oversampled participants and then excluded 47 in order to balance the degree of ADHD symptoms at a group level in HK and UK samples. The number of children having slightly raised levels of ADHD symptoms rated by parents or teachers (subscale score ≥ 5) in the final UK and HK sample were not statistically different, $\chi^2(1) = 1.27$, $p = .26$. The average SDQ subscale scores in the final UK and HK sample were not statistically different, $F(1, 110) = 2.33$, $p = .130$. Full T1 data was available for 112 children and their parents ($n^{UK}=55$ and $n^{HK}=57$; females = 49 and males = 63). All the parent participants in this sample were mothers. Families were contacted for T2 participation 11 months after their T1 testing session; 79.5% of them completed the follow-up ($n^{UK}=39$ and $n^{HK}=50$; females = 42 and males = 47). Reasons for drop-out included moving abroad, time constraint and inability to get in touch with.

Demographic characteristics of the sample at T1 and T2, collected through parent questionnaires, were shown in **Table 2-1** and the statistical comparison between the UK and HK participants were shown in **Table 2-2**.

The mean age of child participants at T1 and T2 was 46.20 months (*S.D.* = 5.73; range = 36.92–59.24) and 60.85 months (*S.D.* = 7.76; range = 48.36–81.30) respectively. UK and HK children's average age at T1 was not statistically different, whereas UK children's age at T2 ($M = 65.06$, *S.D.* = 8.79) was greater than that of HK children ($M = 57.56$, *S.D.* = 4.80), $F(1, 87) = 26.37$, $p < .001$. The original plan to invite participants for a follow-up testing 12 months later was disrupted due to the COVID-19 pandemic. The planned T2 in-person testing, which involved administering the same sets of measures as in T1, was suspended due to school closures and lockdown and thus the follow up T2 data could only be obtained using parent and teacher questionnaires. Contacting parents and teachers during the pandemic was challenging and a large number of parents and teachers, especially those in the UK, needed additional time to complete the questionnaires due to the extra childcare and online teaching support in that period. Note that although the average age of UK children at T2 when their parents and teachers completed the questionnaire was greater than that of HK children, the average age of

UK and HK children at T1 when they completed the IQ test, waiting and non-waiting tasks was not significantly different. The mean IQ of participants was 106.95 (*S.D.* = 11.53; range = 82–132) and no significant difference was found between the UK and HK sample. Children's age and IQ were considered potential covariates and would be controlled for should we find an association between them and the outcome measures.

The family structure and household income, as well as parent participants' age and employment status, between the UK and HK sample were not statistically different ($\chi^2 s \leq 5.33$, $p \geq .095$). UK and HK families were statistically different in three areas: child-care role, educational level and ethnicity. Frist, regarding childcare role, it was found that the percentage of mothers as major caregiver for the child was less in HK than UK families. Such difference was likely due to the availability of affordable childcare options in HK – a recent household survey conducted in HK showed that more than one in four young families had employed live-in domestic worker(s) in the recent ten years (Cheung, 2021). Second, it was found that UK mothers had a higher level of education. Third, for ethnicity, it was as expected that the UK sample was more ethnically diverse than the HK sample with more than one quarter of the parents being either of Asian, Black or mixed ethnicity. Follow-up data had been collected and it was found that 73% of the ethnic minority group were second-generation migrants, having been born in the UK. In relevant chapters, the parent characteristics would be included as potential covariates. The between-ethnic-group differences within the UK sample would be preliminarily explored but only as a supplementary information due to the small number of participants in each ethnic group.

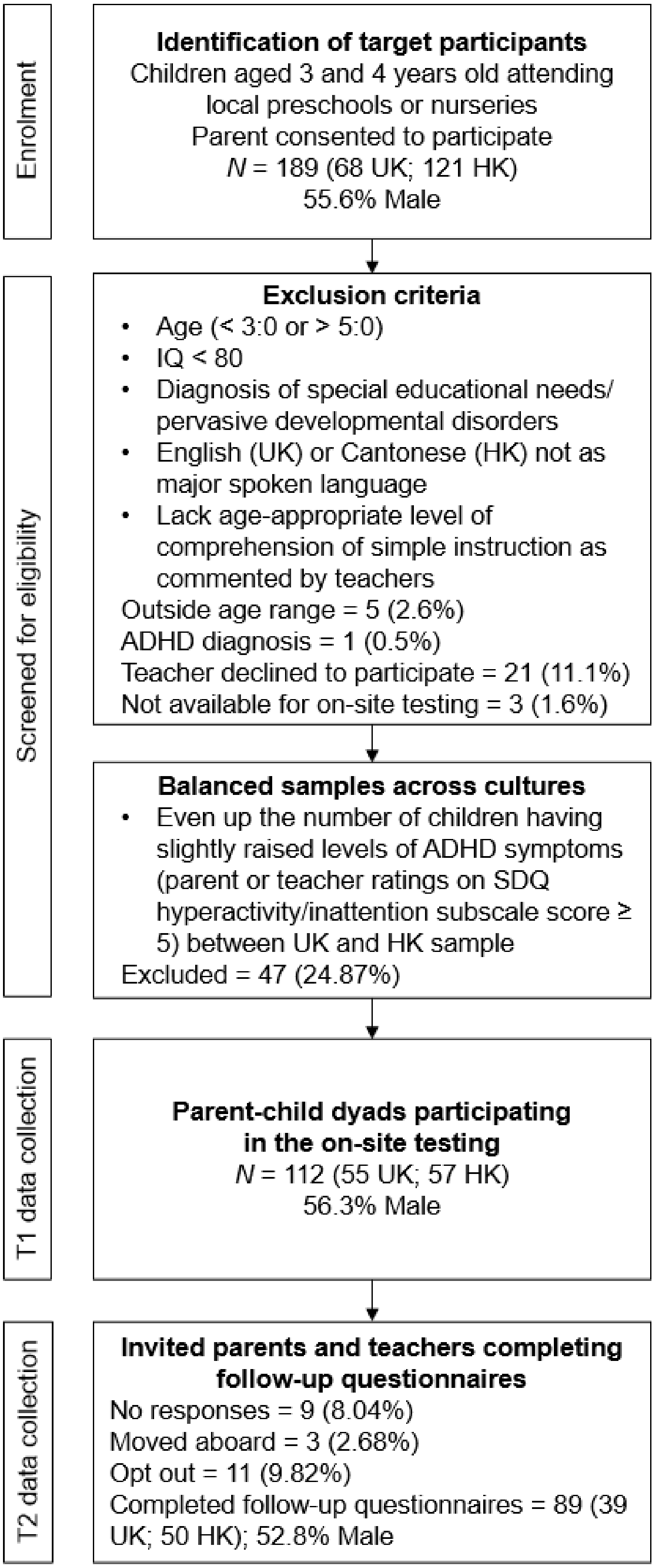

Figure 2-1 Sampling procedure

Table 2-1 Demographic details of participants in UK and HK at T1 and T2

	T1			T2		
	Full (*n* = 112)	UK (*n* = 55)	HK (*n* = 57)	Full (*n* = 89)	UK (*n* = 39)	HK (*n* =50)
Child characteristics						
Age (months) – mean (SD)	46.20 (5.73)	46.55 (6.49)	45.86 (4.91)	60.85 (7.76)	65.06 (8.79)	57.56 (4.80)
IQ – mean (SD)	106.95 (11.53)	108.72 (12.20)	105.26 (10.69)	/	/	/
Female – *n* (%)	49 (43.75)	25 (45.45)	24 (42.11)	42 (47.19)	19 (48.72)	23 (46.00)
Living with both parents	106 (94.64)	51 (92.73)	55 (96.49)	85 (95.51)	37 (94.87)	48 (96.00)
Household characteristics *n* (%)						
Mother as major caretaker:	82 (73.21)	51 (92.73)	31 (54.39)	64 (71.91)	35 (89.74)	29 (58.00)
Monthly household income:						
Below £2000	10 (8.93)	4 (7.27)	6 (10.53)	11 (12.36)	2 (5.13)	9 (18.00)
£2000-2999	8 (7.14)	1 (1.82)	7 (12.28)	8 (8.99)	2 (5.13)	6 (12.00)
£3000-3999	16 (14.29)	8 (14.55)	8 (14.04)	11 (12.36)	5 (12.82)	6 (12.00)
Above £4000	78 (69.64)	42 (76.36)	36 (63.16)	59 (66.29)	30 (76.92)	29 (58.00)
Parent characteristics *n* (%)						
Age group:						
25-34	33 (29.46)	11 (20.00)	22 (38.60)	15 (16.85)	4 (10.26)	11 (22.00)
35-39	53 (47.32)	30 (54.55)	23 (40.35)	47 (52.81)	24 (61.54)	23 (46.00)
Over 40	26 (23.21)	14 (25.45)	12 (21.05)	27 (30.34)	11 (28.21)	16 (32.00)
Highest education level:						
Secondary	16 (14.29)	1 (1.82)	15 (26.32)	13 (14.61)	0 (0)	13 (26.00)
Higher education	14 (12.50)	3 (5.45)	11 (19.30)	11 (12.36)	2 (5.13)	9 (18.00)
Bachelor	43 (38.39)	22 (40.00)	21 (36.84)	32 (35.96)	12 (30.77)	20 (40.00)
Master or above	39 (34.82)	29 (52.73)	10 (17.54)	33 (37.08)	25 (64.10)	8 (16.00)
Ethnicity:						
White	40 (35.71)	40 (72.73)	0 (0)	31 (34.83)	31 (79.49)	0 (0)
Asian	65 (58.04)	8 (14.55)	57 (100)	57 (64.04)	7 (17.95)	50 (100)
Black/ mixed	7 (6.25)	7 (12.73)	0 (0)	1 (1.12)	1 (2.56)	0 (0)
Full-time employment:	45 (40.18)	18 (32.73)	27 (47.37)	36 (40.45)	12 (30.77)	24 (48.00)

Table 2-2 Comparison of demographic characteristics between UK and HK sample

	Statistical comparison between UK and HK sample					
	T1			T2		
	Statistics (F / χ^2)	Significance (p)	Effect size (η^2_p / Cramer's V)	Statistics (F / χ^2)	Significance (p)	Effect size (η^2_p / Cramer's V)
Child characteristics						
Age (months)	F (1, 110) = .41	.526	.00	F (1, 87) = 26.37	<.001	.23
IQ	F (1, 109) = 2.53	.114	.02	/	/	/
Female	χ^2 (1, 112) = .13	.721	.03	χ^2 (1, 89) = .07	.799	.03
Living with both parents	χ^2 (1, 112) = .78	.376	.08	χ^2 (1, 89) = .07	.799	.03
Household characteristics						
Mother as major caretaker	χ^2 (1, 112) = 20.98	<.001	.43	χ^2 (1, 89) = 10.93	<.001	.35
Monthly household income	χ^2 (3, 112) = 5.33	.149	.22	χ^2 (3, 89) = 5.28	.152	.24
Parent characteristics						
Age group	χ^2 (2, 112) = 4.71	.095	.21	χ^2 (2, 89) = 2.90	.235	.18
Highest education level	χ^2 (3, 112) = 26.07	<.001	.48	χ^2 (3, 89) = 27.27	<.001	.55
Ethnicity	χ^2 (2, 112) = 83.93	<.001	.87	χ^2 (2, 89) = 64.06	<.001	.85
Full-time employment	χ^2 (1, 112) = 2.50	.114	.15	χ^2 (1, 89) = 2.70	.100	.17

2.4 Measures

A wide variety of measures with multiple informants and methods were used in this study (summarized in **Table 2-3**).

Table 2-3 Summary of measures used in data collection

Construct	Instrument	Method	Informants
Child cognitive ability	Wechsler Preschool and Primary Scale of Intelligence (WPPSI)	T	C
Child AD/HD symptoms	Strengths and Difficulties Questionnaire (SDQ, version T2-4)	Q	Tr; P
	ADHD-Rating Scale IV Preschool Version (ADHD-RS-IV-P)	Q	Tr; P
Waiting-related responses	Bee Delay Task	T, Ob	C
	Cookie Delay Task	T, Ob	C
	Preschool Delay Frustration Task (P-DeFT)	T, Ob	C
	Parent-Child Delay Frustration Task (PC-DeFT)	T, Ob	C, P
Physical activity level	Wrist-worn activity tracker (actometer)	T	C
Delay aversion/ Delay sensitivity	Quick Delay Questionnaire (QDQ)	Q	Tr; P
Parental reactions to children's behaviours	Free play	Ob	C, P
	Clean-up	Ob	C, P
	Parent-Child Delay Frustration Task (PC-DeFT)	T, Ob	C, P
Parenting style	Parenting Styles and Dimensions Questionnaire – Short Form (PSDQ-SF)	Q	P
Parenting stress	Parenting Stress Index 4 – Short Form (PSI-4-SF)	Q	P
Parental emotional responses	Parental Emotional Response to Children Index (PERCI)	Q	P

Note. T = Testing; Q = Questionnaire; Ob = Observation; Tr = Teacher; P = Parent; C = Child

2.4.1 Child cognitive ability

Children's intelligence quotient (IQ) was estimated using the Block Design (non-verbal concept formation) and Vocabulary (verbal concept formation) subtests of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler, 2003). The WPPSI is a widely used assessment tool to measure the cognitive ability of pre-schoolers and young children aged between 2 years 6 months and 7 years and 3 months. It is a reliable and valid measure with strong psychometric properties (Gordon, 2004). The WPPSI has been translated and normed for clinical and research purposes in many countries including UK and HK. The English (UK) and Traditional Chinese language versions were used in this study. To ensure children have the age-appropriate cognitive ability to comprehend the instructions of the waiting tasks as described in 2.4.3, children with IQ below 80 (*n*=4) were excluded in this study.

2.4.2 Child ADHD symptoms

At T1, parents and teachers rated the child participants' inattentive and overactive behaviours using the Strengths and Difficulties Questionnaire (SDQ, version T2-4). The SDQ is a widely used, psychometrically strong and brief behavioural screening questionnaire designed for research and clinical purposes (Goodman, 1997). The hyperactivity/inattention subscale consists of five items: two measuring inattention (e.g. "easily distracted, concentration wanders"), two hyperactivity (e.g. "restless, overactive, cannot stay still for long") and one impulsivity (e.g. "can stop and think things out before acting"). Informants rate the children's behaviours against the statement on a 3-point scale: 0="Not True", 1="Somewhat True" and 2="Certainly True". Provisional cut-off values of teacher-rated SDQ scores for 2-4 year olds provided by the officials (http://www.sdqinfo.com) in 2015 are: 0-4 (80%) = "Close to average", 5-6 (12%) = "Slightly raised", 7 or above (8%) = "High". Similar cut-off points are shown in an American sample of this age group. The original English language version was used in the UK. A validated Chinese version translated by Lai et al. (2010) was used in HK.

Children's level of attention, activity and impulse-control was evaluated by parents at T1 and by both parents and teachers at T2 using the ADHD Rating Scale IV Preschool Version (ADHD-RS-IV-P; McGoey et al., 2007). This version was modified from the classic ADHD Rating Scale IV (DuPaul et al., 1998), with additional items that were found developmentally appropriate for pre-schoolers. The 18 items were derived from the DSM-5 diagnostic criteria for ADHD. Informants rate the frequency of occurrence of the described behaviours using a 4-point scale: 0="Never or rarely", 1="Sometimes", 2="Often" and 3="Very often". Subscale scores were calculated for inattention and hyperactivity/impulsivity factors by summing scores on odd and even-numbered items respectively. A total score can be computed by adding scores of all the items; a higher score reflects a higher level of ADHD symptoms. The ADHD Rating Scale IV had been validated in a large sample of 1,616 Chinese children (Su et al., 2015); factor analysis confirmed a two-factor model where equal variances were accounted for by the "inattention" and "hyperactivity-impulsivity" dimensions. The psychometric properties of the translated Chinese ADHD Rating Scale IV have been found to be comparable to the original English version; it demonstrated high internal consistency, good test-retest reliability, as well as high convergent and discriminant validity. The ADHD Rating Scale IV has been widely used as a screening tool to assess children's ADHD symptoms in HK. In this sample, Cronbach's *αs* for the full scale in T1 and T2 were .91 and .93 respectively. Test-retest reliability between T1 and T2 was .84. Specifically, in the UK sample. Cronbach's *αs* for the full scale, inattention subscale and hyperactivity-impulsivity subscale were .90, .88 and .81 respectively, whereas in the HK sample, Cronbach's *αs* for the full scale, inattention subscale and hyperactivity-impulsivity subscale were .89, .86 and .80 respectively. The split-group analyses indicated that the internal consistency of each subscale within each subsample was largely comparable.

2.4.3 Waiting-related responses

Chapter 1 described the use of multiple waiting tasks in the research on delay aversion. There are a few putative indices of waiting intolerance: (i) terminating the wait sooner than expected, (ii) choosing smaller-immediate over larger-delayed reward and (iii) showing more intense behavioural and emotional response in inescapable wait. It was previously found that, although children's performance in these different types of waiting tasks showed a small magnitude of correlation, they shared a common variance and could discriminate children with and without ADHD (Bitsakou et al., 2009). In this work, three waiting tasks were used to tap child participant's performance and their behavioural and emotional reactions during delay of different nature (delay of gratification, choice delay and delay frustration). Another newly designed waiting task was used to measure both the parent and child participant's waiting-related responses and reactions.

Most previous studies only include performance indicators of waiting tolerance (e.g. choice of immediate reward, retrieval of prohibited reward before waiting time ends), but it has been shown that individuals with ADHD also had different levels or intensity of emotional responses during delay relative to controls (Chronaki et al., 2019; Mies et al., 2018; Van Dessel et al., 2018). Therefore, in each of the four waiting tasks, participants' waiting-related behavioural agitation (i.e., squirming/fidgeting) and negative emotional reactions/ affect (i.e., observed frustration as indicated by frowning, sighing and pouting) were observed and coded by trained researchers using a 4-point scale with 1="None/ Very rare – 0-10% of time", 2="A little – 11-25% of time"; 3="Quite a lot – 25-50% of time" and 4="A lot - >50% of time". A higher score reflects a higher level of waiting-related agitation and frustrations. Coders were trained using videos from the pilot data and reached a 90% consensus prior to the official video coding. Inter-rater reliability for the behavioural and affective codes was excellent – the intraclass correlation coefficients ICC(2,1) with consistency definition were .98 and .95 respectively, indicating an excellent agreement between the raters.

2.4.3.1 Cookie Delay Task

An adapted version of the Cookie Delay Task (CDT) was administered to measure children's ability to delay gratification and to gauge their reactions during the waiting period (Golden et al., 1977; Campbell et al., 1994). The original task involved hiding an edible treat under one of the three containers and instructing participants to wait for a signal until they were allowed to retrieve it. In this study, as in other recent studies, attractive stickers were used instead of cookies. To make waiting more motivating, a bonus sticker will be rewarded to children if they manage to wait until the researcher presents the signal (clapping) before retrieving the sticker. This adapted version included eight trials with varying delay intervals between 5-sec and 40-sec. Children's willingness/ability to wait for rewards was coded based on their behaviour, with 0 = "not inhibited" (found and retrieved the reward before the signal), 1 = "partially inhibited" (touched the cup but did not take the reward), and 2 = "fully inhibited" (waited until the signal is given) (Sonuga-Barke et al., 2003). Scores are reverse coded in this task; a higher score reflects a higher level of *maladaptive waiting-related responses*. In this sample, Cronbach's α for the eight trials was .72 and test-retest reliability was .87.

2.4.3.2 Bee Delay Task

The Bee Delay Task (BDT) was designed by Markomichali (2015) to be developmentally appropriate for pre-schoolers to measure their waiting-related responses in terms of pre-emptively judging how long they would be able/willing to wait and then seeing if they did wait that long. Distinctive to other computerised choice delay tasks, the BDT was made easier for pre-schoolers to comprehend and was not restricted to a choice between two alternatives of small but sooner rewards (SS) and large but later rewards (LL).

In the BDT, children were shown seven flowers on a computer screen and told that a bee would go to each flower to collect nectar. They were also told that they would earn one point (which could be exchanged for stickers afterwards) for each flower that the bee landed on. It was also explained to them that the bee would get tired with each flower it landed on, and it would take longer for it to fly to the next flower (i.e., the amount of delay between flowers would increase with a rate of 125% per flower). They were asked to choose the number of flowers they wanted their bee to visit before the trial started. Children were also told that they could press a button during a trial to stop the bee before visiting their chosen number of flowers, if they preferred (i.e., to terminate the trial earlier). If they pressed it, the trial ended immediately, and they would get the points they had won up to then. There was a total of ten trials. Discrepancy scores were computed by dividing the number of flowers/waiting time they actually experienced before they stopped the trial by the number of flowers/waiting time chosen; these were reversed coded, and a higher score indicates that the amount of experienced waiting time was less than the amount of chosen waiting time, reflecting a higher level of *maladaptive waiting-related responses*. In this sample, Cronbach's α for the ten trials was .99 and test-retest reliability was .88.

2.4.3.3 Preschool Delay Frustration Task (P-DeFT)

The computerized Preschool Delay Frustration Task (P-DeFT) is a preschool version of a task created by Bitsakou et al. (2006) to measure children's behavioural and affective expressions of frustration when a continuous presentation of a reinforced task is unexpectedly interrupted. This newly developed P-DeFT was designed by the author of this thesis to be a simple, age-appropriate and enjoyable "shopping" game (as illustrated in **Figure 2-2**). The set up included a traffic light system shown on a screen and a "crossing" positioned at the side of participant's chair. In each trial of the game, participants were first shown a red *Wait signal* on the screen and then asked to complete a two-stage task – (1) press a "crossing" button to change that Wait signal to a green *Go-signal* then (2) complete a shopping task at the toy supermarket which involved locating an object shown by the experimenter on a shopping card. The only rule of the game for participants was to wait for the red Wait signal to change to a green *Go-signal* before proceeding to find the item.

There was a total of 18 trials. In the majority of trials (n = 12), the *Go-signal* was shown immediately after the child pressed the crossing button (i.e. no *Pre-Go-signal* waiting period). In six trials, presented in a pseudo-random order, a *Pre-Go signal* waiting period (either 5- or 10-secs; three trials each) was unexpectedly imposed before the *Go*-signal appeared. During this period, the *Wait* signal would continue to be shown until the waiting time was up. Participants were not informed beforehand about the presence of these extra delay periods but were told that the crossing button was rather old and might occasionally be a bit slow to work.

On the P-DeFT, children's *maladaptive waiting-related responses* was indexed in a number of ways: (a) the number and (b) duration of participants' button presses per second during the *pre-Go-signal* waiting periods, indicating participants' attempts to end the waiting period, were recorded electronically; (c) activity levels during the *pre-Go-signal* waiting period and (d) *post-Go-signal* shopping task were recorded using a professional grade actigraph unit (see description in section 2.4.4); and (e) time used to complete the shopping task following the release from *pre-Go-signal* waiting was recorded by computing the differences between the start and end time of participants' movement in each shopping trial. Higher scores in these measures reflect a higher level of *maladaptive waiting-related responses*. To ensure that the children's maladaptive responses are related specifically to the waiting period rather than task difficulty, the shopping task is designed to be game-like, with a very low level of difficulty and motivating rewards such as praise for correct responses. For instance, all target items in the shopping task are highly distinguishable and any pre-schoolers with average cognitive ability should be able to pick the correct items. In our sample, all participants got all the shopping trials correct and reported enjoying the game.

Cronbach's α for the six trials was .86 for number of presses, .88 for duration of presses, .94 for activity during waiting, .91 for activity after waiting, and .86 for time used in the shopping task. The use of the P-DeFT in capturing pre-schoolers' behavioural and emotional markers of waiting-induced frustration *during* the imposed wait-period and *after* the release from waiting was examined in Chapter 3.

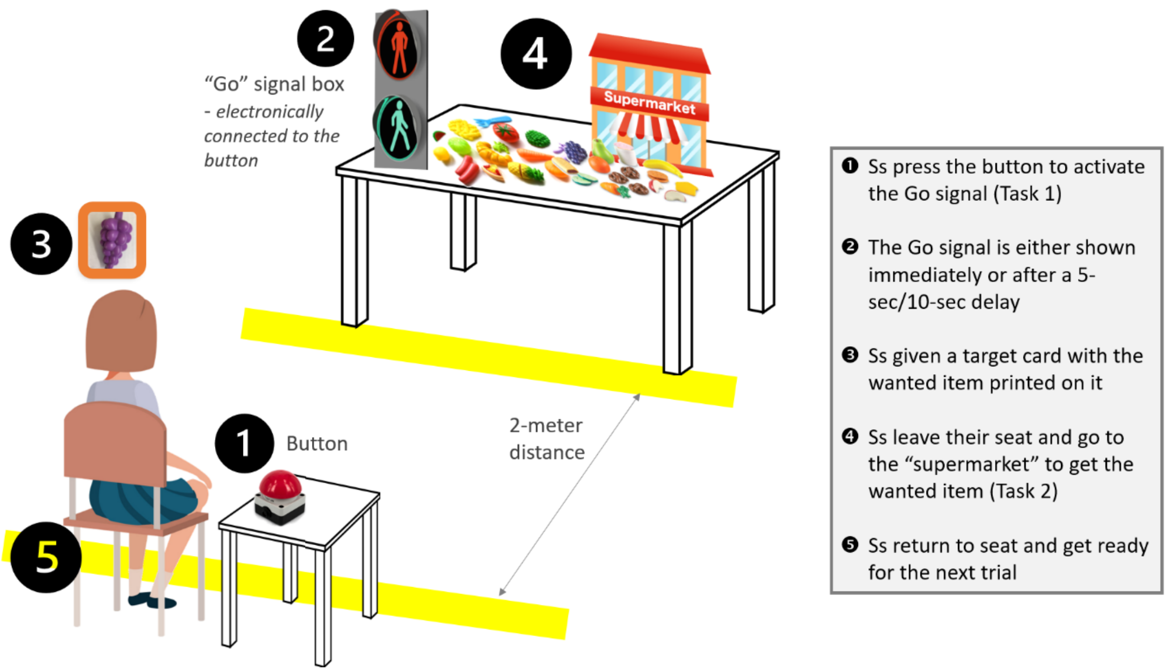

Figure 2-2 The set-up and procedures of the Preschool Delay Frustration Task (P-DeFT).
In the P-DeFT, participants were shown a pedestrian traffic light system, then in each trial, they had to (1) press the button and (2) when the light turned green (immediately or after a short period of delay), they would be (3) shown a shopping card. After that, they could (4) go to the supermarket to pick up the toy, then (5) returned to their seat.

2.4.3.4 Parent-Child Delay Frustration Task (PC-DeFT)

The Parent-Child Delay Frustration Task (PC-DeFT) is a computerized task using the same programme as in the P-DeFT described above, but with slight modification with regard to the role of participants in the task. It was designed to get both the parent and child participants involved, and their reactions and interactions, especially during the *pre-Go-signal* waiting period, were recorded. Similar to the P-DeFT, there were 18 trials in the PC-DeFT and, in each trial, participants were first shown the red *Wait* signal, then the children were instructed to press the button to elicit the green *Go-signal*. In the PC-DeFT, instead of having the child participants to visit the toy supermarket following the presence of the *Go-signal*, the children were instructed to stay at their seat all the time and be in charge of the button pressing only.

The parent participants were assigned the “shopping” role and were responsible for getting the target object from the toy supermarket when the red *Wait signal* turns to the green *Go-signal* (as illustrated in **Figure 2-3**).

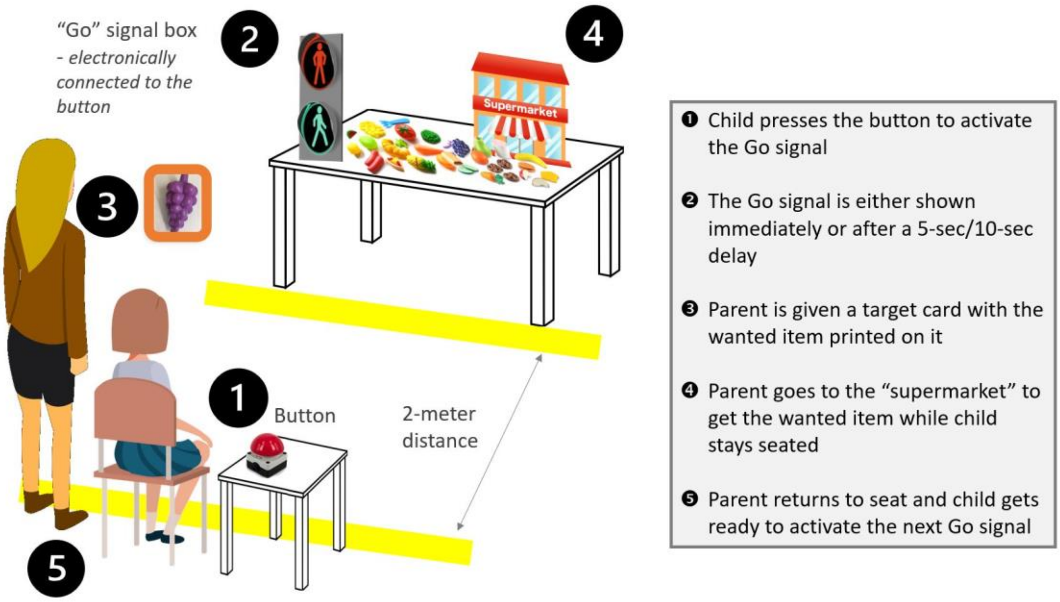

Figure 2-3 The set-up and procedures of the Parent-Child Delay Frustration Task (PC-DeFT).
In the PC-DeFT, participants were shown a pedestrian traffic light system, then in each trial, the child participants had to (1) press the button and (2) when the light turned green (immediately or after a short period of delay), the parent participants would be (3) shown a shopping card. After that, parents could (4) go to the supermarket to pick up the toy while the children have to stay seated. When the parents (5) returned to their seat, the children can press the button again.

On the PC-DeFT, child participants were in the state of waiting for most of the time – in addition to the *pre-Go-signal* waiting periods where they waited for the signal to turn green, they also had to wait for their parents going forth and back from the toy supermarket. Children’s *maladaptive waiting-related responses* were indexed by: (a) the number and duration of button presses during the *pre-Go-signal* waiting periods, indicating participants’ attempts to end the waiting period, were recorded electronically; and (b) activity levels during the task were recorded using the same professional grade actigraph unit. Cronbach's *αs* for the six trials was .85 and .84 for presses and activity levels respectively. In addition, parents' reactions to children's waiting-related behaviours were observed and coded (details in section 2.4.6).

2.4.4 Activity level

Electronic activity trackers were used to measure the child participants' physical activity level in the four waiting tasks described in section 2.4.3. The activity tracker used is a validated wearable CE marked, watch-like actigraph unit designed specifically for use with young children (https://mindpax.me/for-providers/). The safety of the device was tested extensively and approved for use by regulatory authorities. It is unobtrusive, non-invasive and safe. It measures changes in acceleration over short intervals of time. To detect activity, *G* (a measure of acceleration) is recorded by the device's motion sensor signal sampled at 6.5 Hz. The data output is the average *G* for each second. The researcher at the testing session recorded the exact start and end time of each task performed to retrieve the relevant data from the activity output file. The average amount of activity per second across each task was computed. Specifically in the DeFT, children's average *G*s during the 5- and 10-secs *pre-Go-signal* waiting periods and the *post-Go-signal* shopping task were also computed to test the research questions detailed in Chapter 3.

2.4.5 Delay aversion/ Delay sensitivity

The Quick Delay Questionnaire (QDQ) was originally designed to measure adults' self-reported delay aversion and sensitivity to delay (Clare et al., 2010). Markomichali (2015) adapted it to be used to evaluate pre-schoolers' delay related behaviours by teachers or parents.

There are ten items in total tapping two aspects: (a) Delay Aversion (DA: 5 items, e.g. "Hates waiting for things") and (b) Delay Discounting (DD: 5 items, e.g. "Often gives up on things he or she can't have immediately"). In this study, parents and teaches rated each statement on a 5-point Likert scale from 1 = "Not at all like him/her" to 5 = "Very much like him/her". This revised version was found to have high internal consistency (Cronbach's αs for full scale at T1 and T2 were .94 and .86 respectively) and good test-retest reliability (r = .89, .88 and .83). A higher score reflects a higher level of delay aversion/ delay sensitivity. In this sample, Cronbach's α for the ten items was .84 and test-retest reliability between T1 and T2 was .75.

2.4.6 Parental reactions to children's behaviours

Parents' reactions to children's behaviours in waiting and non-waiting settings were observed and coded using the Parent-Child Interaction System (PARCHISY; Deater-Deckard, 2000; Deater-Deckard et al., 1997). The PARCHISY has been used extensively across cultures in research with both typically developing population and children with externalizing or internalizing behaviour problems (Aspland & Gardner, 2003; Funamoto & Rinaldi, 2015). The original setting of the PARCHISY involved an unstructured free play session and a drawing task (Etch-A-Sketch) that was suitable for children aged between 3 and 12 years, but previous research showed that it was not restricted to specific tasks and coders could be selected flexibly to address the specific research purposes. As stated in the manual, the observation coding system was designed for easy application and inter-observer reliability could be achieved within hours of training. Previous research suggested high levels of inter-rater reliability (αs$\geq$.80) were demonstrated and the PARCHISY scores were found to be associated with child outcomes (Aspland & Gardner, 2003; Funamoto & Rinaldi, 2015).

In this study, how the parents reacted to their children was observed in two non-waiting settings (unstructured free play and clean-up) and one waiting setting (PC-DeFT). During the unstructured free play that lasted eight minutes, the parent-child dyads were allowed to choose any activity or toys available and play together as they would in everyday life. After the play session, the parents were asked to instruct their children to tidy up all the toys but were reminded not to give any actual assistance. There was no time limit for completing the tidy up; experimenters recorded the exact start and end time. All these sessions were videotaped and all the records were double-coded and rated by at least two trained researchers (author of the thesis and postgraduate students).

Out of the 18 codes in the original PARCHISY, two "on task" codes were not included as they were relevant in the Etch-A-Sketch task but not in the tasks used in the present thesis. The descriptive statistics of the 16 codes observed and scored in free play, clean-up and PC-DeFT were presented in Appendix A (Table A1, Table A2 and Table A3 respectively). Referring to Table A3, there were a few codes that were not applicable in the PC-DeFT setting – 1) participants' 'responsiveness' was not recorded in around one-third of the participants as some of the participants remained quiet in this relatively short task and thus their mother/child teammates did not have the opportunity to respond; 2) 'conflict' and 3) 'cooperation' were rarely recorded due to the task nature and statistics showed that these ratings were heavily skewed. On the other hand, subsequent analyses found that the child codes, especially negative affect, activity and noncompliance, were significantly correlated with the waiting-related behavioural agitation (i.e., squirming/fidgeting, $rs > .50$, $p < .001$) and negative emotional reactions/ affect (i.e., observed frustration as indicated by frowning, sighing and pouting, $rs > .56$, $p < .001$) observation codes used commonly in all the other three waiting tasks. To ensure the consistency in the measurement of children's waiting-related frustrations across the thesis, we used the latter in the analyses of children's behaviours during the PC-DeFT. For the purpose of studying parental reactions to children's behaviours in the three contexts, five applicable codes were put into the analyses: (a) positive content; (b) positive affect; (c) reciprocity; (d) negative content; (e) negative affect. Parental reactions were coded in the same way across the three settings. Researchers rated the parents' positive and negative reactions to their child's behaviour on a 7-point scale from 1 = "None or never" to 7 = "Always or constantly". The codes and ratings were summarized in **Table 2-4**. In this sample, the average intraclass correlation coefficients ICC(2,1) with consistency definition for the five codes in free play, clean-up and PC-DeFT were .96 (range = .90 – 1.00), .80 (range = .68 – .88) and .86 (range = .82 – .93) respectively, indicating good to excellent agreement between the raters.

Table 2-4 Summary of the PARCHISY codes applied in this study

(A) Positive content/control: use of praise, explanation, and open-ended questions (1) No positive control shown (2) One or two instances of positive control (3) A few/several instances of positive control; reliance on explicit directions ("up, down, stop") (4) Moderate amounts of positive control shown; reliance on explicit directions with at least one instance of praise, explanation, or questioning (5) Two or more instances of explanation, questioning, or praise, with some explicit directions (6) Substantial use of explanation, questioning, and praise, and few explicit directions; only one or two instances of non-positive control shown (7) Exclusive use of explanation, questioning, and praise
(B) Positive affect/ warmth: smiling, laughing (1) No positive affect displayed (2) One or two instances of positive affect (3) A few/several instances of positive affect (4) Moderate amounts of positive affect - smiling, laughing for about half of interaction (5) Positive affect for more than half of interaction (6) Substantial amounts of positive affect; only one or two instances of non-positive affect (7) Constant positive affect - smiling and laughing throughout task
(C) Reciprocity: shared positive affect, eye contact, a "turn taking" quality of interaction (1) No evidence of reciprocity

(2) One or two instances of reciprocity - either shared affect or eye contact
(3) A few/several instances of reciprocity (either shared affect or eye contact)
(4) Moderate levels of reciprocity; evidence of both shared affect and eye contact; some evidence of "conversation-like" interaction
(5) Clear evidence of reciprocity; one or two episodes of intense shared positive affect coupled with eye contact that is sustained for several "turns" between parent and child
(6) Substantial reciprocity involving numerous episodes of intense shared positive affect coupled with eye contact that is sustained for several "turns"; only one or two instances of non-reciprocity
(7) Highly integrated and reciprocal - constant shared positive affect and eye contact that never loses "turn taking" quality

(D) Negative content/control: use of physical control of child's hand/arm/body, use of criticism;
(1) No negative control shown
(2) One or two instances of negative control
(3) A few/several instances of negative control
(4) Moderate amounts of negative control: reliance on critical comments ("no, don't do that") and/or manipulation of dials
(5) Negative control used for more than half the interaction
(6) Substantial use of criticism, and physically "taking over" task; only a few instances of non-negative control shown
(7) Exclusive use of criticism (can include shaming) and physical control of dials and/or child's hand/arm/body; may include instances of corporal punishment

(E) Negative affect/ rejection: frowning, cold/harsh voice
(1) No negative affect displayed
(2) One or two instances of negative affect
(3) A few/several instances of negative affect
(4) Moderate amounts of negative affect - frowning, stern looking, harsh/cold voice for about half of interaction
(5) Negative affect for more than half of interaction
(6) Substantial amounts of negative affect; only one or two instances of non-negative affect
(7) Constant negative affect - always scowling/frowning, voice always in harsh tones

2.4.7 Parenting measures

2.4.7.1 Parenting style

The Parenting Styles and Dimensions Questionnaire – Short Form (PSDQ-SF) was used in this study to examine parents' style of parenting. It is a 32-item self-report instrument developed by Robinson et al. (2001) to measure three dimensions of parenting style: a) authoritative (15 items, including connection, regulation and autonomy, e.g. “I give my child reasons why rules should be obeyed”), b) authoritarian (12 items, including physical coercion, verbal hostility, punitive, e.g. “I spank when my child is disobedient”); and c) permissive (5 items, e.g. “I find it difficult to discipline my child”). For each item, parents rated how often they exhibit that behaviour with their child as described on a 5-point scale from 1 = “Never” to 5 = “Always”. Review showed that the PDSQ-SF has been widely used in research across cultures, many of which concerned pre-schoolers (Olivari et al., 2013). Psychometric properties of the PDSQ-SF were proven to be satisfying, with adequate internal consistency (Cronbach’s αs=.86, .82 and .64 for Authoritative, Authoritarian and Permissive scales respectively) (Robinson et al., 2001) and criterion validity (Olivari, et al., 2013; Russell et al., 2003). A Chinese version was translated and validated by Wu et al. (2002). In this sample, Cronbach’s αs for the authoritative, authoritarian and permissive subscales were .82, .80 and .80 respectively, and test-retest reliability between T1 and T2 were .84, .79 and .83 respectively.

2.4.7.2 Parenting stress

The Parenting Stress Index 4th edition Short Form (PSI-4-SF) is a brief version of the PSI developed by Abidin (1983). The original full scale included 101 items and was found to have strong psychometric properties. It has been widely used in the research field, resulting the development of validated versions in different languages. The PSI-SF was produced using Confirmatory Factor Analysis, aiming to enhance its cost-effectiveness (Abidin, 1990). It consists of 36 items, with 12 items evaluating each of the three dimensions: a) Parental Distress (e.g. “I feel trapped by my responsibilities as a parent”), b) Parent-Child Dysfunctional Interaction (e.g. “I expected to have closer and warmer feelings for my child than I do, and this bothers me”), and c) Difficult Child (e.g. “My child's behaviour is more of a problem than I expected”). A high correlation (*r*=.94) was found between the total stress score of the PSI and PSI-SF (Abidin, 1990). Both the English and Chinese versions of the PSI-SF were found to have good reliability and validity (Abidin, 2012; Liu & Wang, 2015; Yeh, et al., 2001). In this sample, Cronbach’s αs for the full scale and the three subscales were .92, .86, .81 and .84 respectively, and test-retest reliability between T1 and T2 were .87, .83 and .81 respectively.

2.4.7.3 Parental emotional responses to ADHD and related behaviours

The Parental Emotional Response to Children Index (PERCI) is a self-report rating scale designed to measure parents’ emotional response to AD/HD and related behaviours (Lambek et al., 2017). The five-factor model suggested by Lambek et al. (2017) was supported by confirmatory factor analysis and the internal consistency of the five subscales were satisfactory: a) Inattention (9 items, e.g. “It irritates me when my child is forgetful in daily activities”, α =.86); b) Hyperactivity (6 items, e.g. “It bothers me when my child runs about or climbs in situations where it is inappropriate”, α =.86); c) Impulsivity (3 items, e.g. “It gets to me when my child interrupts or intrudes on others”, α =.71); d) Delay Discounting (6 items, e.g. “It annoys me when my child gives up on things he or she cannot have right away”, α =.82); e) Delay Aversion (3 items, e.g. “It angers me when my child does not wait until it is his or her turn”, α =.80). For use in the present study, the PERCI was translated into Chinese, back-translated and revised. Overall, in the full sample, Cronbach’s α for the full scale was .92 and test-retest reliability between T1 and T2 was .74.

2.5 Procedures

At T1, invitations and study information were sent to parents via local nurseries, preschools and parent communities. Parents who consented to participate were then mailed or emailed the screening questionnaire. With the consent and assistance from parents, the child participants' class teachers or key workers were contacted, and they completed the screening questionnaire over the phone or using the online or paper form. Non-response was followed up with text messages, emails or/and telephone calls. Participants were included or excluded based on the results of screening questionnaires (refer to section 2.3 for inclusion and exclusion criteria).

Selected parent-child dyads were contacted over the phone – the trained researchers, one in each university, invited them to attend an in-person testing session at the university (Denmark Hill Campus, King's College London or Department of Psychology, the University of Hong Kong), explained to them the procedures of the session, answered their questions and affirmed their right to participate and withdraw voluntarily. The sessions took place in quiet rooms with children's tables and chairs, boxes of toys, computer and screen available. Participants were first briefed that this was a longitudinal cross-cultural study exploring pre-schoolers' behaviours in tasks that require patience and waiting. After the introduction, the parent-child dyads completed eight minutes of free play time. Before moving on, parents were asked to instruct their children to tidy up their toys without assistance. Upon completing the clean-up, if the child agreed, the parent would leave the room and fill in questionnaires in a separate area, while the researcher would administer the cognitive assessment and waiting tasks to the child. Afterwards, the parent and child were brought together to do the joint waiting task. Throughout the session, the children wore the actometer on their non-dominant wrist. Participants were informed that the sessions would be video-recorded during free-play, clean-up and the four waiting tasks. All participants in this sample consented for the videos to be taken for research purposes. The session lasted for approximately 90 minutes with breaks. At the end of the session, the researcher presented a certificate and book voucher to each participating dyad as a token of appreciation.

At T2, parents were contacted by email, text messages or phone. The researcher restated the aims of the study and explained the change of the data collection plan due to the unexpected circumstances of COVID-19. Parents were invited to complete a set of follow-up questionnaires and if they agreed, contacted the children's current class teacher or keyworker on our behalf to invite them completing a brief questionnaire or provided information for us to send the invitation. Teachers would receive an information packet by email or mail and those who consented completed the questionnaire using online or paper form or over the phone. Participating families were mailed a certificate and book voucher upon the receipt of the completed questionnaires.

2.6 Statistical analyses

The data analysis plans in the four empirical chapters shared the same rationale and procedures, with Chapter 3 and 4 focusing on the cross-sectional data and Chapter 5 and 6 covering the relationship between measures across time. A small proportion of data (CDT: 3%; BDT: 7%, P-DeFT: 1%, PC-DeFT: 5%, actometer reading: 4%) was missing due to technical issue (e.g. programme crashing, data storage error in actometer) and participants' withdrawal from particular tasks. Where data were missing, we used pairwise deletion to optimize data availability. In each chapter, we first explored if the children's sex, age, IQ and family income group have an effect on the outcome variables using chi-square tests (for categorical variables), analysis of variance (ANOVA) and correlational analyses (for continuous variables). In chapters examining parental factors on symptom ratings and development of ADHD symptoms over time, potential confounding factors related to parents' characteristics were also examined.

Corrections for multiple testing were made using the Bonferroni formula. Confounding variables, if any, were included in subsequent analyses.

As a range of tasks and measures were used in this work to examine children's waiting-related behaviours and parental reactions to children's behaviours, there were a relatively large number of variables. To minimize the need for multiple testing, particularly in Chapter 5 and 6, we explored the relationship between different measures of the same trait and reduced the number of variables, if possible, by conducting a series of exploratory factor analyses. Factor scores were computed and used in subsequent analyses.

To explore the relationship between variables at T1, correlation analyses were mostly used. Partial correlation and multiple regression analyses were used to examine the relationship between T1 independent variables and T2 outcome variables (ADHD symptoms and delay sensitivity ratings), controlling for baseline data. In line with the view of ADHD as a continuum (Coghill & Sonuga-Barke, 2012; Greven et al., 2016), in most of the analyses, we used the full range of symptom scores instead of classifying the participants into ADHD and non-ADHD groups; this also helps minimizing the loss of statistical power. In some chapters, we also ran PROCESS macro tests of mediation developed by Hayes (2013) using SPSS (model 4 for mediation with covariates, model 59 for moderated mediation, model 6 for serial mediation, 5000 bootstrap samples) to test if the relationship between variables was statistically mediated by another factor(s). The default number of bootstrap samples in PROCESS was 5000 and for these analyses, standardized coefficients were reported unless otherwise specified.

In each chapter, the possible cross-cultural differences in the interested variables were explored using ANOVA. Split-sample correlational analyses were conducted, and the correlation coefficients between variables in the two samples were compared using Fisher's Z-transformation. To test if the relationship between variables was statistically moderated by national group, SPSS PROCESS macro tests of moderation (model 1, 5000 bootstrap samples) were used. To achieve the specific objectives and answer the relevant research questions in particular chapters, other analyses such as repeated measures ANOVAs and test of moderated mediation were also used.

Chapter 3 An experimental task to measure preschool children's frustration induced by having to wait unexpectedly: The role of delay sensitivity and culture

The primary goal of this thesis is to address the gap in the literature regarding preschool ADHD symptoms in relation to delay aversion and waiting behaviours in a cultural context. However, there has been a lack of testing tools available to explore pre-schoolers' behaviours and frustration in waiting situations of different nature. Chapter 3 introduces the development and application of a new task, the Preschool Delay Frustration Task (P-DeFT), to measure preschool children's delay aversion as evident by their behavioural agitation and negative affect during and after the delay. This chapter also includes a cross-cultural comparison on how children in HK and UK differ in their behavioural and emotional frustrations during the unexpected delay situations. Chapter 3 can be read as an individual study as well as a part of this whole work exploring the relationship between ADHD, delay aversion and waiting-related behaviours. The subsequent chapters, 4 and 5, also include the use of P-DeFT as one of the three waiting tasks to understand cultural differences in children's waiting behaviours and how these associate with parents' report of children's ADHD symptoms and delay aversion.

3.1 Summary

The ability to manage frustration induced by having to wait for valued outcomes emerges across childhood and is an important marker of self-regulatory capacity. However, approaches to measure this capacity in preschool children are lacking. The P-DeFT was designed specifically to identify children's behavioural and emotional markers of waiting-induced frustration *during* the imposed wait period and *after* the release from waiting. We then explored how waiting-induced frustration related to individual differences in delay sensitivity and whether it differs between two cultural groups thought to have different attitudes to children's conduct and performance, Hong Kong and UK.

One-hundred-and-twelve preschool children (mean age = 46.22 months) completed the P-DeFT in a quiet laboratory. Each trial had–two-stages - first a button press elicited a *Go-signal* which, second, allowed the child to go to a "supermarket" to pick a target toy. On most trials the *Go-signal* occurred immediately on the first press. On six trials an unexpected/un-signalled 5-or-10-sec *pre-Go-signal* period was imposed. Waiting-related frustration was indexed by performance (button presses and press-duration), behavioural agitation and negative affect during the *pre-Go-signal* wait-period and the *post-Go-signal* shopping task. Parents rated their children's delay sensitivity.

Waiting-related frustration expressed during both the *pre-Go-signal* wait-period and the *post Go-signal* task varied with (a) the length of wait and (b) individual differences in parent-rated delay sensitivity. UK children displayed more negative affect during delay than their HK counterparts, though the relationship between delay sensitivity and frustration was culturally invariant.

Keywords: Waiting; Delay aversion; Delay sensitivity; Frustration; Pre-schoolers; Cross-cultural differences

3.2 Introduction

3.2.1 Ability to manage waiting-related frustration

The development of the ability to regulate emotional responses to frustrating events is essential for social and emotional development during the preschool years (Bell & Deater-Deckard, 2007; Blair, 2002; Brownell & Kopp, 2007; Cole et al., 2011; Stansbury & Sigman, 2000). By the time children start formal education, teachers expect children to be able to self-regulate their behaviours and emotions during periods of frustration (Blair, 2002; Eisenberg et al., 2010; Ursache et al., 2012). A common trigger for frustration among young children is being asked to wait for desired outcomes or events – especially when the waiting period imposed is unexpected (e.g., Calkins, 2007; Cole et al., 2003; Gilliom et al., 2002; Sarafino, 1984). Individual difference in this capacity is an important predictor of interpersonal skills, prosocial behaviours, mental health, early academic success and self-esteem in later development (Cole et al., 2011; Eigsti et al., 2006; Fabes & Eisenberg, 1992; Fabes et al., 1994; Graziano et al., 2007; Mischel et al., 1988).

3.2.2 Measure of preschool children's waiting-related frustration

Numerous studies have examined children's ability to wait for delayed rewards using paradigms such as the Snack Delay Task and Gift Wrap Task (Breaux et al., 2016; Lin et al., 2019; Pauli-Pott & Becker, 2021; Rademacher & Koglin, 2019; Smith-Donald et al., 2007). They have also examined their preference for small-immediate over larger-delayed rewards using tasks like Maudsley Index of Delay Aversion and Preschool Choice-delay Task (Antrop et al., 2006; Marco et al., 2009; Pecora et al., 2014; Solanto et al., 2001; Sonuga-Barke et al., 2003). Most of these existing delay tasks have involved a waiting period that was pre-signalled and expectable. Although delay in these settings is likely to induce frustration – we felt that the imposition of unexpected delay would probe frustration to an even greater degree. An innovative delay frustration task was designed by Bitsakou et al. (2006) to explore adults' reactions in face of unexpected and inescapable delay, it however was not applicable in the preschool population.

To study pre-schoolers' behavioural and emotional responses during unexpected waiting periods, we developed the Preschool-Delay Frustration Task (P-DeFT). In the P-DeFT, the task given to the pre-schoolers is to press a button to trigger a *Go-signal* which allows them to leave their seat and visit a toy supermarket to get a target object. On most trials the *Go-signal* followed immediately after the first button press. However, on some trials a period of either 5- or 10-secs waiting is unexpectedly imposed before the *Go*-signal appeared – i.e., *Pre-Go-signal* waiting period. On the P-DeFT, waiting-induced frustration is indexed in a number of ways: Performance (number and duration of button presses and time used to complete the shopping task) as well as behavioural agitation (actometer-recorded physical activity and observed squirming) and negative affect (observed frustration). Relevant measures are recorded both during the *pre-Go-signal* waiting period and following the release from waiting during the *post-Go-signal* shopping task.

The P-DeFT builds on the theoretical insights of Amsel's (1958) theory of "frustrative non-reward". This theory predicted frustration effects when a reward is withheld. First seen in studies with rats, these involved the increase of frustration-related activity level and running speed in the period *following* the end of the frustrating event. Amsel and others argued that frustration increases task motivation that facilitated subsequent responses (Dunlap et al., 1974).

A similar phenomenon has been seen in preschool children – with increased speed in lever pressing following non-reward trials (Penney, 1960; Ryan & Watson, 1968).

3.2.3 The current research

In this chapter we used the P-DeFT to test four main hypotheses. First, in line with Amsel's model, that waiting-related frustration will be seen *both* during the imposed waiting period and after it (i.e., when the child is released from waiting).

Second, that frustration will vary as a function of the length of that waiting period. Third that it will be greater in children who are rated as being more delay sensitive in general. Hypotheses two and three are based on Sonuga-Barke's (1994) observation that some children are especially sensitive to the experience of delay when waiting for outcomes – a motivational orientation he termed delay aversion. This leads them to try to escape from delay (Sonuga-Barke et al., 1992a; Sonuga-Barke et al., 1992b). When possible, delay-averse children choose the lesser delay even if that means sacrificing rewards (Sonuga-Barke et al., 1994). When delay is inescapable, as is the case with the new task here, he argued, they try to reduce the perceived duration of delay by increasing activity and engaging in stimulus seeking behaviours (Sonuga-Barke et al., 1992a). Consistent with this view, existing research has found that common reactions by children during pre-reward delay include terminating their wait sooner (Paloyelis et al., 2009), applying strategies like distraction and bidding to adults (Gilliom et al., 2002; Mischel & Mischel, 1983; Ratcliff et al., 2021), and expressions of negative emotions (Cole et al., 2011; Dennis et al., 2009). However, the proposed relationship between delay duration and levels of frustration has rarely been tested in the preschool population, perhaps due to the fact that most existing delay discounting tasks are hypothetical-based, with choices of a range of reward size and waiting interval up to month(s), that makes them difficult for pre-schoolers and younger children to comprehend (Sjöwall et al., 2013). To test hypotheses two and three, we varied the length of the unexpected waiting period and also asked parents to rate their children's delay sensitivity.

Fourth, we hypothesized that expressions of waiting-related frustration would be less frequent in cultures with stricter views on the need for children's self-control. Cultures vary in their expectations relating to children's behaviour in general and to self-regulation in particular. For instance, the culture in Hong Kong places great value on the control of behaviours and suppression of emotional expression (Chao, 1994; Chao, 1995; Chen, 2005; Lam & Ho, 2010; Thompson et al., 2017). Indeed, in a recent cross-cultural study, Chan et al. (2022) found that the observed behavioural agitation of HK children, as indicated by the objectively measured activity level, was lower than that of their UK counterparts; but their parents rated them as more hyperactive. Therefore, in the current chapter, apart from looking at the cultural differences in children's performance and reactions during the new version of the delay frustration task, we also explored the impact of culture on the relationship between parent ratings of children's delay sensitivity and children's actual performance. We expected children from HK to show less delay-related frustration on the task but to be rated by their parents as being more delay averse than their UK counterparts. In contrast, we also hypothesized that the positive relationship between delay sensitivity and expression of frustration during delay would be similar across cultures.

3.2.3.1 Research Questions

In summary we addressed three research questions:

1. Do children's levels of frustration in the P-DeFT increase as a function of the length of the waiting periods duration – 0-sec vs 5-sec vs 10-sec – in terms of performance, behavioural agitation and negative affect? Are these effects seen both during the imposed *pre-Go-signal* waiting period and in the *post-Go-signal* shopping task afterwards?
2. Are children's levels of frustration in the P-DeFT and the differences found between short and long waiting periods related to individual differences in delay sensitivity as rated by parents?
3. Do children's levels of rated delay sensitivity and waiting-related frustration differ between UK and HK participants? Does the strength of association between rated delay sensitivity and frustration expression on the P-DeFT different in the UK and HK samples?

3.2.3.2 Hypotheses

Our specific predictions based on an integration of the delay aversion (Sonuga-Barke et al., 1992a; 1992b; 1994) and the frustrative non-reward (Amsel, 1958) theories are:

1. Children will display higher levels of frustration on the long, compared to the short, delay trials in terms of elevated rates of button pressing, greater behavioural agitation and more negative affect during the *pre-Go-signal* waiting periods and higher levels of *post-Go-signal* activity during the shopping task.
2. There would be a positive correlation between parent ratings of delay sensitivity and children' frustration expression on the P-DeFT – with effects exacerbated on the longer delays.

3. UK participants would display higher levels of frustration in the P-DeFT than HK participants, while the parent-rated delay sensitivity would be higher in HK participants.

3.3 Methods

3.3.1 Participants

Participants in this study were recruited via local nurseries, preschools and online parent groups using social media adverts in London, UK, and Hong Kong. One-hundred-and-eighty-nine preschool children and their parents gave their consent to participate in the initial screening (UK: *n*=68, 51 % male; HK: *n*=121, 58 % male).

The screening questionnaires completed by teachers and parents provided basic demographic information of the child participants, whether the child had a diagnosis of special educational needs and/or pervasive developmental disorders (e.g., autism spectrum disorder), and their primary language spoken at home and at school. Thirty children (n^{UK}=13 and n^{HK}=17) were excluded— five were outside the age range; one had an existing diagnosis; 21 without teachers' data on screening questionnaire; and three had families unable to attend the session. No one was excluded for low IQ (<80) or being unable to comprehend spoken English (UK) or Cantonese (HK).

The performance indicators of the P-DeFT include the measure of physical activity and waiting-related responses which have previously been found to be associated with ADHD (Pauli-Pott U & Becker, 2021; Patros et al., 2016; Sonuga-Barke et al., 2008). To enable a comparison of like with like across cultures and minimize confounding factors in our analysis of cultural differences in delay frustration, participants in UK and HK were matched for age, sex, as well as their levels of activity and attentional symptoms. These symptoms were rated on the five-item hyperactivity/inattention subscale of the Strengths and Difficulties Questionnaire completed by parents and teachers (SDQ, version T2-4). We oversampled participants and then excluded 47 in order to balance the HK and UK samples in the three aspects described at a group level.

The mean age of children in the final UK and HK sample was 46.55 and 45.85 months respectively, with no significant statistical difference between groups, $F(1, 110) = .41$, $p = .526$. The sex ratio and initial levels of hyperactivity/inattention symptoms rated by parents and teachers were not significantly different, $\chi^2(1, 112) = .13$, $p = .721$ and $F(1, 110) = 2.33$, $p = .130$ respectively. No children had been formally diagnosed with ADHD and none were taking ADHD medications. Full data was available for one-hundred-and-twelve children ($n^{UK}=55$ and $n^{HK}=57$; females = 49 and males = 63).

3.3.1.1 Measures

3.3.1.2 Screening measures

Inattentive and overactive behaviours screener: The parent and teacher versions of the Strengths and Difficulties Questionnaire (SDQ, version T2-4) are widely used psychometrically strong, brief screening questionnaire designed for research/clinical purposes (Goodman, 1997). The hyperactivity/ inattention subscale consists of five items: two measuring inattention, two hyperactivity and one impulsivity. The original English language version was used in the UK. A validated Chinese translation was used in HK (Lai et al., 2010).

Intelligence: Children's IQ was estimated using the Block Design and Vocabulary subtests of Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler, 2003). The WPPSI measures the cognitive ability of preschoolers and young children between 2 years 6 months and 7 years and 3 months. The English (UK) and Traditional Chinese language versions were used in the UK and HK respectively.

3.3.1.3 Preschool Delay Frustration Task (P-DeFT)

The Preschool Delay Frustration Task was developed based on the Delay Frustration Task created by Bitsakou et al. (2006) to measure children's responses when the continuous presentation of a simple rewarded task was unexpectedly interrupted. The P-DeFT was designed in a simplified form for the preschool-age population – it was introduced to the participants as a fun and easy to engage with "shopping" game where they had to cross the road to visit a toy supermarket (as illustrated in **Figure 3-1**). In each trial of the game the participants were presented with a red *Wait signal* and then asked to complete a two-stage task - (a) to press a "crossing" button positioned at the side of their chair to change that signal to a green *Go-signal* and then to (b) complete a shopping task at the toy supermarket which involved locating an object shown by the experimenter on a shopping card. The only rule of the game for participant was to wait for the red *Wait signal* to change to a green *Go-signal* before going to find the item.

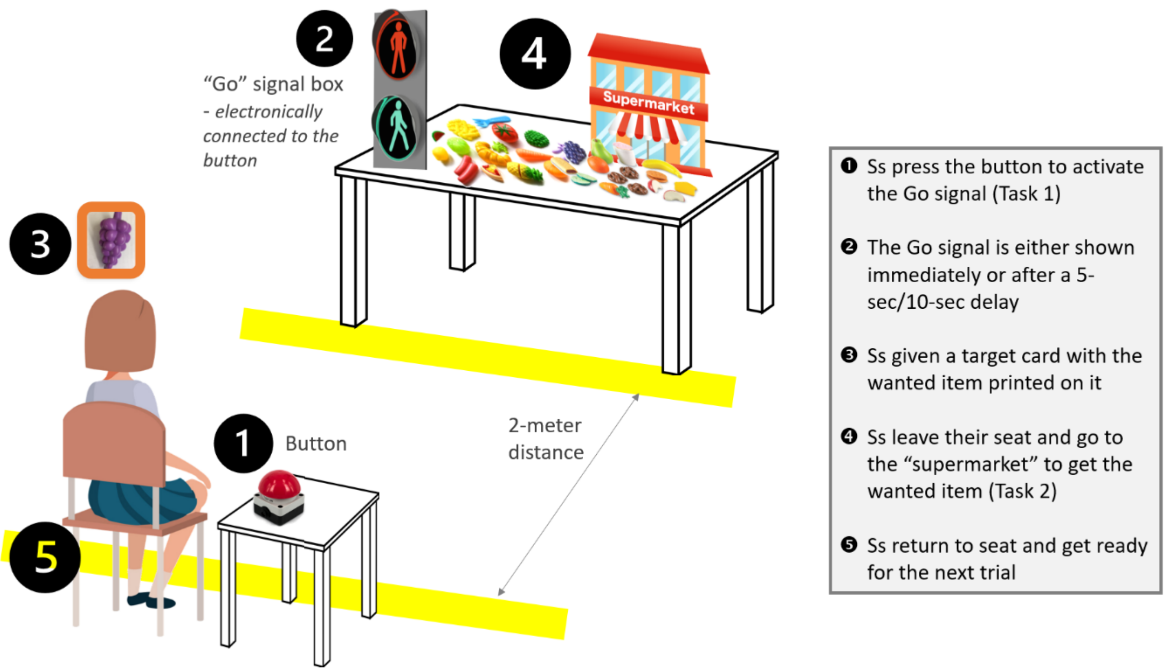

Figure 3-1 The set-up and procedures of the Preschool Delay Frustration Task (P-DeFT).
In the P-DeFT, participants were shown a pedestrian traffic light system, then in each trial, they had to (1) press the button and (2) when the light turned green (immediately or after a short period of delay), they would be (3) shown a shopping card. After that, they could (4) go to the supermarket to pick up the toy, then (5) returned to their seat.

There was a total of 18 trials (3 conditions: no-delay, 5-sec delay and 10-sec delay). In the majority of trials, the green *Go-signal* was shown immediately after the child pressed the crossing button (i.e. no *pre-Go-signal* delay). In six trials, a *pre-Go-signal* waiting period was imposed (either by 5-sec or 10-sec; three trials each). To account for the potentially confounding effects of fatigue and boredom across trials, we presented the 5-sec and 10-sec delay trials in a pseudo-random order. During this period, the *Wait* signal would continue to be shown until the waiting time was up. Participants were not informed before the start of the task about the presence of these waiting periods but were told that the crossing button was rather old and might occasionally be a bit slow to work.

To make sure that the children's frustration was related specifically to the waiting period rather than task difficulty or the amount of rewards received, we designed the shopping task to be easy to complete (all target items were highly distinguishable and the difficulty level of picking the correct items was very low), fun and motivating, with correct responses being rewarded with praise. In the briefing before the trials, participants were told that getting all the correct items from the supermarket would result in stickers being rewarded on game completion. All participants in this study got all the shopping trials correct and therefore received all rewards available. Although children were reminded in the pre-study briefing to return to their seat as soon as they selected the item, they were not prompted to sit down once the game had started – this allowed activity and time used in the shopping task to be measured. The complete administration of P-DeFT lasted around 5 to 15 minutes, much dependent on the children's efficiency in the shopping task.

The **number and duration of participants' button presses** per second during the *pre-Go-signal* waiting periods, which were intended to index participants' attempts to end the waiting period, were recorded electronically. Participants' **activity levels** during the *pre-Go-signal* waiting period and the *post-Go-signal* shopping task were recorded using a professional grade actigraph unit (see description in section 3.3.1.4). The **time used** to complete the shopping task was computed by extracting the start and end time of participants' movement in each shopping trial from the output file.

Participants' **negative affect** (frustration as indicated by frowning, sighing and pouting) and **behavioural agitation** (squirming and fidgeting) during the 5- and 10-sec delay were also observed and coded using a 4-point scale. The details of the observation coding are presented in section 3.3.2.4. All task measures had adequate internal consistency (αs $\geq .89$) and good test-retest reliability (rs $\geq .75$).

3.3.1.4 Activity Level

Activity was measured using an unobtrusive wrist-worn activity tracker. This was a validated wearable CE marked actometry sensor (a small actigraph unit). The safety of the device was tested extensively and approved for use by regulatory authorities. The device measured changes in acceleration over short intervals of time (actigraphy). The data output was average *G* (a measure of acceleration recorded by the motion sensor signal sampled at 6.5 Hz) for each second.

3.3.1.5 Observation coding

Participants' waiting-related frustration, expressed in terms of behavioural agitation and negative affect, was coded for each of the six delay trials in the P-DeFT by two separate coders. All the sessions were videotaped, and all the records were double-coded and rated by at least two trained coders, who used videos from the pilot data for training and reached a 90% consensus prior to the official video coding. The cues for frustration were (1) **behavioural agitation**: squirming and fidgeting, and (2) **negative affect**: frowning, sighing and pouting. Coders were instructed to take the duration of wait into account and code each of the cues using a 4-point scale with 0="None/ Very rare - 0-10% of time"; 1="A little - 11-25% of time"; 2="Quite a lot - 25-50% of time" and 3="A lot - >50% of time/ behaviours". Inter-rater reliability, as measured by intraclass correlations (ICC), was calculated to determine if there was significant agreement between raters. The ICCs for the behavioural agitation codes were .92 or higher (average = .95), whereas the ICCs for the negative affect codes were .95 or higher (average = .95), indicating an excellent agreement between the raters.

3.3.1.6 Delay Sensitivity

The Quick Delay Questionnaire (QDQ) was originally designed to measure adults' self-reported delay-related behaviours (Clare et al., 2010). Markomichali (2015) adapted it to be used for pre-schoolers' and rated by teachers or parents. There were two subscales (5 items in each): (i) Delay Aversion (DA, e.g. "I hate waiting for things") and (ii) Delay Discounting (DD; "I often give up on things I cannot have immediately"). The 10 items are rated against a 5-point Likert scale from 1="not at all like him/her" to 5="very much like him/her". In this sample, the scale has high internal consistency (α =.84) and good test-retest reliability (r=.75).

3.3.2 Data Analysis

Preparatory analyses: A small proportion of P-DeFT programme data and actometer reading data were missing due to technical issue and participants' hesitation to wear the actometer. Where data were missing, we used pairwise deletion, so that all available data were used. We then conducted analyses to compare the demographic characteristics of the UK and HK samples and examined if there were age, sex, IQ and family income effects on the delay sensitivity ratings and P-DeFT responses using analysis of variance (ANOVA), chi-square test and correlational analyses. Corrections for multiple testing were made using Bonferroni formula. Confounding variables, if any, were controlled for in the subsequent analyses.

Core analyses: The first part of the analysis plan focused on the impact of delay duration and delay sensitivity on participants' performance and reactions in the P-DeFT in the full sample. Repeated measures ANOVAs were conducted to test whether indices of waiting-related frustration were different between trials with and without imposed waiting as well as between 5-sec and 10-sec delay trials. Correlational analyses were then used to explore the relationship between parent-rated delay sensitivity and participants' waiting-related frustration. Difference scores were computed to estimate participants' change in frustration between short and long waiting trials and to examine their relations with rated delay sensitivity. Following these, the second part of the analyses focused on the between-nation differences. We ran ANOVAs to test if UK and HK children differed in their P-DeFT responses and PROCESS macro test of moderation (model 1, 5000 bootstrap samples) to explore whether the relationship between delay sensitivity and P-DeFT responses was moderated by national group.

3.4 Results

3.4.1 Descriptive statistics

Table 3-1 presents the demographic characteristics of participants in UK and HK. The two national groups did not differ significantly in age, sex ratio, IQ and family household income.

3.4.2 Covariates

Table 3-2 presents the intercorrelations between IQ, age, parent-rated delay sensitivity and P-DeFT measures. Time used to complete the *post-Go-signal* shopping task on the delay trials was negatively associated to participants' IQ and age. Time used to complete the task on the no-delay trials was negatively associated with age. IQ and age were subsequently controlled for as confounding variables.

On the other hand, there were no significant sex or household income group differences in the delay sensitivity rating or P-DeFT responses (**Table 3-3**). These two factors were not included in subsequent analyses.

Table 3-1 Demographic characteristics of participants in UK and HK

	UK (*n* = 55)	**HK** (*n* = 57)	Statistical comparison
Participant characteristics			
Age (months) – mean (SD)	46.55 (6.49)	45.86 (4.91)	$F(1, 110) = .41$, $p = .526$
Female – *n* (%)	25 (45.45)	24 (42.11)	$\chi^2(1) = .13$, $p = .721$
IQ – mean (SD)	108.72 (12.20)	105.26 (10.69)	$F(1, 109) = 2.53$, $p = .114$
Monthly household income – *n* (%)			
Below £2000	4 (7.27)	6 (10.53)	
£2000-2999	1 (1.82)	7 (12.28)	$\chi^2(3) = 5.33$, $p = .149$
£3000-3999	8 (14.55)	8 (14.04)	
Above £4000	42 (76.36)	36 (63.16)	

Table 3-2 Correlations between IQ, age, delay sensitivity ratings and P-DeFT measures

			IQ	Age
1	Parent-rated delay sensitivity		-.15	.08
2	During *pre-Go* waiting	Number of button presses	.03	-.06
3		Duration of button press	.01	-.22
4		Activity measured	-.04	-.13
5		Behavioural agitation	-.05	-.13
6		Negative affect	.01	.03
7	*Post-Go* task (no-delay trials)	Activity measured	-.03	.03
8		Time used in task completion	-.18	-.37**
9	*Post-Go* task (delay trials)	Activity measured	-.02	-.05
10		Time used in task completion	-.30*	-.36**

Note: *Pre-Go* waiting = *pre-Go-signal* waiting period; *Post-Go* task = *post-Go-signal* shopping task. Number of button presses, duration of button press and activity measured was computed as a unit per second (/sec). Behavioural agitation and negative affect (fidgeting and facial expression of frustration) were coded using a 4-point scale. The unit of time used in task completion was second (sec). * $p < .007$ ** $p < .001$ (adjusted p values based on Bonferroni correction).

Table 3-3 Sex and household income group differences in delay sensitivity ratings and P-DeFT measures

			Sex difference	**Household income difference**
1	Parent-rated delay sensitivity		F^{a} = 2.54, p = .114	F^{d} = .30, p = .825
2	During *pre-Go* waiting	Number of button presses	F^{b} = .39, p = .532	F^{e} = .09, p = .968
3		Duration of button press	F^{b} = 2.23, p = .138	F^{e} = .11, p = .953
4		Activity measured	F^{c} = 1.74, p = .190	F^{f} = .44, p = .727
5		Behavioural agitation	F^{a} = .03, p = .873	F^{d} = .26, p = .851
6		Negative affect	F^{a} = 2.55, p = .113	F^{d} = 1.09, p = .358
7	*Post-Go* task (no-delay trials)	Activity measured	F^{c} = .02, p = .899	F^{f} = 1.17, p = .326
8		Time used in task completion	F^{a} = .38, p = .542	F^{d} = 1.32, p = .271
9	*Post-Go* task (delay trials)	Activity measured	F^{c} = .17, p = .677	F^{f} = .56, p = .642
10		Time used in task completion	F^{a} = .17, p = .677	F^{d} = .63, p = .599

Note. The *df* of variables for *t* statistics are *a* = (1, 110); *b* = (1, 109); *c* = (1, 106); *d* = (3, 108); *e* = (3, 107); *f* = (3, 104) respectively.

3.4.3 Differences between participants' P-DeFT responses in trials with different waiting duration

Table 3-4 shows the comparison of participants' responses in the *pre-Go-signal* waiting period and *post-Go-signal* shopping task in trials with different waiting durations.

Comparing participants' responses in the 5-sec versus 10-sec delay trials, analyses showed that participants' behavioural agitation and negative affect during the delay, as well as their level of activity and the amount of time used in the *post-Go-signal* shopping task were greater in the 10-sec than 5-sec delay trials, i.e. participants were more frustrated, exhibited higher levels of movement and took longer to complete the task in the trials with longer than shorter delay. The comparison was visualised in **Figure 3-2**.

Analyses showed significant differences between participants' responses in trials with and without delay. Successive pairwise comparison showed that participants' level of activity in the 10-sec delay trials, but not the 5-sec delay trials, were significantly higher than that in the no-delay trials (F = 32.71, p < .001). Regarding time used to complete the *post-Go-signal* task, participants' time used in both the 5-sec and 10-sec delay trials was significantly greater than that in the no-delay trials (F = 26.73 & F = 47.66, ps < .001 respectively).

Table 3-4 Comparison of P-DeFT responses in trials with different waiting duration

		Condition							
		No-delay (1)		**5-sec delay** (2)		**10-sec delay** (3)		Statistical comparison	Pairwise contrasts
		M	S.D.	*M*	S.D.	*M*	S.D.		
During *pre-Go-signal* waiting period									
1	Number of button presses			.83	.34	.80	.36	$F = 1.52$	
2	Duration of button press			2.59	2.90	2.82	2.57	$F = 2.45$	
3	Activity measured	*Not applicable*		152.97	57.29	149.10	61.24	$F = .82$	*Not applicable*
4	Behavioural agitation			2.03	.91	2.34	1.00	$F = 43.61^{***}$	
5	Negative affect			1.34	.52	1.62	.70	$F = 49.45^{***}$	
During *post-Go-signal* shopping task									
6	Activity measured during task	284.07	58.63	282.29	63.72	310.21	71.85	$F = 25.00^{***}$	$1 < 3^{***}$, $2 < 3^{***}$
7	Time used in task completion	13.43	3.26	15.16	5.02	16.36	6.15	$F = 34.06^{***}$	$1 < 2^{***}$, $1 < 3^{***}$, $2 < 3^{***}$

Note: Number of button presses, duration of button press and activity measured was computed as a unit per second (/sec). Behavioural agitation and negative affect (fidgeting and facial expression of frustration) were coded using a 4-point scale. Activity measured was computed as units per second (/sec). The unit of time used in task completion was second (sec). * $p < .05$; ** $p < .01$; *** $p < .001$.

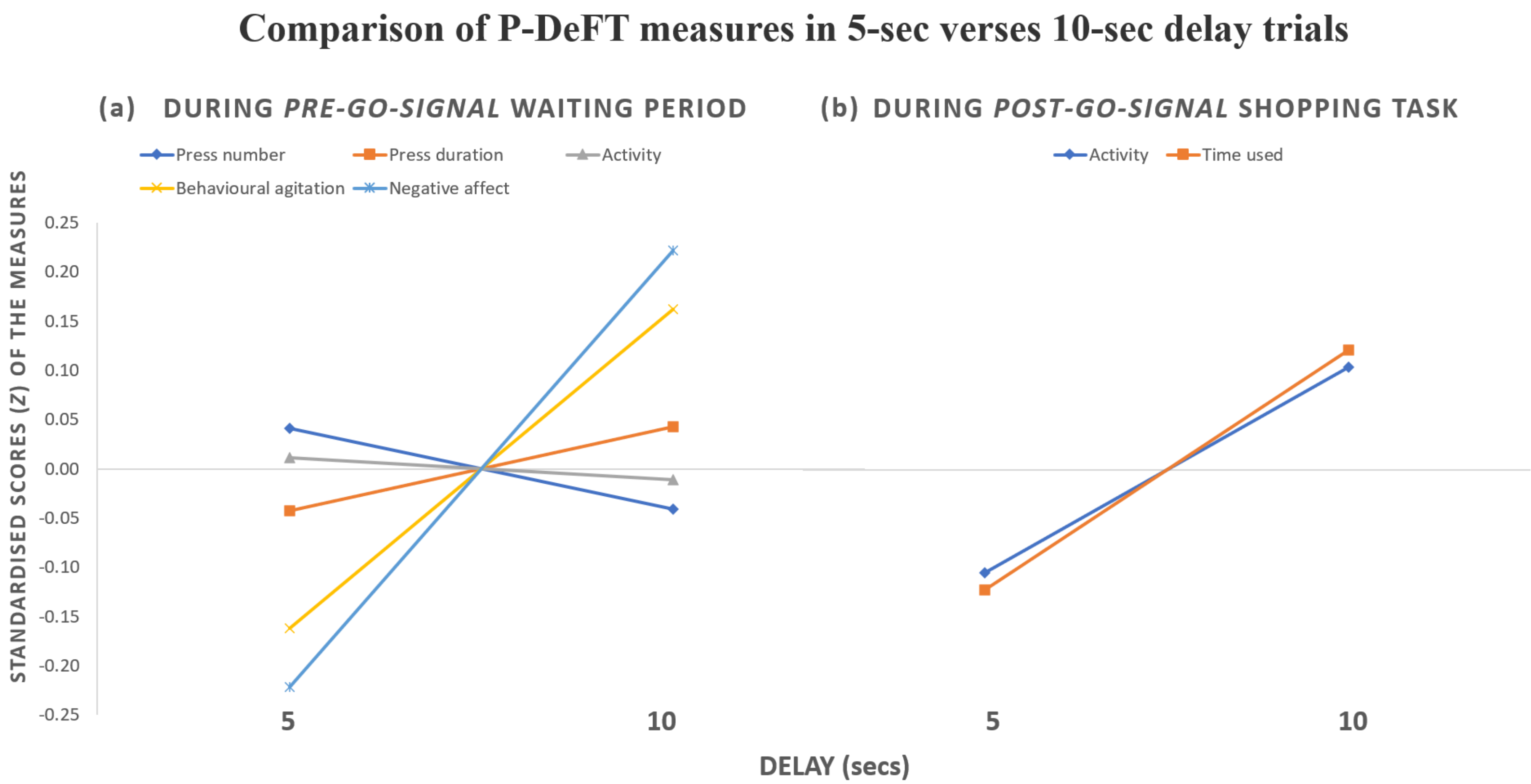

Figure 3-2 Comparison of P-DeFT responses in 5-sec verses 10-sec delay trials.
(a) During the pre-Go-signal waiting period, participants' behavioural agitation and negative affect were greater in the 10-sec than 5-sec delay trials. (b) During the post-Go-signal shopping task, participants' activity level and time used in the task were also greater in the 10-sec than 5-sec delay trials.

3.4.4 Association between delay sensitivity and P-DeFT responses

Table 3-5 shows that the association between delay sensitivity ratings and the P-DeFT responses in trials with different delay duration, controlling for participants' age and IQ. Delay sensitivity ratings were not correlated with any measures in the no-delay trials. In contrast, delay sensitivity significantly correlated with participants' behavioural agitation and negative affect during the *pre-Go-signal* waiting period, as well as their level of activity in the *post-Go-signal* shopping task in both the 5-sec and 10-sec delay trials ($rs \geq .30$, $p \leq .002$).

To further explore how delay sensitivity ratings associate with participants' change in frustration between short and long delay trials, subsequent correlational analyses between delay sensitivity and difference scores were conducted (**Table 3-6**) and results showed that delay sensitivity was significantly associated with the differences between participants' *post-Go-signal* shopping task responses in no-delay and 10-sec delay trials ($rs \geq .30$, $p \leq .002$). The differences between participants' responses in short and long delay trials however were not significantly correlated with their parent-rated delay sensitivity.

Table 3-5 Correlations between delay sensitivity ratings and P-DeFT responses in trials with different waiting duration, controlling for participants' age and IQ

INDIVIDUAL SCORES			Delay sensitivity ratings			
			No-delay	Delay (average)	5-sec delay	10-sec delay
1	During *pre-Go* waiting	Number of button presses	*Not applicable*	.07	.05	.09
2		Duration of button press		.19	.18	.19
3		Activity measured		.23	.20	.23
4		Behavioural agitation		.34**	.34**	.31*
5		Negative affect		.33**	.31*	.31*
6	During *post-Go* task	Activity measured	.14	.32**	.30*	.31*
7		Time used in task completion	-.06	.21	.15	.25

Note: *Pre-Go* waiting = *pre-Go-signal* waiting period; *Post-Go* task = *post-Go-signal* shopping task. Number of button presses, duration of button press and activity measured was computed as units per second (/sec). Behavioural agitation and negative affect (fidgeting and facial expression of frustration) were coded using a 4-point scale. The unit of time used in task completion was second (sec). * $p < .007$ ** $p < .001$ (adjusted p values based on Bonferroni correction).

Table 3-6 Correlations between delay sensitivity ratings and difference scores computed between P-DeFT responses in trials with different waiting duration, controlling for participants' age and IQ

DIFFERENCE SCORES			Delay sensitivity ratings		
			0 vs 5-sec	0 vs 10-sec	5-sec vs 10-sec
1	During *pre-Go* waiting	Number of button presses	*Not applicable*	*Not applicable*	.07
2		Duration of button press			-.02
3		Activity measured			.07
4		Behavioural agitation			.02
5		Negative affect			.15
6	During *post-Go* task	Activity measured	.25	.30*	.07
7		Time used in task completion	.25	.37**	.24

Note: Difference scores were computed by deducting the P-DeFT response scores of short delay trials from the ones of long delay trials. *Pre-Go* waiting = *pre-Go-signal* waiting period; *Post-Go* task = *post-Go-signal* shopping task. Number of button presses, duration of button press and activity measured was computed as units per second (/sec). Behavioural agitation and negative affect (fidgeting and facial expression of frustration) were coded using a 4-point scale. The unit of time used in task completion was second (sec). * $p < .007$ ** $p < .001$ (adjusted p values based on Bonferroni correction).

3.4.5 Cross-cultural differences in delay sensitivity and P-DeFT responses

Table 3-7 compares the UK and HK participants' delay sensitivity ratings and P-DeFT responses. It shows that the two groups only differed significantly in the negative affect observed during the waiting period, with UK children appeared more frustrated than HK children (F = 20.89, p < .001). The same pattern of results was found in separate analyses of the 5-sec and 10-sec delay conditions.

Despite such difference in negative affect, the PROCESS macro test of moderation showed that the relationship between delay sensitivity and negative affect observed during the delay was not significantly moderated by national group (B = -.20, t = -1.22, p = .225). **Table 3-8** showed the interaction effects between national group and delay sensitivity ratings on participants' P-DeFT responses and all of them were not significant ($ts \leq 1.74$, $ps \geq .086$).

Table 3-7 Main effects of national group on delay sensitivity ratings and P-DeFT responses

		UK			HK			Statistical comparison		
		M	S.D.	*n*	*M*	S.D.	*n*	*F*	*p*	η^2
Parent ratings on children's										
1	Delay sensitivity	2.84	.70	55	2.94	.48	57	.78	.378	.01
During *pre-Go-signal* waiting period										
2	Number of button presses	.83	.36	54	.80	.30	57	.31	.582	.00
3	Duration of button press	2.82	2.73	54	2.60	2.54	57	.20	.657	.00
4	Activity measured	159.42	53.68	53	142.95	55.53	55	2.45	.120	.02
5	Behavioural agitation	2.20	.93	55	2.17	.92	57	.03	.875	.00
6	Negative affect	1.72	.66	55	1.25	.37	57	20.89	<.001	.16
During *post-Go-signal* shopping task (no-delay trials)										
7	Activity measured	286.88	62.32	53	281.36	55.29	55	.24	.627	.00
8	Time used in task completion	13.12	2.65	55	13.72	3.74	57	.97	.327	.01
During *post-Go-signal* shopping task (delay trials)										
9	Activity measured	299.98	69.34	53	292.65	57.94	55	.36	.552	.00
10	Time used in task completion	15.41	4.23	55	16.10	6.32	57	.45	.502	.00

Note: Number of button presses, duration of button presses and activity measured was computed as a unit per second (/sec). Behavioural agitation and negative affect (fidgeting and facial expression of frustration) were coded using a 4-point scale. The unit of time used in task completion was second (sec).

Table 3-8 Interaction effects of national group and delay sensitivity on P-DeFT responses

Interaction effects of national group and delay sensitivity on:		Coefficients	Standard error	Statistics	Sig. level	95% Bootstrapping Confidence Interval	
		B	*SE*	*t*	*p*	LLCI	ULCI
During *pre-Go-signal* waiting period							
1	Number of button presses	.19	.11	1.74	.086	-.03	.42
2	Duration of button press	-.30	.88	-.34	.737	-2.05	1.45
3	Activity measured	7.45	19.06	.39	.697	-30.34	45.24
4	Behavioural agitation	-.16	.30	-.54	.591	-.75	.43
5	Negative affect	-.20	.17	-1.22	.225	-.54	.13
During *post-Go-signal* shopping task (no-delay trials)							
7	Activity measured	13.88	20.85	.67	.507	-27.47	55.24
8	Time used in task completion	1.03	1.11	.93	.353	-1.16	3.23
During *post-Go-signal* shopping task (delay trials)							
9	Activity measured	2.82	21.68	.13	.897	-40.18	45.81
10	Time used in task completion	.60	1.81	.33	.741	-2.98	4.18

Note. LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.

3.5 Discussion

3.5.1 Summary of main findings

Preschool children's ability to regulate their emotional and behavioural responses to frustration can predict their future socio-emotional development (Cole et al., 2011; Eigsti et al., 2006; Fabes & Eisenberg, 1992; Fabes et al., 1994; Graziano et al., 2007; Mischel et al., 1988). Having to wait for desired outcomes is a particularly powerful source of frustration, but little is known about how increasing the length of the waiting period before the eventual delivery of the reward affects frustration levels either during or after the imposed wait. The role of delay sensitivity and cultural background in determining waiting-related frustrations is also yet to be explored. In this chapter, we used the P-DeFT to examine these questions. There were a number of findings to note.

3.5.1.1 Waiting-related frustration increased as a function of waiting duration

First, consistent with the delay aversion theory, children's waiting-related frustration was greater on trials with imposed *pre-Go-signal* delay than on those without it. Frustration also increased in intensity as waiting periods were increased from 5-sec to 10-sec. These results highlight just how sensitive preschool children are to delay when frustrated given that the two delay intervals only differed by 5-secs. This highlights how important it is for researchers to take into account even small differences in delay when interpreting findings in this age group.

3.5.1.2 Frustration induced both during and after the imposed waiting

Second, the duration of the waiting period affected children's expressions of frustration both during and after the waiting interval in terms of activity and time used in the post-Go-signal shopping task. At first sight, this post-Go effect might appear to support Amsel's model of frustrative non-reward, a closer look reveals the opposite to be the case – Amsel's view was that the delivery of reward after a period of frustration was positively motivating in terms of subsequent activity and running speed (Amsel, 1958; Dunlap et al., 1974); however, the current results in fact showed that the frustrative effect was disruptive. The children displayed higher level of activity and took longer to complete the shopping task after the long versus the short pre-Go-signal waiting period. In the past, the delay aversion model has focused exclusively on children's responses during delay. The current findings demonstrated that the negative effects of delay extend to after the imposed delay is terminated and extend the delay aversion concept in important ways.

There are several explanations of this post-delay response disruption after the experience of frustration. From a *delay aversion hypothesis* perspective, it may be that children were taking longer to complete the task because they were trying to avoid going back to the frustrating delay situation in the next trial. By contrast, the *surplus energy theory* suggests that the additional activity and time spent on the post-delay task might have been a compensation for the frustration and boredom they experienced during the delay – leading to the build-up of surplus energy – that needed to be expended (Pellegrini & Smith, 1993). It may also be possible that frustration, instead of energy, was accumulated during the inescapable waiting period and that some children, particularly the ones with higher delay sensitivity, may have greater needs to compensate or release their frustration in the form of activity and free movements. Finally, individual differences have been found in young children's rate of recovery from frustration

(Kahle et al., 2016; Northrup et al., 2020; Santucci et al., 2008). Neurological studies (Brown et al., 2021; Gatzke-Kopp et al., 2015) also found that some children had greater difficulty in regulating their emotion expression evident in their neural activity (especially the P3 area that is responsible for attention allocation) in period following a frustrative event. Brown et al. (2021) suggested that there were carryover effects of frustration and some children experienced particular challenges in recovering from frustrating events and this difficulty was found to be associated with future psychological difficulties. The present findings call into question whether the more delay sensitive children have greater difficulty in recovering from the waiting-related frustrations.

3.5.1.3 Positive correlation between delay sensitivity and waiting-related frustration

The third finding was that parent's ratings of delay sensitivity correlated with individual differences in waiting-related frustration expression. On one hand, these findings provide a degree of validation of the QDQ as a measure of children's sensitivity towards delay, while on the other they highlight its potential value as a measure of longer-term risk for negative socio-emotional outcomes. Future studies need to address this point using longitudinal data. Interestingly there was no evidence that a higher level of delay sensitivity was associated with greater differences between short and long delay trials in their responses *during* the waiting delay. There was, however, evidence that higher level of delay sensitivity was associated with greater frustration differences between short and long delay in their post-delay performance *after* it – a higher intensity of activity and lower efficiency in the 10-sec condition. This again refocuses attention of accounts of delay aversion to the post- rather than during-delay period.

3.5.1.4 Cultural invariance in the relationship between delay sensitivity and waiting-related frustration

Fourth, as hypothesized, UK participants expressed stronger negative affect during the delay. The relationship between delay sensitivity and all the P-DeFT measures is however invariant across nations. This means that while there were predictable differences between the children in absolute terms, nevertheless these measures appeared to have similar predictive value in both cultures. Again, longitudinal research will be important in addressing this.

3.5.2 Strengths

The current study had a number of strengths including the experimental design, the use of subjective and objective measures of waiting-related frustration and the relatively large sample recruited from two cultures. The development of the P-DeFT provides researchers a tool to study pre-schoolers' waiting-induced behavioural and emotional responses. The results in the present work highlighted that even small changes in waiting duration are possible to bring about significant differences in young children's performance and reactions. The findings that frustration experienced during a delay can spill over to affect subsequent activities after the delay has finished extended the delay aversion concept and provided insight for researchers to explore the after-effect of waiting-related frustration.

3.5.3 Limitations and future directions

There were a number of limitations. First, it is noted that not all the measures in the P-DeFT are significantly correlated with delay sensitivity; and only some measures captured participants' increase of frustration as a function of delay duration. The slight but non-significant reduction in press number and activity during delay between 5- and 10-sec delay trials may be due to the fact that children expressed their frustration differently in longer versus shorter delays (i.e. children pressed the button for a longer period of time and showed higher levels of emotional agitation). Future studies can vary the delay duration further, using longer delay intervals, to explore how the different indictors of waiting-related frustration change in magnitude and direction as the length of delay increases. Despite the limitation in the number of delay trials and variation of waiting times in the P-DeFT due to the age of the participants, the behavioural and emotional performance was found to be sensitive to delay duration, supporting its potential usefulness as a short (it lasted 10 minutes on average), easy to use, and objective measure of delay frustration in pre-schoolers.

Second, in this study, children's delay sensitivity was only rated by parents. Previous research has reported low agreement between parent and teacher ratings of children's behaviour, with parents tending to overrate children's problems compared to teachers (Verhulst & Akkerhuis, 1989). It would be valuable to include teachers' report and explore if the relationship between delay sensitivity and P-DeFT measures also holds for teachers. Third, although we matched for hyperactivity symptoms as rated by parents across cultures, in hindsight it might have also been important to match for objectively measured activity. This is because such ratings appear to be subject to cultural sensitivity thresholds meaning that the two groups may still differ in their objective levels of activity although rated by parents as being the same. Fourth, although the instructions were designed to be age-appropriate and the pre-schoolers in this sample showed good understanding of the task, how children actually interpreted the unexpected delay instruction was not explored systematically and we acknowledge it may have impacted performance in this young age group. For future research directions, delay duration can be altered, and a longitudinal element can be included to explore how the expressed frustrations during and after a waiting period in early years affect one's socio-emotional development years later and whether this will link to psychopathology over time.

3.5.4 Conclusion

Preschool children's frustration expression, during and after the waiting period, varied in its extent systematically as a function of the pre-reward delay duration and individual differences in their delay sensitivity. Post-delay activity may be more sensitive than activity during the delay as a marker of delay aversion.

Chapter 4 Attention-deficit/hyperactivity disorder (ADHD) in cultural context I: Do parents in Hong Kong and the United Kingdom adopt different thresholds when rating symptoms, and if so why?

In Chapter 3, we introduced the Preschool Delay Frustration Task (P-DeFT) and its application in measuring preschool children's delay aversion. In this chapter, we build on that work and explore how pre-schoolers from HK and UK differ in their objectively measured activity levels during a battery of waiting tasks, including the P-DeFT. Chapter 4 also explores the relationship between levels of parent-rated ADHD symptoms and children's activity level in a cultural context. The findings showed that UK and HK parents operated on different ADHD symptom endorsement thresholds – a higher level of activity level was required for UK parents to endorse a symptom as present. This chapter demonstrates cross-cultural differences in parents' perceptions and reports of ADHD-related behaviours, which gives rise to the research initiatives described in Chapter 5, to examine if the association between parent-rated ADHD symptoms and children's actual performances and reactions in different waiting situations is culturally invariant.

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Attention-deficit/hyperactivity disorder (ADHD) in cultural context: Do parents in Hong Kong and the United Kingdom adopt different thresholds when rating symptoms, and if so why?

Wendy W. Y. Chan[1,2] | Kathy Kar-man Shum[2] | Edmund J. S. Sonuga-Barke[1,3]

[1]School of Academic Psychiatry, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK

[2]Department of Psychology, The University of Hong Kong, Hong Kong, China

[3]Department of Child & Adolescent Psychiatry, Aarhus University, Aarhus, Denmark

Correspondence

Edmund J. S. Sonuga-Barke, Department of Child & Adolescent Psychiatry, Institute of Psychiatry, Psychology & Neuroscience, De Crespigny Park, SE5 8AF, London, UK.
Email: edmund.sonuga-barke@kcl.ac.uk

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Abstract

Objectives: Attention-deficit/hyperactivity disorder (ADHD) prevalence is similar across world regions. However, because informants' decision thresholds may vary between regions, these similarities may mask regional variations in actual ADHD behaviours. We tested this by comparing the relationship between informant's ratings and children's measured activity in United Kingdom (UK) and Hong Kong (HK) and then explored whether any national differences in endorsement thresholds discovered are linked to cultural variations in parenting factors.

Methods: Parents rated the 18 ADHD symptoms in 112 three-to-five-year-old children stratified for ADHD symptom levels (49 girls and 63 boys; 55 from the UK and 57 from HK) and completed some parenting questionnaires. Children's task-related activity was measured using actometers.

Results: In both groups, measured activity was positively correlated with hyperactivity/impulsivity ($r = 0.44^{HK}$; $r = 0.41^{UK}$). While HK children were less active than UK children ($p < 0.01$), HK parents rated their children as more hyperactive/impulsive and inattentive ($ps < 0.05$). The lower *rating threshold* indicated by this pattern in HK parents were explained by their higher child-related stress levels.

Conclusions: UK and HK parents operated different ADHD symptom endorsement thresholds. The link between these and child-related stress may mark a more general role of cultural pressure for child conformity and school achievement in HK.

KEYWORDS

attention-deficit hyperactivity disorder, cross-cultural study, parenting, rating threshold, social norms

1 | INTRODUCTION

Attention deficit/hyperactivity disorder (ADHD) is a life span neurodevelopmental disorder characterized by age inappropriate and impairing levels of inattention and/or hyperactivity/impulsivity (American Psychiatric Association, 2013; Posner et al., 2020). Interestingly, global comparisons of epidemiological studies have found little evidence that the prevalence of ADHD varies between nations and/or cultural and ethnic groups, once methodological variations are accounted for; the best global estimate for child ADHD being around 5% (Polanczyk et al., 2007, 2015). In this paper we explore the possibility that these cross-regional similarities in ADHD prevalence mask cross-region differences in actual ADHD related-behaviours. This possibility stems from the fact that decisions to diagnose an individual depend on the subjective reports and interpretations of adults (i.e., parents and teachers) filtered through the prism of clinical judgement: The key question being *"Is a child's ADHD behaviour displayed to a sufficient degree to cross the threshold for it to be endorsed as a symptom"* (Canino & Alegria, 2008; MacDonald et al., 2019; Reid & Maag, 1994). This of course means that factors that change the endorsement threshold will affect whether a behaviour is considered a symptom. Some factors are linked to child characteristics such as sex (Meyer et al., 2020) or ethnicity (Sonuga-Barke et al., 1993). Others are linked to informant characteristics such as mental health (De Los Reyes & Kazdin, 2005; Najman et al., 2001), parenting style (Bajeux et al., 2018; Luk et al., 2002) and/or values (Gross et al., 2004). Still others may derive from family factors (Stone et al., 2013). In the *threshold model*, Weisz et al. (1988) proposed that cultural differences in levels of parental distress over a child's troubling behaviours—associated with social norms regarding children's conduct and child-rearing practices—will also impact these thresholds (Canino & Alegria, 2008; Gomez & Vance, 2008; Hillemeier et al., 2007; Porter et al., 2005; Thompson et al., 2017; Weisz et al., 1988).

On this basis it can be hypothesized that cultural variations in endorsement thresholds for ADHD-related behaviours could lead to the same symptom ratings being associated with different levels of actual behaviour. Here we test this possibility by studying endorsement thresholds in two nations, the UK and HK. To do this we compared the levels of directly measured child activity associated with UK and HK parent's ratings of hyperactivity/impulsivity and inattention symptoms. We then explored the cultural differences in some parenting-related factors that might explain any regional rating threshold differences found. We chose these two nations because, although they are reported to have a similar prevalence of ADHD (Child Assessment Service Department of Health, HKSAR, 2007; Leung et al., 2008; NICE, 2000), parenting research suggests that they have different cultural views about how children should behave, which may be reflected in their ADHD rating thresholds. For instance, it has been repeatedly noted that HK parents, compared to western parents, have relatively high expectations for their children's behaviours when it comes to conformity to rules (Chao, 1994; Chen, 2005; Lam & Ho, 2010; Thompson et al., 2017). In Chinese culture, social norms require individuals to exercise self-control and compliance to avoid creating trouble or inconvenience for others (Chao, 1995). Parents of children who behave in ways that breach these standards may experience higher level of parenting stress (Leung et al., 2005). In western culture, parents are more likely to adopt a more child-centered approach, with more freedom given to children to exercise their "energy" (Chen et al., 2003). We hypothesize that this general approach to parenting and attitudes to children, and the stress that occurs where children do not conform, will be associated with a lower threshold for ADHD-behaviours in HK compared to UK parents.

Previous studies provide indirect evidence that HK parents rate their children as having more ADHD symptoms than UK parents. Ho et al. (1996) found that HK boys were rated as having twice the levels of ADHD symptoms compared to UK children on Rutter's questionnaires items—"restless", "fidgety", "can't settle" (Rutter et al., 1970). A more recent study found similar results for teacher ratings (Lai et al., 2010; Meltzer et al., 2000).

Despite these rating scale findings, studies of actual behaviour tend to suggest that HK children are less active than their UK counterparts. For instance, Luk et al. (2002) compared a HK epidemiological study of hyperactivity (Leung et al., 1996) against a separate but similar British study (Taylor et al., 1991) and found that the measured activity level was significantly lower in HK than UK children. Conformity and self-control are highly valued by parents in HK culture (Chao, 1994; Chen, 2005; Lam & Ho, 2010; Thompson et al., 2017), we therefore predicted that parents in HK would be especially sensitive to more deviant hyperactive behaviours (Ho et al., 1996).

Although these initial studies are consistent with the hypothesis of cross-national differences in ADHD rating thresholds, they have limitations. The comparisons across cultures were not direct, relying instead on data that were collected at different times and often for different purposes, creating potentially important methodological inconsistencies. Furthermore, the cultural differences in the relationship between informant ratings and measured activity were usually addressed separately, with no recent studies examining the two constructs concurrently. Finally, there was no attempt to explore what might underlie these cultural differences in rating thresholds: Are they, as suggested by the Weisz et al. (1988) model, mediated by differences in parenting attitudes, values and tolerances? In the current study we addressed these limitations by applying a common protocol to collect data in the UK and HK, with informant ratings of ADHD symptoms and actual activity collected for the same children using the same approach. We then explored whether the differences found could be explained by cross-national differences in general parenting attitudes and reactions to their children in terms of ADHD-specific emotional responses and more general child related stress.

We addressed four research questions; (i) Do UK and HK parents differ in their ADHD rating thresholds as reflected in the relationship between their ratings of ADHD symptoms and their children's actual behaviour? (ii) Are these effects different for children with high and low levels of rated ADHD? (iii) Do UK and HK parents differ in their parenting attitudes, parenting stress and emotional reactions to ADHD symptoms? (iv) Do such cultural differences in parental characteristics mediate the national differences in ADHD rating thresholds? Based on prior studies, we hypothesized that; (i) UK children would be more active than HK children who have the same level of parent-rated hyperactivity/impulsivity symptoms; (ii) this national difference in activity level would be more marked in children rated high for ADHD, suggesting that HK parents ratings are particularly sensitive to severe ADHD symptoms; (iii) HK parents would have more authoritarian parenting attitudes, experience more parenting stress and have stronger emotional reactions to ADHD symptoms; (iv) these cultural differences in parental characteristics would statistically explain the relationship between national groups and rating thresholds.

2 | METHOD

2.1 | Participants

One-hundred-and-eighty-nine preschool children and their parents living in London UK ($n = 68$; 51% male) and HK ($n = 121$; 58% male), recruited from nurseries and preschools and via social media adverts. Children were screened for ADHD symptoms using the five-item subscale of *The Strengths and Difficulties Questionnaire* completed by parents and teachers (SDQ, version T2-4; Goodman, 1997). Thirty children ($n^{UK} = 13$ and $n^{HK} = 17$) were excluded based on the following criteria—they were outside the age range, had an IQ below 80, had special educational needs and/or a diagnosis of pervasive developmental disorder, a teacher not engaging or family not able to attend testing sessions. No participant has been formally diagnosed with ADHD and none of them was taking ADHD medications. We attempted to minimize differences in symptom levels between UK and HK at the group level by oversampling children and then excluding some based on parents and teachers SDQ hyperactivity/inattention subscale ratings; a larger proportion of HK children was being rated by their parents as having subclinical/clinical levels of ADHD symptoms, we eventually excluded 47 of those so that the numbers of children in each symptom group would be similar in UK and HK. The number of children having subclinical/clinical levels of ADHD symptoms rated by parents or teachers (subscale score ≥ 5) in the final UK and HK sample were not statistically different, $\chi^2(1) = 1.27$, $p = 0.26$. Full data was available for 112 children ($n^{UK} = 55$ and $n^{HK} = 57$).

2.2 | Measures

2.2.1 | Screening measures

Children were screened for ADHD behaviours and IQ.

ADHD symptom screener

The parent and teacher SDQ (version T2-4) are widely used psychometrically strong, brief behavioural screening questionnaire designed for research and clinical purposes (Goodman, 1997). The hyperactivity/inattention subscale consists of five items: two measuring inattention, two hyperactivity and one impulsivity. The original English language version was used in the UK. A validated Chinese translation was used in HK (Lai et al., 2010).

Intelligence

Children's intelligence was estimated using the Block Design and Vocabulary subtests of *Wechsler Preschool and Primary Scale of Intelligence* (WPPSI-III; Wechsler, 2003). The WPPSI measures the cognitive ability of pre-schoolers and young children between 2 years 6 months and 7 years and 3 months. The English (UK) and Traditional Chinese language versions were used in the UK and HK respectively.

2.2.2 | ADHD symptom ratings

Parents rated children on the 18 DSM-IV ADHD symptoms using a version of the *ADHD Rating Scale IV* (DuPaul et al., 1998) adapted for pre-schoolers (ADHD-RS-IV-P; McGoey et al., 2007). Subscale scores were calculated for inattention and hyperactivity/impulsivity factors by summing scores on odd and even-numbered items respectively. A total score can be computed by adding scores of all the items.

2.2.3 | Children's activity levels

Electronic activity trackers were used to measure children's activity while they performed three tasks. These were selected because they have been shown to elicit increased activity in individuals with high levels of ADHD. Each required waiting during delay: *Cookie Delay Task* (Campbell et al., 1994; Golden et al., 1977), *Bee Delay Task* (Markomichali, 2015) and the *Preschool Delay Frustration Task* (a new task developed based on the *Delay Frustration Task* created by Bitsakou et al., 2006). In the *Cookie Delay Task*, children were instructed to wait for a signal until they could retrieve the reward. In the *Bee Delay Task*, children chose between smaller sooner and larger later rewards. In the *Preschool Delay Frustration Task*, children played a game with unexpected delays presented intermittently. More information on these tasks is available in the appendix.

The activity tracker was a validated wearable CE marked, watch-like actigraph unit designed specifically for use with young children (https://mindpax.me/for-providers/). It is unobtrusive, non-invasive and safe. It measures changes in acceleration over short intervals of time. To detect activity, G (a measure of acceleration) is recorded by the device's motion sensor signal sampled at 6.5 Hz. The data output is the average G for each second. The tester recorded the exact start and end time of each task performed to retrieve the relevant data from the activity output file. For the purposes of the current study, the average amount of activity per second across each task was used as the dependent variable.

2.2.4 | Parenting measures

Parenting styles

The Parenting Styles and Dimensions Questionnaire—Short Form (PSDQ-SF) is a 32-item self-report instrument developed by Robinson et al. (2001) to measure three dimensions of parenting; (i) authoritative; (ii) authoritarian; (iii) permissive. It has good internal consistency (Robinson et al., 2001) and criterion validity (Olivari et al., 2013). A Chinese version was prepared and validated by Wu et al. (2002).

Parenting stress

The Parenting Stress Index 4th edition (PSI-4-SF) is a brief version of the PSI developed by Abidin (1983). It consists of 36 items, with 12 items evaluating each of the three dimensions: (i) Parental Distress, (ii) Parent-Child Dysfunctional Interaction and (iii) Difficult Child. A high correlation ($r = 0.94$) was found between the total stress score of the PSI and PSI-SF. Both the English and Chinese versions of the PSI-SF have good reliability and validity (Abidin, 2012; Liu & Wang, 2015; Yeh et al., 2001).

Parental emotional reaction to child ADHD symptoms

The Parental Emotional Response to Children Index (PERCI) is a self-report rating scale designed to measure parents' emotional response to AD/HD and related behaviours (Lambek et al., 2017). The five subscales have satisfactory internal consistency. For this study, only the three relevant subscales relating to (i) inattention, (ii) hyperactivity, (iii) impulsivity were used. For use in the present study, the PERCI was translated into Chinese, back-translated and revised. This translated version was found to have good internal consistency (Cronbach's $\alpha = 0.92$).

3 | PROCEDURES

Assessment sessions took place in quiet rooms either at King's College London or the University of Hong Kong. Mother-child dyads were briefed that this was a cross-cultural study exploring pre-schoolers' behaviours in tasks that require sustained attention, patience and waiting. After the introduction, the mother-child dyad enjoyed a period of free play. The children then completed the tasks administered by trained researchers (one each in UK and HK) while their parents filled in questionnaires in a separate room. Throughout the session, the children wore the actometer on their non-dominant wrist. The session lasted for approximately 90 min with breaks. The research team presented a certificate and book voucher to each participating parent-child pair as a token of appreciation.

4 | DATA ANALYSIS

A small proportion of actometer reading data was missing due to technical issue and participants' hesitation to wear the actometer. Where data were missing, we used pairwise deletion, so that all available data were used. The measured activity scores for the three tasks were correlated ($rs^{UK} > 0.51$, $p < 0.001$; $rs^{HK} > 0.48$, $p < 0.001$) and were combined to produce a single *average activity level* variable. The correlations between this score and parent hyperactivity/impulsivity and inattention ratings were calculated in the UK and HK samples. ADHD ratings by UK and HK parents were compared using analysis of variance (ANOVA). The UK and HK groups were then subdivided into *low* and *high* rated hyperactivity/impulsivity symptoms based on the published US norms for the ADHD-RS-IV-P (above or below 10.5 cut-off, i.e., the 80th percentile) (McGoey et al., 2007). The effects of *national group* (UK vs. HK) and *rated symptom level* (hyperactivity/impulsivity) ($\leq$80th vs. >80th percentile), and their interaction, on *average activity level* were tested using a two-way ANOVA. A *rating threshold ratio* was then computed for each child by dividing the *average activity level* by the impulsivity/hyperactivity rating: a higher rating threshold indicated that more activity was required before a symptom was rated as present. Correlational analyses then examined whether parenting factors were associated with this *rating threshold ratio* in the UK and HK. Finally, selecting those parenting factors that were different for UK and HK parents and were correlated with the ratio, we used regression analyses and the SPSS PROCESS macro developed by Hayes (2013) to explore whether these factors statistically accounted for the relationship between national group and *rating threshold ratio*.

5 | RESULTS

Table 1 presents the demographics and background characteristics of the sample. UK and HK participants differed on just three variables. First, the percentage of mothers who were not the major caregiver for the child was greater in HK compared to UK families. A substantial proportion of HK families employed a live-in domestic helper (i.e., nanny) who took on the main child-care role. Second, UK mothers had a higher level of education. Third, the UK sample was more ethnically diverse than the HK sample with around 27% of parents being either of Asian, Black or mixed ethnicity. Seventy-three percent of these parents were second generation, having been born in the UK. No significant differences in symptom scores and parenting measures were found between the parents with different educational levels or from different ethnic groups (in the UK sample). These factors were not included in subsequent analyses (see Table S1 in Supplementary Information).

In both UK and HK groups, the *average activity level* was positively correlated with hyperactivity/impulsivity ($r^{UK} = 0.41$, $p < 0.01$; $r^{HK} = 0.44$, $p < 0.01$) and, to a lesser extent, inattention ($r^{UK} = 0.18$, $p = .23$; $r^{HK} = 0.38$, $p < 0.01$) ratings. HK parents rated their children as significantly more symptomatic than UK parents on both

TABLE 1 Demographic, background, parent-rated ADHD symptoms, rating threshold ratios and parenting factors of participants in UK and HK

	UK (n = 55)	HK (n = 57)	Statistical comparison and effect size
Child characteristics			
Age (months)—mean (SD)	46.6 (6.6)	45.9 (4.9)	$F(1, 110) = 0.44$, *n.s.*
Female—*n* (%)	25 (45.5)	24 (42.1)	$\chi^2(1) = 0.13$, *n.s.*
IQ—mean (SD)	108.7 (12.2)	105.3 (10.7)	$F(1, 109) = 2.53$, *n.s.*
ADHD symptom screening; high group—*n* (%)	26 (47.3)	33 (57.9)	$\chi^2(1) = 1.27$, *n.s.*
Mother/caregiver characteristics *n* (%)			
Mother as major caretaker	51 (92.7)	31 (54.4)	$\chi^2(1) = 20.98$, $p < 0.001$
Living with both parents	51 (92.7)	55 (96.5)	$\chi^2(1) = 0.78$, *n.s.*
Full-time employment	18 (32.7)	27 (47.4)	$\chi^2(1) = 2.50$, *n.s.*
Age group			
25–34	11 (20)	22 (38.6)	$\chi^2(2) = 4.71$, *n.s.*
35–39	30 (54.5)	23 (40.4)	
Over 40	14 (25.5)	12 (21.2)	
Highest education level			
Secondary	1 (1.8)	15 (26.3)	$\chi^2(3) = 26.07$, $p < 0.001$
Higher education	3 (5.5)	11 (19.3)	
Bachelor	22 (40)	21 (36.8)	
Master or above	29 (52.7)	10 (17.5)	
Monthly household income			
Below £2000	4 (7.3)	6 (10.5)	$\chi^2(3) = 5.33$, *n.s.*
£2000–2999	1 (1.8)	7 (12.3)	
£3000–3999	8 (14.5)	8 (14.0)	
Above £4000	42 (76.4)	36 (63.2)	
Ethnicity			
White	40 (72.7)	0 (0)	*Not applicable*
Asian	8 (14.5)	57 (100)	
Black/mixed	7 (12.7)	0 (0)	
Parent ratings on child ADHD symptoms—mean (SD)			
Hyperactivity/impulsivity	10.67 (5.15)	12.86 (5.57)	$F(1, 110) = 4.64$, $p < 0.05$, $\eta^2_p = 0.04$
Inattention	8.45 (4.85)	10.47 (4.99)	$F(1, 110) = 4.72$, $p < 0.05$, $\eta^2_p = 0.04$
Average activity level[a]	162.68 (40.28)	147.59 (37.30)	$F(1, 100) = 3.85$, $p = 0.05$, $\eta^2_p = 0.04$
Rating threshold ratio[b]	22.05 (21.26)	13.74 (6.88)	$F(1, 100) = 7.50$, $p < 0.01$, $\eta^2_p = 0.07$
Parenting style—mean (SD)			
Authoritarian	1.49 (0.27)	1.85 (0.35)	$F(1, 110) = 36.82$, $p < 0.001$, $\eta^2_p = 0.25$
Authoritative	4.11 (0.36)	4.10 (0.41)	$F(1, 110) = 0.03$, *n.s.*
Permissive	2.16 (0.49)	2.19 (0.56)	$F(1, 110) = 0.07$, *n.s.*
Parenting stress—mean (SD)			
Parental distress	2.21 (0.59)	2.64 (0.66)	$F(1, 110) = 13.27$, $p < 0.001$, $\eta^2_p = 0.11$
Parent-child dysfunctional interaction	1.73 (0.43)	2.09 (0.52)	$F(1, 110) = 16.00$, $p < 0.001$, $\eta^2_p = 0.13$
Difficult child	2.24 (0.68)	2.50 (0.56)	$F(1, 110) = 5.05$, $p < 0.05$, $\eta^2_p = 0.04$

(Continues)

TABLE 1 (Continued)

	UK (*n* = 55)	HK (*n* = 57)	Statistical comparison and effect size
ADHD-specific emotional response—mean (SD)			
Inattention	2.79 (0.76)	2.81 (0.53)	$F(1, 110) = 0.02$, *n.s.*
Hyperactivity/impulsivity	2.68 (0.55)	3.03 (0.49)	$F(1, 110) = 13.09$, $p < 0.001$, $\eta^2_p = 0.11$

Abbreviations: ADHD, Attention-deficit/hyperactivity disorder; HK, Hong Kong; UK, United Kingdom.

[a]Participants' task-related activity level was measured using actometers; $n^{UK} = 47$; $n^{HK} = 55$.

[b]The rating threshold represented the amount of average activity level divided by the parent hyperactivity rating; $n^{UK} = 47$; $n^{HK} = 55$.

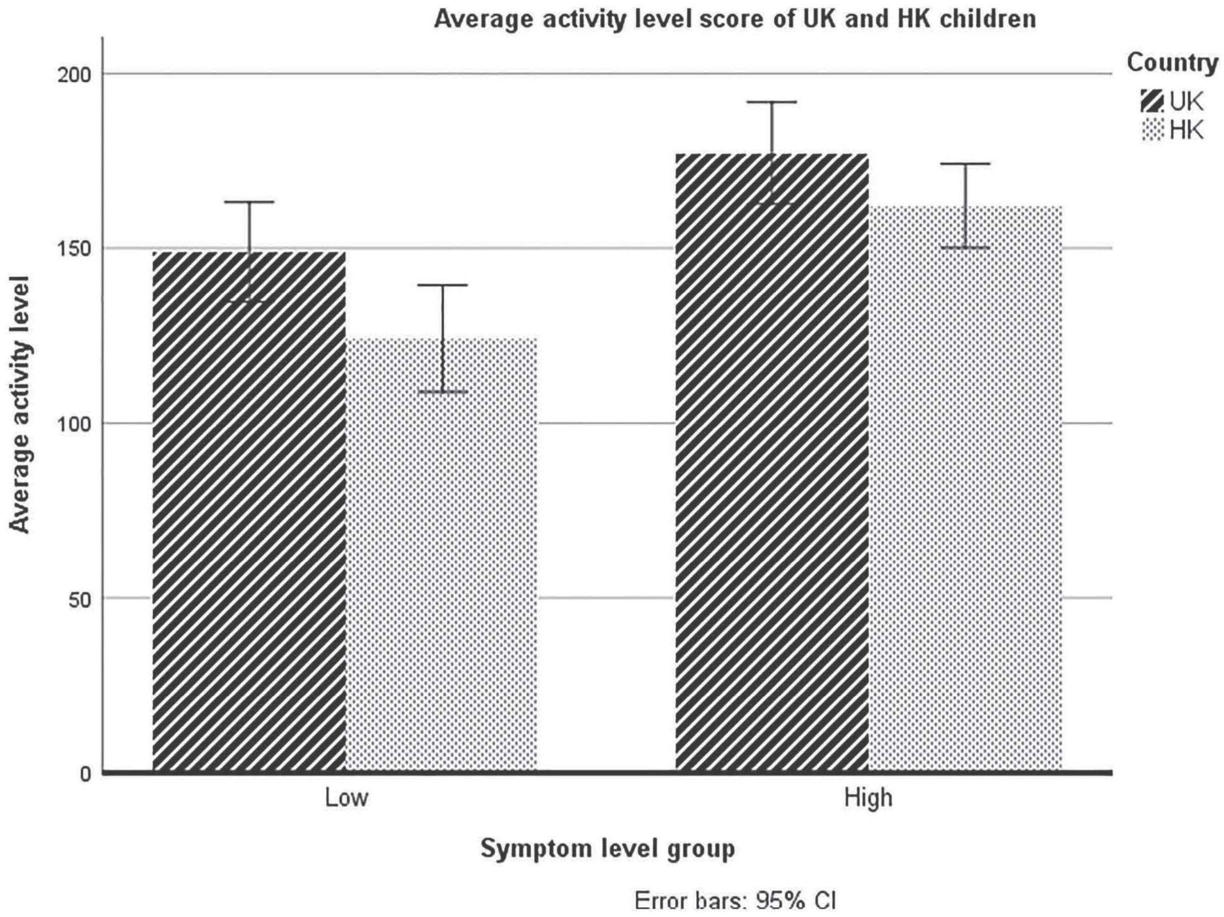

FIGURE 1 Child participants' average activity level as a function of high and low symptom level groups and national group. Average Activity Level was based on the mean actometry score across the three tasks. Symptom level group was based on high and low (above and below the 80th percentile) on the hyperactivity/impulsivity scale of the ADHD-RS-IV-P

the hyperactivity/impulsivity and inattention subscales (Table 1). Figure 1 presents average activity level scores as a function of *national group* and *rated symptom severity* (higher or lower than the 80th percentile). There was a main effect of *national group* ($F = 7.84$, $p < 0.01$) and *rated symptom severity* ($F = 21.73$, $p < 0.001$) but no interaction ($F = 0.45$, $p = 0.50$) - demonstrating that HK children were significantly less active than their UK counterparts at both high and low levels of rated symptoms.

UK parents employed higher *rating thresholds* than HK parents ($F = 7.50$, $p < 0.01$) (Table 1): A higher activity level was required for the endorsement of symptom presence in the UK than HK group. Within-UK group ethnic differences (White vs. Black vs. Asian) were not related to the *Rating Threshold Ratio* ($F = 0.67$, $p = 0.65$). The clinical significance of the HK versus UK difference in *Rating Threshold Ratio* is illustrated in Figure 2 with separate lines representing the relationship between hyperactivity/impulsivity ratings and *average activity levels* in the UK and HK groups. It demonstrates that the average activity level associated with UK parent ratings at the 80th percentile equates to the 93rd–98th percentile of HK parent ratings.

Parents in HK in general rated themselves as more authoritarian, more stressed and having a stronger emotional reaction to children's hyperactive and impulsive behaviours (Table 1). Significant correlations between the *rating threshold ratio* and authoritarian parenting, and child behaviour related parenting stress were found after correction for multiple testing using Bonferroni formula (Table 2).

Statistical mediation was then explored. PROCESS macro tests showed that when authoritarian parenting and child behaviour-related parenting stress were introduced into a parallel model as potential mediators, they reduced the relationship between national group and threshold ratio to a non-significant level. The indirect effects were tested using the bootstrap confidence intervals approach (Hayes, 2013). The 95% bias-corrected confidence interval (−0.4.78, −0.55) based on 10,000 bootstrap samples indicated that the indirect effect (−2.38) was different from zero, suggesting that the effect of national group on rating threshold

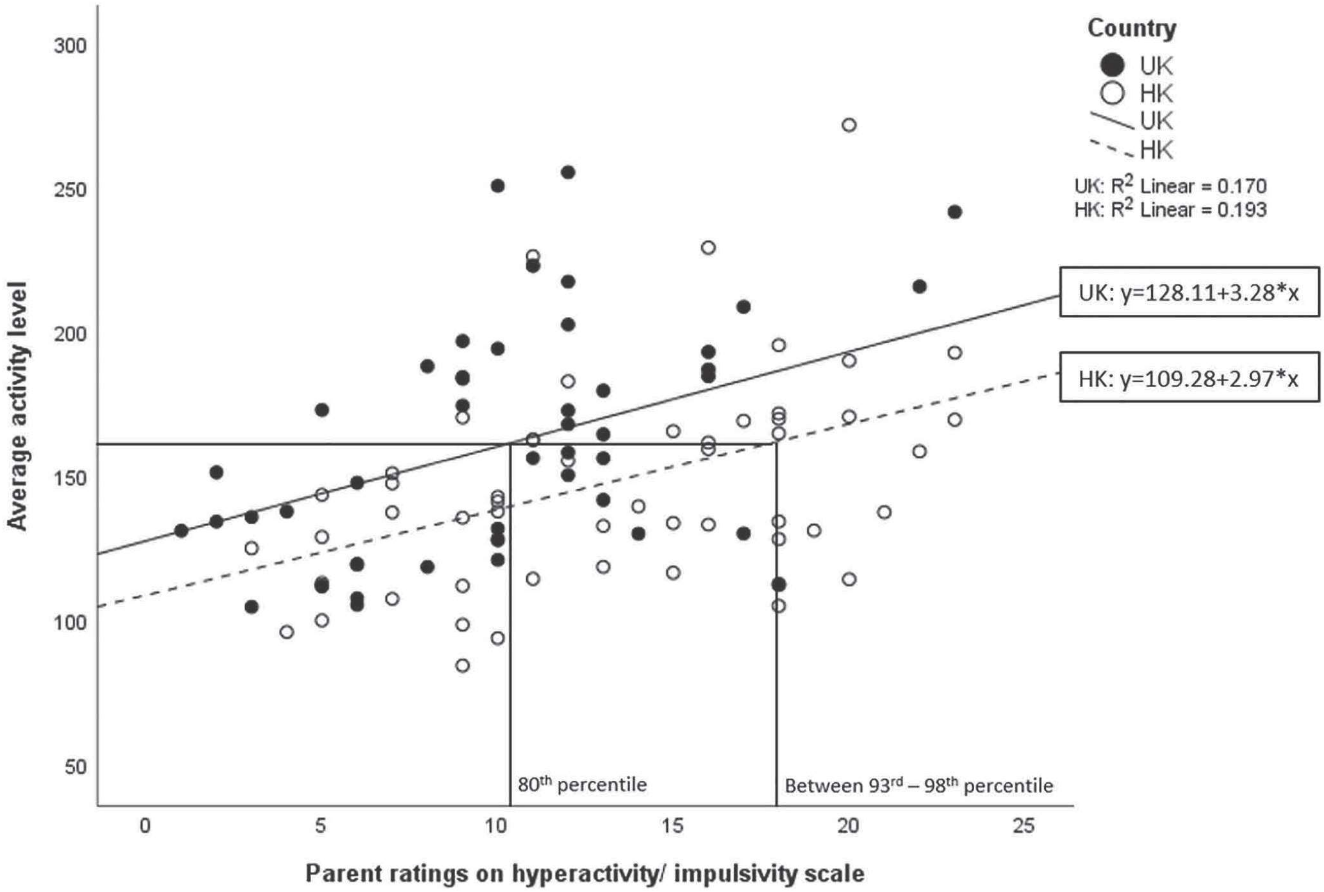

FIGURE 2 Relationship between parent hyperactivity/impulsivity ratings and average activity level in UK and HK. Raw scores of 10.5, 14, 16 and 21 indicated the 80th, 90th, 93rd and 98th percentile respectively

TABLE 2 Correlations between parenting-related factors and Rating Threshold Ratio

		Hyperactivity/impulsivity rating threshold ratios
1	Authoritarian parenting	−0.28*
2	Authoritative parenting	0.05
3	Permissive parenting	−0.08
4	Parental distress	−0.22
5	Stress related to parent-child dysfunctional interaction	−0.18
6	Stress related to difficult child	−0.36**
7	Parental emotional response to inattention	−0.03
8	Parental emotional response to hyperactivity/impulsivity	−0.09

*$p < 0.006$; **$p < 0.001$ (adjusted p values based on Bonferroni correction).

ratio was significantly mediated by child behaviour-related parenting stress (Figure 3).

6 | DISCUSSION

The current study had two aims. First, to test whether HK and UK parents apply different thresholds for the endorsement of ADHD symptoms—as a specific case of a more general phenomenon reflecting the culturally relative nature of informant ratings of children's behaviour. We achieved this by comparing informant ratings against their children's actual activity levels in two countries. Second, to test the hypothesis that differences in these thresholds would be linked to national differences in parenting practices and reactions to their children.

We had four research questions. With regard to the first, we found compelling evidence that HK and UK parents applied very different thresholds when rating ADHD symptoms. This was driven by two separate effects. First, children in HK were significantly less active than children in the UK. Second, despite this HK parents rated their children as more symptomatic than UK parents rated theirs. In terms of clinical thresholds, this led to the striking finding that the average activity level associated with UK parent ratings made at the 80th percentile equated to the ratings at the 93rd–98th percentile of HK parent ratings. This means that nearly all HK children rated in the clinical range by HK parents, if transported to the UK and rated by UK parents, would be in the normal range. This finding is consistent with previous cross-national data comparisons in preliminary studies but using exactly the same methods contemporaneously (Ho et al., 1996; Lai et al., 2010; Luk et al., 2002; Meltzer et al., 2000). It is also consistent with studies in which adult clinicians from different cultural groups rate the severity of a standard description of ADHD in vignettes (e.g., Mann et al., 1992). With regard to the second question, against prediction, we found no evidence that these rating threshold differences operated only at the high end of rating severity. HK parents were differentially more sensitive to activity across the full distribution of ratings not just to hyperactivity of potential clinical significance. This suggests a general shift in cultural perceptions of a linear nature with the whole rating distribution being transposed rather than just the tail extended.

In addressing our third question, and in line with our prediction, we found that HK parents rated themselves as more authoritarian (i.e., stricter) than UK parents. It is important to point out that despite these national differences, overall HK parents still rated themselves on balance as more authoritative than authoritarian. This is consistent with previous findings that Chinese mothers scored significantly higher than European/US mothers on ratings of authoritarianism, but were similar in terms of authoritativeness (Chao, 1994; Pearson & Rao, 2003). It is also possible that this somewhat stricter parenting style contributes, along with potential bio-genetics factors (Bronson, 1972; Freedman & Freedman, 1969; Leung et al., 2017), to the lower actual levels of hyperactivity (Bronson, 1972; Luk et al., 2002) and disruptive behaviour (Chao, 1994; Fung et al., 2018) seen in the HK as compared to UK children. In this regard, it will be interesting to explore the secular trends in parenting attitudes of both local HK parents and those in populations that have migrated to other cultural settings—do changes in parenting style and attitudes lead to changes in directly observed children's behaviours. Interestingly, attempts to promote positive parenting approaches in recent decades have led HK parents to become less demanding and more positive in their interactions with their children than before (Chan et al., 2021), but still comparatively more authoritarian than the UK parents (Yip et al., 2019).

In the current study, HK parents also described feeling more parenting-related stress—in terms of general stress as well as the specific stress related to parent-child interactions and their children's

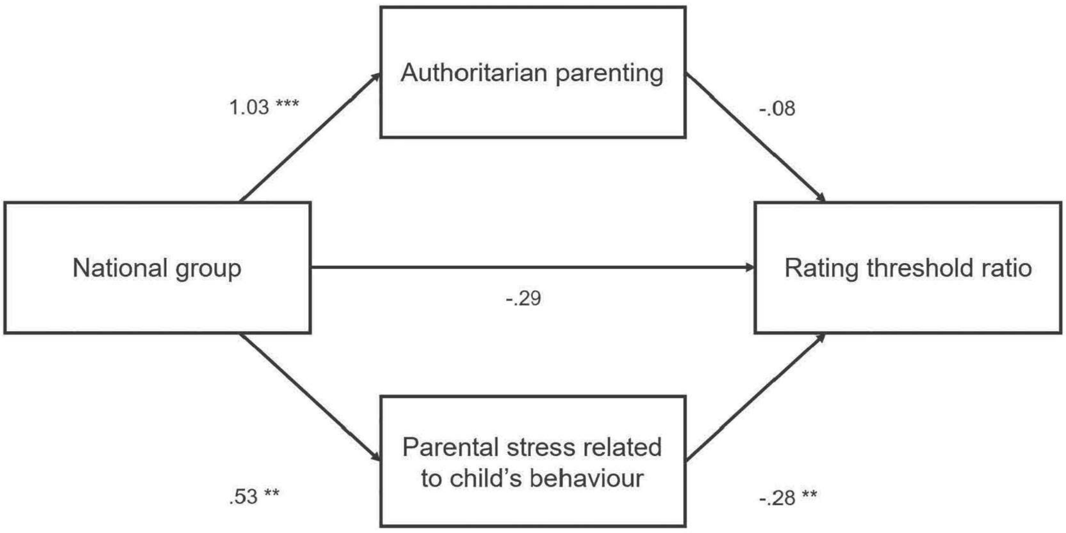

FIGURE 3 The mediation effect of authoritarian parenting and child behaviour related parenting stress in the relationship between national group and rating threshold ratio. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; all presented effects are standardised coefficients

behaviour—and having a stronger emotional response to ADHD behaviours. It is not difficult to see why parents in HK might feel both more stressed than UK parents and react more negatively when their children display hyperactivity. Specifically, the higher level of parenting stress in HK parents may reflect the cultural expectations with regard to children's behaviour and performance. Docility, conformity, and self-control are social norms in the HK culture, especially for children and in educational/classroom settings (Chao, 1994; Chen, 2005; Lam & Ho, 2010; Thompson et al., 2017). Academic achievement is highly emphasized in HK; the school system expects even preschool children to sit properly in class and stay focused on learning tasks (Chen & Stevenson, 1989), whereas a preschool classroom in the UK is much less structured and children are usually free to move around to choose activities they are interested to engage in Luk et al. (2002). HK parents may feel under a lot of pressure to bring up their children to conform to culturally relevant behavioural standards and achieve academically. Furthermore, it was previously found that parents in Chinese cultures had a higher tendency than Western parents to attribute children's problem behaviours to their own behaviour (Chiang et al., 2000); they expressed more self-blame and assumed responsibility for their children's behavioural and developmental difficulties (Ryan & Smith, 1989). It has been argued that it is this sense of pressure which creates high stress levels in HK parents that we see in their responses to their children's ADHD (Chao, 1995). Children's level of activity and behaviours that are deviant, even slightly, from cultural expectations are likely to trigger parents' reactions and stress (Ho et al., 1996). It is also possible that stress is experienced more strongly in the current generation of parents as they are caught in the middle between professionals' encouragement to develop a more child-centred, less authoritarian approach, and the need to maintain their children's standard of behaviour and patterns of achievement.

With regard to our fourth question, of the two candidate parenting factors (that were related to both *national group* and the *rating threshold ratio*), it was the child behaviour-related parenting stress that was most strongly and specifically related to cross-national variations in rating thresholds. Statistically, parenting stress fully mediated the association between national grouping and the threshold. Given the design of the current study, we cannot, of course, examine the causal direction of the stress-threshold relationships. It is possible that variations in stress drive threshold levels or that variations in threshold levels drive stress. It is also possible that there is a reciprocal and transactional relationship between stress and the threshold—with strict thresholds driving stress and then stress exacerbating the strict thresholds further. It is also possible that stress is simply a marker of a more general sense of cultural pressure for high standards of behaviour. Longitudinal studies need to be conducted to explore these different explanations.

There are a number of potential clinical implications of our findings. First, it seems that as suggested, similarities in the estimates of ADHD diagnoses observed across different regions and cultures do mask marked differences in actual levels of children's ADHD behaviour—at least regard HK and UK. This raises important and thorny conceptual and practical questions. Are children in some nations/cultures with comparatively low levels of actual activity being rated as symptomatic when they shouldn't be, or that in other nations children who should be being identified as symptomatic are being ignored? Should we impose a universal threshold based on actual behaviour or should the level of behaviour considered symptomatic be left to vary from culture-to-culture—if so, where should those cultural boundaries be drawn? The most obvious answer to these questions is that rating thresholds should be set to reflect levels of activity that are associated with impairment and/or a poor prognosis, and studies of rating thresholds need to be grounded in measurement of these constructs. However, this does not fully solve the problem of the cultural relativity of ADHD symptom endorsements but rather pushes the problem to the next level—as the notion of what constitutes impairment and poor prognosis are also culturally determined. Second, the finding of elevated stress in HK parents is of concern given that we know from previous research that stress can manifest as parental mental ill-health and also increase the risk for child maltreatment. Interventions need to be developed that are culturally adapted to address the problem of parenting stress in HK.

This study provided the strongest evidence to date that parents in HK operate different rating thresholds when endorsing ADHD symptoms when compared to the UK. It also provided some of the first direct evidence that these effects are accounted for by differences in parenting stress. It had many strengths. However, there were also a number of limitations. First, the current study was limited to preschool children. The effects may not extend to other developmental periods. Second, parents did not rate their children's behaviours during the specific episode of task performance when their activity level was being recorded, but rather gave more general ratings on children's behaviours over the last 3 months. However, the recorded activity was strongly correlated with those general ratings—including those for inattention, suggesting that activity during the testing sessions were representative of the child's activity more generally. Third, there was no direct measure of inattention. It therefore remains unclear whether the findings with regard to hyperactivity generalise to less obtrusive behaviours such as inattention. On the one hand, it is possible that the less obtrusive behaviours may trigger less marked parental reactions. On the other, they may be more strongly related to educational achievement and thus associated with an even lower threshold in HK given the importance of academic achievement. Fourth, there was a potential selection bias of participants in this study, with more UK parents having completed tertiary education than their HK counterparts. However, there was no association between education level and rating threshold ratio scores. Finally, as expected, the UK group had a more diverse ethnic composition, with around one quarter of the sample being of black or Asian ethnicity. Interestingly, thresholds did not differ significantly between these participants ($F = 0.33$, $p = 0.723$) though within-ethnic-group variance (in the UK sample) was particularly high in the White and Black/mixed ethnic groups, whereas the variance in Asian group was similar to the HK participants (see Table S2 in Supporting Information). It is possible that the broader range of sensitivity within the UK group was due to the different parenting philosophies expressed in different ethnic groups. This raises interesting issues of migration and enculturation for future studies.

In summary, we found strong evidence that parents in HK and UK adopt different thresholds when endorsing ADHD symptoms based on their children's activity levels, with these national differences linked to cultural differences in parental stress related to their child's behaviour. This confirms the notion that national similarities in ADHD symptom endorsement and diagnostic rates mask, at least in this case, substantial differences in actual ADHD-related behaviour.

AUTHOR CONTRIBUTIONS

Wendy W. Y. Chan: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing. **Kathy Kar-man Shum:** Resources, Supervision, Writing – review & editing. **Edmund J. S. Sonuga-Barke:** Conceptualization, Methodology, Resources, Supervision, Writing – review & editing.

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CONFLICT OF INTEREST

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request (Edmund J. S. Sonuga-Barke).

ETHICS STATEMENT

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. This study was reviewed and approved by Research Ethics Committee of the University of Hong Kong (EA1812027) and King's College London (HR-18/19-8506).

ORCID

Wendy W. Y. Chan https://orcid.org/0000-0003-2097-9298
Kathy Kar-man Shum https://orcid.org/0000-0003-4340-3160
Edmund J. S. Sonuga-Barke https://orcid.org/0000-0002-6996-3935

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Supplementary information

Table S1. Educational level and ethnic group differences in symptom scores and parenting measures

	Educational level difference	Ethnic group difference (UK sample)
Parent ratings on child ADHD symptoms		
Hyperactivity/impulsivity	$F^{a} = .07$, $p = .786$	$F^{c} = 1.19$, $p = .311$
Inattention	$F^{a} = .97$, $p = .328$	$F^{c} = .71$, $p = .498$
Rating threshold ratio	$F^{b} = .32$, $p = .573$	$F^{d} = .33$, $p = .723$
Parenting style		
Authoritarian	$F^{a} = .56$, $p = .454$	$F^{c} = .23$, $p = .795$
Authoritative	$F^{a} = .33$, $p = .567$	$F^{c} = 3.28$, $p = .045$
Permissive	$F^{a} = .01$, $p = .940$	$F^{c} = .42$, $p = .657$
Parenting stress		
Parental Distress	$F^{a} = .76$, $p = .384$	$F^{c} = .50$, $p = .608$
Parent-Child Dysfunctional Interaction	$F^{a} = .57$, $p = .451$	$F^{c} = 1.41$, $p = .254$
Difficult Child	$F^{a} = .08$, $p = .785$	$F^{c} = 1.05$, $p = .356$
ADHD-specific emotional response		
Inattention	$F^{a} = .03$, $p = .861$	$F^{c} = .57$, $p = .569$
Hyperactivity/ impulsivity	$F^{a} = .18$, $p = .672$	$F^{c} = 1.14$, $p = .329$

Note. The *df* of variables for *t* statistics are $a = 110$, $b = 100$, $c = 52$, $d = 44$ respectively.

Table S2. Mean and standard deviation of rating threshold ratios across ethnic groups

	UK			HK
	White	Asian	Black/mixed	Asian
Rating threshold ratio – mean (SD)	21.95 (22.95)	17.10 (5.54)	26.79 (22.17)	13.74 (6.88)

Chapter 5 Attention-deficit/hyperactivity disorder (ADHD) in cultural context II: A comparison of the links between ADHD and waiting-related responses in Hong Kong and UK

Chapter 4 compared the association between parent-rated ADHD symptoms and children's measured activity in HK and UK. In Chapter 5, we build on the work and extend the cross-cultural comparison to test the delay aversion hypothesis – whether there is a significant linkage between parent-rated ADHD symptoms and children's performances and reactions in different waiting situations, and if so, whether this association is culturally invariant. The findings in this chapter supported a positive relationship between levels of ADHD symptoms and maladaptive waiting-related responses. In the following chapter, we further explore the socio-developmental origins of delay aversion by examining how parental reactions during waiting affect children's delay aversion and ADHD symptom levels over time.

Chapter 5 can be read as an individual study as well as a part of this whole work exploring the relationship between ADHD, delay aversion and waiting-related behaviours in a cultural context.

5.1 Summary

The concept of ADHD was considered to have cross cultural validity. However, direct comparisons of the psychological characteristics of ADHD in different cultural settings are currently lacking. In this chapter, we asked whether preschool children's ADHD symptoms, expressed in two cultures with different views on child behaviour and parenting, HK and the UK, showed the same pattern of associations with their waiting-related abilities and reactions, an important marker of early self-regulation. We also explored whether children's initial waiting-related abilities (T1) could independently predict their delay aversion and ADHD symptom levels one year later (T2) in both national groups.

At T1, the 112 UK and Hong Kong participants (mean age = 46.22 months) completed three tasks measuring different waiting elements – *waiting for rewards, choosing the amount of time to wait,* and *having to wait unexpectedly when a task is interrupted.* Waiting-related behavioural and emotional reactions were coded. Parents rated their children's symptoms and levels of delay aversion at both T1 and T2.

Compared to those in HK, UK children were rated by parents as having lower levels of ADHD symptoms but more intense negative or maladaptive responses during waiting. However, associations between ADHD symptoms and waiting-related responses were present, to a similar degree, in the UK and HK samples. Moreover, multiple regression analyses showed that children's negative responses during waiting at T1 significantly predicted their ADHD symptom ratings at T2, after controlling for their T1 ratings. The interaction terms between national group and waiting-related responses were not significant. Our findings support the cultural invariance of the psychological nature of ADHD with regard to its association with waiting behaviours. Future studies should extend this sort of analysis to other psychological domains and cultures.

Keywords: Waiting; Attention-deficit/hyperactivity disorder (ADHD); Delay aversion; Pre-schoolers, Self-regulation; Cross-cultural differences.

5.2 Introduction

5.2.1 Does ADHD have the same clinical meaning across cultures?

ADHD is a persistent neurodevelopmental condition characterized by age inappropriate and impairing levels of inattentiveness and/or impulsiveness/hyperactivity (American Psychiatric Association, 2013; Posner et al., 2020). ADHD is generally considered to be manifested in similar ways and to similar degrees in different cultures (Bauermeister et al., 2010; Davis et al., 2011; Rohde et al., 2005). Indeed, meta-analyses have shown that ADHD prevalence is similar across a wide range of cultural contexts and national groupings (Polanczyk et al., 2007; Polanczyk et al., 2015). However, judgements about what level of behaviour constitutes a symptom, and therefore, who meets criteria for a diagnosis, vary considerably from one culture to another depending on adults' sensitivity to children's ADHD behaviours and standards of expected conduct (Canino & Alegría, 2008; MacDonald et al., 2019; Thompson et al., 2017; Weisz et al., 1988). A recent cross-cultural comparison of parents' ratings of ADHD against objective measures of activity in Hong Kong and the UK – cultures that the literature suggests differ greatly in their child-related expectations and perceptions — found that although UK children had greater objectively measured activity levels, HK children were rated as having higher level of ADHD symptoms (Chan et al., 2022). This suggests a degree of cultural relativity in terms of ADHD-rating thresholds – though whether these cultural differences impact the clinical meaning of the diagnosis was not tested, leaving open the possibility that lower levels of activity could be of greater clinical significance in HK than the UK.

In the current study, we extend this analysis of the cross-cultural meaning of ADHD symptoms in HK and the UK by studying their psychological correlates. This is important as the cross-national application of the ADHD construct, especially extending outside of western societies, makes the tacit assumption that it is underpinned by the same factors and mediating psychological processes in different cultural settings. Indirect comparisons of studies of ADHD neuropsychological correlates in Eastern and Western cultures supports this view. For instance, studies of ADHD and executive function conducted in Asian countries find similar ADHD-related deficits on working memory, self-control, planning and attention shifts tasks (Chan et al., 2006; Gau et al., 2009; Li et al., 2005; Yang et al., 2011) as shown in meta-analyses of Western-based studies (Martinussen et al., 2005; Willcutt et al., 2005). However, this assumption of cultural invariance has rarely been tested through direct cross-cultural comparison.

5.2.2 Relationship between ADHD symptom levels and the ability to wait

In this chapter, we test the assumption of cultural invariance with regard to the ability of preschool children to wait for future events and outcomes; an important early marker of a child's capacity to manage his/her behaviour and emotional expressions with respect to long-term consequences, rewards and/or social standards (Hongwanishkul et al., 2005; Mischel et al., 1988; Raghunathan et al., 2023; Wilson et al., 2009). This capacity typically starts to develop in the preschool years and continues to mature during childhood (Bell & Deater-Deckard, 2007; Blair, 2002; Brownell & Kopp, 2007; Cole et al., 2011; Montroy et al., 2016; Stansbury & Sigman, 2000). Early emerging individual differences in this capacity predict future socio-emotional development, academic achievement, mental well-being and self-efficacy (Cole et al., 2011; Eigsti et al., 2006; Eisenberg et al., 2010; Graziano et al., 2007; Mischel et al., 1988).

The delay aversion hypothesis suggested that symptoms of ADHD could be understood as a motivation to reduce or avoid the experience of delay when waiting for valued outcomes or important events (Sonuga-Barke, 1994, 2005; Sonuga-Barke et al.,1992a, 1992b). When delay is unavoidable, inattention and hyperactivity are perceived as ways to reduce the subjective experience of delay by speeding up the passage of time (Zakay, 1992; Zakay & Tsal, 1989). It has been consistently found that children with ADHD, relative to typically developing peers, exhibit greater difficulty in inhibiting their impulse when asked to wait for a 'forbidden' reward (Breaux et al., 2016; Pauli-Pott U & Becker, 2021). In addition, the level of participants' inattention and hyperactivity was found to increase as a function of delay duration (Bitsakou et al., 2006; Mies et al., 2018). These findings supported the hypothesis that individuals with ADHD were more sensitive to delay and had less optimal performance in waiting situations. Meta-analyses revealed medium-to-large sizes for these effects (Pauli-Pott U & Becker, 2021; Patros et al., 2016; Sonuga-Barke et al., 2008). This is also true in preschool populations (Dalen et al., 2004; Sonuga-Barke et al., 2003).

5.2.3 Cross-cultural differences in the ability to wait

Waiting-related responses and abilities are also likely to be shaped by cultural factors (Göllner et al., 2018; Mischel & Metzner, 1962; Silverman, 2003). For instance, motivated by Confucianism and collectivist ideology, self-regulation is highly valued in Eastern cultures. Adults, both parents and teachers, have high expectation for their children's behaviours (Chao, 1994; Chao, 1995; Leung et al., 2005). Children are trained to exercise self-discipline and self-regulation (Eisenberg et al., 2010; Hue, 2007; Lan et al., 2011; Ng & Rao, 2008; Phelps, 2005; Sun, 2015). In contrast, in Western cultures, adults are generally more relaxed about their children and show more acceptance of a broader range of conduct (Chen et al., 1998; Chen et al., 2003). These cultural differences between East and West seem especially relevant to the study of self-regulation (Canino & Alegría, 2008; Thompson et al., 2017; Weisz et al., 1988). Indeed, Asian children generally outperform their Western peers on behavioural inhibition and impulse control tasks involving waiting, across preschool-to-adolescence (Lan et al., 2011; Ellefson et al., 2017; Fujita et al., 2022; Sabbagh et al., 2006; Schirmbeck et al., 2020; Schmitt et al., 2019; Wang et al., 2016). In, what is to the best of our knowledge, the only cross-cultural study directly and specifically comparing children's waiting-related behaviours in Western and Eastern cultures, Ding et al. (2021) found that Chinese children were more able/willing to wait for larger-but-delayed rewards compared to British children. Interestingly, Chinese parents still rated their children as having poorer inhibition than parents in Sweden, Spain and Iran (Thorell et al., 2013) – perhaps supporting the notion that they have higher expectation for children's self-regulatory behaviours.

5.2.4 The current research

With regard to the focus of the current study it is striking that all research exploring the relationship between waiting and ADHD have been conducted in Western cultures. The aim of the current study was therefore to explore the cultural difference in the relationship between preschool ADHD symptoms and waiting-related performance and reactions through a direct comparison of children in HK and the UK. Based on prior findings and cultural differences in attitudes and values, we hypothesized that -

1. Children in the UK would display less adaptive waiting-related responses than children from HK.

2. Children with higher levels of ADHD symptoms would show less adaptive waiting-related performance (e.g. lower tendency to wait and a greater emotional negativity during waiting).
3. Children's waiting-related responses at T1 could independently predict their ADHD symptom ratings at T2, after controlling for their T1 ratings.
4. The associations between ADHD and waiting-related performance would be invariant across UK and HK settings.

Because waiting-related responses occur across a range of different settings and take a number of forms, we employed three tasks to measure different waiting elements and recorded outcomes in a number of different ways. The three tasks measured: *willingness/ability to wait for rewards, choosing the amount of time to wait,* and *frustration when having to wait unexpectedly when a task is interrupted*. In terms of outcomes, in addition to task performance, we looked at participants' waiting-related behavioural agitation (i.e., squirming and fidgeting) and negative emotional reactions (i.e., expression of frustrations).

5.3 Methods

5.3.1 Participants

At T1, 189 preschool children and their parents living in London UK (*n*=68; 51 % male) and HK (*n*=121; 58 % male) were recruited from nurseries/preschools and via social media adverts. Informed consent had been appropriately obtained. Based on the results of the screening questionnaire completed by teachers and parents, thirty children (n^{UK}=13 and n^{HK}=17) were excluded on the following criteria— outside the age range; with IQ below 80; with special educational needs and/or a diagnosis of a pervasive developmental disorder (e.g., autism spectrum disorder); teacher non-engagement; family not able to attend testing sessions. No participants had been formally diagnosed with ADHD and none was taking ADHD medications.

Children were screened for ADHD symptoms using the five-item hyperactivity/ inattention subscale of the *Strengths and Difficulties Questionnaire* completed by parents and teachers (SDQ, version T2-4; Goodman, 1997). In order to minimize differences in ADHD symptoms between the UK and HK samples so as to compare like with like across cultures, we oversampled participants and then excluded forty-seven based on the subscale scores so that the groups had similar mean symptom levels. The average subscale scores in the final UK and HK sample were not statistically different, $F(1, 110) = 2.33$, $p = .130$. Full data was available for 112 children ($n^{UK}=55$ and $n^{HK}=57$; females = 49 and males = 63; mean age = 46.20 months, *S.D.* = 5.73; range = 36.92–59.24).

Families were contacted for the T2 follow-up one year later; 79.5% of them completed the follow-up ($n^{UK}=39$ and $n^{HK}=50$; females = 42 and males = 47). Reasons for drop-out included moving abroad, time constraint and inability to get in touch with.

5.3.2 Measures

5.3.2.1 Screening measures

Inattentive and overactive behaviours screener: The parent and teacher versions of the *Strengths and Difficulties Questionnaire* (SDQ, version T2-4) are widely used psychometrically strong, brief screening questionnaire designed for research/clinical purposes (Goodman, 1997). The hyperactivity/inattention subscale consists of five items: two measuring inattention, two hyperactivity and one impulsivity. The original English language version was used in the UK. A validated Chinese translation was used in HK (Lai et al., 2010).

Intelligence: Children's IQ was estimated using the Block Design and Vocabulary subtests of *Wechsler Preschool and Primary Scale of Intelligence* (WPPSI-III; Wechsler, 2003). The WPPSI measures the cognitive ability of preschoolers and young children between 2 years 6 months and 7 years and 3 months. The English (UK) and Traditional Chinese language versions were used in the UK and HK respectively.

5.3.2.2 Waiting tasks

We employed three waiting tasks that tapped participant's performance and their behavioural and emotional reactions to different waiting situations. In each task, waiting-related behavioural agitation (i.e., squirming/fidgeting) and negative emotional reactions (i.e., frustration as indicated by frowning, sighing and pouting) were observed and coded by trained researchers (one in each university) using a 4-point scale with– 1="None/ Very rare - 0-10% of time", 2="A little - 11-25% of time"; 3="Quite a lot - 25-50% of time" and 4="A lot - >50% of time". Inter-rater reliability for the squirming/fidgeting and frustration codes was excellent at r = .98 and r =.95 respectively.

Willingness/ability to wait for rewards: An adapted version of the Cookie Delay Task (CDT) was developed to measure children's ability to delay gratification and to gauge their reactions during the waiting period (Golden et al., 1977; Campbell et al., 1994). The original task involved hiding an edible treat under one of the three containers and instructing participants to wait for a signal until they were allowed to retrieve it. In this study, as in other recent studies, attractive stickers were used instead of cookies. To make waiting more motivating, a bonus sticker will be rewarded to children if they manage to wait until the researcher presents the signal (clapping) before retrieving the sticker. This adapted version included eight trials with varying delay intervals between 5-sec and 40-sec. Children's willingness/ability to wait for rewards was reverse-coded based on their behaviour, with 2 = "not inhibited" (found and retrieved the reward before the signal); 1 = "partially inhibited" (touched the cup but did not take the reward); and 0 = "fully inhibited" (waited until the signal is given) (Sonuga-Barke et al., 2003). In this sample, Cronbach's α for the eight trials was .72 and test-retest reliability was .87.

Choosing the amount of time to wait: The Bee Delay Task (BDT) was designed by Markomichali (2015) to be developmentally appropriate for pre-schoolers to measure their waiting-related responses in terms of pre-emptively judging how long they would be able/willing to wait and then seeing if they did wait that long. Children were shown seven flowers on a computer screen and told that a bee would go to each flower to collect nectar. They were also told that they would earn one point (which could be exchanged for stickers afterwards) for each flower that the bee landed on. It was also explained to them that the bee would get tired with each flower it landed on, and it would take longer for it to fly to the next flower (i.e., the amount of delay between flowers would increase with a rate of 125% per flower). They were asked to choose the number of flowers they wanted their bee to visit before the trial started. Children were also told that they could press a button during a trial to stop the bee before their chosen number of flowers, if they preferred (i.e., to terminate the trial earlier). If they pressed it, the trial ended immediately, and they would get the points they had won up to then. There was a total of ten trials. Children's judgements about how long they would wait were indicated by the discrepancy between the number of flowers/waiting time chosen and the number of flowers/waiting time they actually experienced before they stopped the trial. In this sample, Cronbach's α for the ten trials was .99 and test-retest reliability was .88.

Having to wait unexpectedly when a task is interrupted: The computerized Preschool Delay Frustration Task (P-DeFT) is a preschool version of a task created by Bitsakou et al. (2006) to measure children's behavioural and affective expressions of frustration when a continuous presentation of a reinforced task is unexpectedly interrupted (Bitsakou et al., 2006; Bitsakou et al., 2009). The P-DeFT was designed to be a simple and enjoyable "shopping" game. In each trial of the game, participants were first shown a red *Wait* signal and then asked to complete a two-stage task – (1) press a "crossing" button to change the *Wait* signal to a green *Go-signal* then (2) visit a "toy supermarket" and get a target object as shown by the experimenter. The only rule of the game for participants was to wait for the red signal to turn green before proceeding to find the item. There was a total of 18 trials. In the majority of trials (n = 12), the *Go-signal* was shown immediately after the child pressed the crossing button (i.e. no *pre-Go-signal* delay). In six trials, presented in a pseudo-random order, a *pre-Go signal waiting period* (either 5-secs or 10-secs; three trials each) was unexpectedly imposed. Participants were not informed beforehand about the presence of these extra delay periods but were told that the crossing button was rather old and might occasionally be a bit slow to work. The P-DeFT task performance scores comprised two areas: as discussed in Chapter 3, participants' frustration levels are deemed demonstrated by both the amount of button presses per second during the *pre-Go-signal* waiting period and by the amount of activity displayed in *post-delay* shopping task. *Post-delay* activity was measured by an unobtrusive wrist-worn tri-axial actigraph unit accelerometer, which measured the g-force (g) at 6.5Hz over and provided an average g per 1 second epoch. In this sample, Cronbach's α for the six trials was .88 for duration of presses and .91 for post-delay activity.

5.3.2.3 Rating scales

ADHD symptom rating: Parents rated their children on the 18 DSM-IV ADHD symptoms at two timepoints using the ADHD Rating Scale IV Preschool Version (ADHD-RS-IV-P; McGoey et al., 2007). Informants rate the frequency of occurrence of the described symptom using a 4-point scale: 0="Never or rarely", 1="Sometimes", 2="Often" and 3="Very often". A total score can be computed by adding scores of all the items. The cut-off point of the 80th percentile was indicated as 19 in the published norm for the ADHD-RS-IV-P (McGoey et al., 2007). In this sample, Cronbach's α for the full scale was .91 and test-retest reliability was .84.

Delay aversion rating: Parents rated their children's delay aversion at two timepoints using a 10-item Quick Delay Questionnaire (QDQ). The QDQ was originally designed to measure adults' self-reported delay related behaviours (Clare et al., 2010). It was adapted to be used to evaluate pre-schoolers' delay aversion and related difficulties by teachers or parents (Markomichali, 2015). The ten items (e.g. "Hates waiting for things", "Often gives up on things he or she can't have immediately") were rated against a 5-point Likert scale from 1="Not at all like him/her" to 5="Very much like him/her". The scale has high internal consistency (α = .84) and good test-retest reliability (r = .75).

5.3.3 Data Analysis

Preparatory analyses: A small proportion of the CDT (3%), BDT (6%) and P-DeFT (1%) programme data and actometer reading data (4%) were missing due to technical issue and participants' withdrawal from particular tasks. Where data were missing, we used pairwise deletion to optimize data availability. Presented as a supplementary information (**Table 5-9**), participants were divided into *low* and *high* rated ADHD symptoms group based on the 80th percentile cut-off (i.e. rating raw score ≤ 19 vs > 19) and we ran analysis of variance (ANOVA) to explore the effect of symptom groups on participants' waiting task performance and responses and their rated levels of ADHD symptoms and delay aversion at T1 and T2. These analyses provided additional information using a different approach, while the core analyses examined relationship between constructs with ADHD conceptualized as a continuum rather than a dichotomous variable.

To facilitate data reduction, we first explored the correlations between task performance and behavioural and emotional reactions across the three tasks and conducted exploratory factor analyses to see if we could reduce the number of factors to minimize multiple testing. After analysing and comparing the demographic characteristics of the UK and HK samples, we then examined if there were age, sex, IQ and family income effects on the delay aversion ratings and waiting-related measures using ANOVA, chi-square test and correlational analyses. Corrections for multiple testing were made using Bonferroni formula. Confounding variables, if any, were controlled for in the subsequent analyses.

Core analyses: Correlation analyses were first used to examine the cross-sectional relationship between participants' ADHD symptom levels, delay aversion ratings, waiting task performance and waiting-related reactions. Multiple regression analyses were then conducted to explore if participants' waiting-related responses at T1 could significantly predict their ADHD symptom and delay aversion ratings at T2, while controlling for their T1 ratings. Series of ANOVAs were conducted to explore if there were any significant differences between UK and HK participants on their delay aversion rating and waiting task performance and reactions. We then compared the coefficients of the correlation between ADHD symptoms, delay aversion and waiting-related responses in the UK and HK samples using Fisher's Z-transformation.

PROCESS macro test of moderation (model 1, 5000 bootstrap samples) was subsequently conducted to confirm whether the relationship between waiting-related measures at T1 and ADHD symptom/ delay aversion ratings at T2, with baseline T1 ratings being controlled for, was moderated by national group.

5.4 Results

5.4.1 Descriptive statistics

Table 5-1 presents the demographic characteristics of participants in UK and HK. The two national groups did not differ significantly in age, sex ratio, IQ and family household income.

Table 5-1 Demographic characteristics of participants in UK and HK

	UK (*n* = 55)	**HK** (*n* = 57)	Statistical comparison
Participant characteristics			
Age (months) – mean (SD)	46.55 (6.49)	45.86 (4.91)	$F(1, 110) = .41$, $p = .526$
Female – *n* (%)	25 (45.45)	24 (42.11)	$\chi^2(1) = .13$, $p = .721$
IQ – mean (SD)	108.72 (12.20)	105.26 (10.69)	$F(1, 109) = 2.53$, $p = .114$
Monthly household income – *n* (%)			
Below £2000	4 (7.27)	6 (10.53)	$\chi^2(3) = 5.33$, $p = .149$
£2000-2999	1 (1.82)	7 (12.28)	
£3000-3999	8 (14.55)	8 (14.04)	
Above £4000	42 (76.36)	36 (63.16)	

5.4.2 Data reduction

Table 5-2 shows the intercorrelations between the waiting-related measures from the three tasks. Within tasks, there were positive correlations between waiting task performance, waiting-related behavioural agitation–and negative affect - BDT: *rs* $\geq$ .20, *ps* $\leq$ .038; CDT: *rs* $\geq$ .44, *ps* < .001; P-DeFT: *rs* $\geq$ .36, *ps* < .001).

Between tasks, performance scores on the BDT, CDT and P-DeFT were positively correlated (*r*s $\geq$ .17; *p*s $\leq$ .080). Factor analyses supported a single latent factor for these three variables which explained 48.6% of the variance. This factor was termed *waiting task performance*.

Meanwhile, the observed waiting-related behavioural agitation and negative affect from the three tasks were positively correlated with each other (*r*s $\geq$ .31, *p*s $\leq$ .001 and *r*s $\geq$ .44, *p*s < .001 respectively). Factor analyses supported a single latent factor for all these six reaction codes which explained 54.5% of the variance. This factor was termed *waiting-related behaviours and reactions*.

Table 5-2 Intercorrelations between waiting task performance, observed waiting-related behavioural agitation and negative affect

			1	2	3	4	5	6	7	8
1		BDT								
2	Waiting task performance	CDT	.25*							
3		P-DeFT	.27*	.17						
4		BDT	.22	.25*	.33**					
5	Waiting-related behavioural agitation	CDT	.32*	.44**	.54**	.47**				
6		P-DeFT	.34**	.36**	.49**	.31*	.60**			
7		BDT	.20	.21	.17	.43**	.50**	.31*		
8	Waiting-related negative affect	CDT	.17	.46**	.35**	.39**	.55**	.37**	.44**	
9		P-DeFT	.28*	.36**	.36**	.49**	.50**	.42**	.54**	.54**

Note: BDT = Bee Delay Task; CDT = Cookie Delay Task; P-DeFT = Preschool Delay Frustration Task. * $p < .02$; ** $p < .001$ (adjusted p values based on Bonferroni correction).

5.4.3 Covariates

Table 5-3 presents the intercorrelations between IQ, age, parent-rated ADHD symptoms and delay aversion and the two waiting-related factors. Participants' IQ and age were not significantly associated with the ratings, the waiting task performance and the waiting-related behaviours and reactions ($rs \leq .23$, $ps \geq .020$) – these were therefore not included as covariates in subsequent analyses.

Table 5-4 shows the analyses testing the sex and household income group differences in ratings and waiting-related factors. There were no significant differences in these measures between male and female participants ($Fs \leq 2.54$, $ps \geq .114$), as well as families in different household income groups ($Fs \leq 1.33$, $ps \geq .270$).

Table 5-3 Correlations between IQ, age, ADHD and delay aversion ratings and waiting task measures

		IQ	Age
1	ADHD symptom ratings	-.21	-.08
2	Delay aversion ratings	-.15	.08
3	Waiting task performance	-.21	-.23
4	Waiting-related behaviours and reactions	.00	-.03

Note: * $p < .01$; ** $p < .001$ (adjusted *p* values based on Bonferroni correction).

Table 5-4 Sex and household income group differences in ADHD and delay aversion ratings and waiting task measures

		Sex difference	Household income difference
1	ADHD symptom ratings	$F^{a} = 2.26$, $p = .135$	$F^{c} = .75$, $p = .522$
2	Delay aversion ratings	$F^{a} = 2.54$, $p = .114$	$F^{c} = .30$, $p = .825$
3	Waiting task performance	$F^{b} = 1.59$, $p = .210$	$F^{d} = 1.33$, $p = .270$
4	Waiting-related behaviours and reactions	$F^{b} = .42$, $p = .519$	$F^{d} = .82$, $p = .484$

Note. The *df* of variables for *t* statistics are *a* = (1, 110); *b* = (1, 100); *c* = (3, 108); *d* = (3, 98) respectively.

5.4.4 Association between ADHD symptom levels, delay aversion and waiting-related responses

Table 5-5 shows that the cross-sectional correlations between participants' ADHD symptom levels, delay aversion ratings and waiting-related responses were significant. The effect sizes of the correlation between the two ratings and waiting-related measures were medium ($rs \geq .30$, $p \leq .002$), while the correlation between ADHD symptom and delay aversion ratings was strong ($r = .63$, $p < .001$).

Table 5-6 shows the multiple regression analyses with participants' T1 waiting-related responses as predictors and their T2 ADHD symptom and delay aversion ratings as the outcome variables, while controlling for their T1 ratings. The T1 variables significant predicted T2 ADHD symptom ratings, $F(4, 78) = 34.71$, $p < .001$, $R^2 = .640$. While T1 ADHD ratings, as expected, remained the strongest predictor, participants' waiting task performance at T1 also significantly and independently predicted their T2 ADHD symptom ratings one year later ($\beta = .19$, $t = 2.22$, $p = .030$). Similarly, the T1 variables also significant predicted T2 delay aversion ratings, $F(4, 78) = 16.28$, $p < .001$, $R^2 = .455$, with participants' T1 delay aversion and waiting-related responses as significant predictors.

Table 5-5 Correlations between ADHD symptom levels, delay aversion and waiting-related responses

		1			2			3		
		Whole	UK	HK	Whole	UK	HK	Whole	UK	HK
1	ADHD symptom ratings									
2	Delay aversion ratings	.63**	.72**	.55**						
3	Waiting task performance	.38**	.33	.51**	.37**	.32	.47**			
4	Waiting-related behaviours and reactions	.30*	.42*	.50**	.38**	.46**	.46**	.62**	.69**	.55**

Note: * $p < .01$; ** $p < .001$ (adjusted p values based on Bonferroni correction).

Table 5-6 Regression models of participants' parent-rated ADHD symptoms/ delay aversion ratings at T2, with their waiting task performance and responses at T1 as predictors, controlling for ADHD symptoms and delay aversion at T1

		Outcome variables at T2			
		ADHD symptoms		Delay aversion	
Predictors (T1)		β	t	β	t
1	ADHD symptom ratings	.59	7.14**	.11	1.11
2	Delay aversion ratings	.07	.86	.38	3.56**
3	Waiting task performance	.19	2.22*	.15	1.36
4	Waiting-related behaviours and reactions	.15	1.72	.23	2.11*
	R^2	.64		.46	
	F	34.71**		16.28**	

Note. * $p < .05$; ** $p < .001$.

5.4.5 Cross-cultural differences in ADHD symptom levels, delay aversion and waiting-related responses and their relationship

Table 5-7 compares the UK and HK participants' ADHD symptom and delay aversion ratings as well as their waiting-related performance and reactions. HK children were rated by their parents as having significantly higher levels of ADHD symptoms than UK children, UK children however showed significantly more intense waiting-related behaviours and reactions than HK children.

Split-sample cross-sectional correlational analyses were conducted (**Table 5-5**), and the correlation coefficients between ADHD symptom levels, delay aversion and waiting-related responses in the two samples were compared using Fisher's *Z*-transformation. The *Z*-tests showed that there were no significant differences between the correlation coefficients in the UK and HK samples ($Zs \leq 1.51$, $p \geq .131$). Despite the national group differences in ADHD symptom ratings and waiting-related behaviours and reactions, there was cultural invariance in the associations between ADHD symptom levels and waiting-related responses. Further, PROCESS macro test of moderation controlling for T1 ratings showed that the prediction of T2 ADHD symptoms/ delay aversion ratings from T1 waiting-related responses were not significantly moderated by national group. **Table 5-8** showed the interaction effects between national group and T1 waiting task measures on participants' ADHD symptoms/ delay aversion ratings at T2 and all of them were not significant ($ts \leq 1.07$, $ps \geq .287$).

Table 5-7 Main effects of national group on ADHD symptom levels, delay aversion and waiting-related responses

		UK			HK			Statistical comparison		
		M	S.D.	*n*	*M*	S.D.	*n*	*F*	*p*	η^2
1	T1 ADHD symptom ratings	19.13	9.05	55	23.33	9.68	57	5.64	.019	.05
2	T1 Delay aversion ratings	-.09	1.17	55	.08	.80	57	.78	.378	.01
3	T1 Waiting task performance	.03	1.20	47	-.02	.80	55	.06	.804	.00
4	T1 Waiting-related behaviours and reactions	.31	1.21	47	-.27	.69	55	9.06	.003	.08
5	T2 ADHD symptom ratings	17.60	7.96	39	21.52	7.78	50	5.48	.021	.06
6	T2 Delay aversion ratings	2.74	.54	39	2.87	.46	50	1.50	.224	.02

Table 5-8 Interaction effects of national group and T1 waiting-related responses on T2 ADHD symptom/ delay aversion ratings

Prediction of T2 ADHD symptoms:		Unstandardized coefficients	Standard error	Statistics	Sig. level	95% Bootstrapping Confidence Interval	
		B	*SE*	*t*	*p*	LLCI	ULCI
1	National group x waiting task performance	.31	1.16	.27	.790	-1.99	2.61
2	National group x waiting-related behaviours and reactions	1.32	1.24	1.07	.287	-1.14	3.78

Prediction of T2 delay aversion:		Unstandardized coefficients	Standard error	Statistics	Sig. level	95% Bootstrapping Confidence Interval	
		B	*SE*	*t*	*p*	LLCI	ULCI
1	National group x waiting task performance	-.06	.09	-.71	.480	-.23	.11
2	National group x waiting-related behaviours and reactions	-.05	.09	-.53	.599	-.23	.13

Note. LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.

5.5 Discussion

5.5.1 Summary of main findings

The current research is the first study to examine the assumption of cultural invariance, between HK and UK populations, in the association between ADHD symptoms and waiting-related responses. There were a number of findings of note.

5.5.1.1 Cultural difference in waiting-related responses

First, our findings supported the hypothesis that UK and HK children behaved differently in situations that involved waiting. UK children were observed to have more intensive negative reactions, behaviourally and emotionally, during the waiting tasks. However, HK children were rated by their parents as showing more ADHD symptoms than their UK counterparts. This cultural discordance between ADHD ratings and measured behaviour is consistent with a recent finding that showed that UK and HK parents operate different ADHD symptom endorsement thresholds, with the former having a higher rating threshold – more ADHD related activity was required before a symptom is recognised (Chan et al., 2022). Social norms in HK culture that emphasize the importance of self-control and restraint of emotional expressions could contribute to these effects.

5.5.1.2 Cross-sectional and longitudinal relationship between waiting-related responses and ADHD symptom levels

Second, there were medium to strong cross-sectional associations between ADHD symptom ratings and the two aggregated waiting-related measures. These findings are consistent with previous research where children with elevated ADHD symptom levels had a higher tendency to retrieve a ‘forbidden’ reward before the waiting was over (Pauli-Pott & Becker, 2021); and exhibited more intense waiting-related behavioural and emotional responses (Bitsakou et al., 2006; Bitsakou et al., 2009; Antrop et al., 2000; Mies et al., 2018; Van Dessel et al., 2018). In addition, regression analyses showed that participants’ waiting-related responses at T1 significantly predicted their ADHD symptoms and delay sensitivity ratings at T2, even after controlling for their baseline ratings at T1. The current findings are consistent with the delay aversion hypothesis that individuals with ADHD find pre-reward delay emotionally aversive thus would take actions to avoid or escape from it if possible (Sonuga-Barke et al., 1992a, 1992b; Sonuga-Barke, 1994), and the significant prediction of T2 ADHD ratings suggests that the negative waiting-related affect may in turn exacerbate children’s hyperactivity and inattentive behaviours over time.

5.5.1.3 Cultural invariance in the relationship between ADHD symptom levels and waiting-related responses

Third, despite the HK and UK differences, the associations between ADHD symptoms, delay aversion and waiting-related responses were not moderated by national group. This suggests that within each country, ADHD symptoms are correlated with waiting-related performance and responses in a similar way – that, in this regard, ADHD symptoms have the same neuropsychological signature across cultures. This is important because in both countries these associations could provide a focus for early identification and prevention efforts.

5.5.2 Strengths and clinical implications

The current study had a number of strengths including the use of multiple direct measures of waiting-related performance and responses and the relatively large sample in two cultures. Although the nature of the waiting required in the three tasks is different, the performance and responses on these tasks were intercorrelated, which is consistent with prior studies (Bitsakou et al., 2009; Mies et al., 2018; Van Dessel et al., 2018; Chronaki et al., 2019). There are a number of potential clinical implications of our findings. First, the between-nation difference found in the parent ratings and waiting-related responses suggests the need to apply a different cultural threshold when conceptualizing and assessing early waiting-related difficulties, while at the same time recognizing that common processes appear to drive the relationship between ADHD ratings and waiting-related responses in both cultures.

Second, this cultural invariance in the prediction of T2 ADHD symptoms from T1 waiting-related responses may provide insights for early intervention efforts – enhancing children's ability to deal with waiting and its associated frustration by, for instance, teaching them self-directed speech and distraction techniques may lower their level of ADHD symptoms (Feldman et al., 2011).

Third, the present findings showed that ADHD symptoms significantly correlated with the preschool children's waiting task performance and reactions. Whether preschoolers' waiting-related responses are predictors of future impairment and ADHD diagnosis requires longitudinal studies to verify, but the results in this study preliminarily highlight the potential value of measuring individuals' emotional and behavioural reactions to waiting in future research of waiting, executive control and delay aversion.

5.5.3 Limitations and future directions

However, there were also limitations. First, this study lacked a non-waiting task that allows us to measure and compare UK and HK children's behavioural and emotional reactions in situations without delay. Further testing is needed to explore whether UK children are more emotionally expressive generally or only specifically in the presence of waiting-induced frustration. Second, there was a lack of individuals with very clinical levels of ADHD which reduced the power to explore associations between ADHD symptoms, delay aversion and waiting task responses in the clinical range. These should be included in future studies.

5.5.4 Conclusion

In summary, parent ratings of ADHD symptoms were associated with preschoolers waiting-related performance, negative emotions and behavioural agitation in both HK and the UK. The results highlight the cultural invariance in the neuropsychological correlates of ADHD in the aspects of waiting, despite the between-nation differences in rating threshold and waiting-related responses in absolute terms.

Table 5-9 Symptom level group differences in children's age, IQ, T1 measures and T2 ADHD symptom/ delay aversion ratings

			ADHD symptoms level						Statistical comparison		
			Low			High					
			Mean	SD	Range	Mean	SD	Range	*F*	*p*	η^2_p
T1		*N*	52			60					
		Age	46.28	5.23	36.92-58.55	46.13	6.17	37.22-59.24	.02	.894	.00
		IQ	108.33	10.54	88.00-132.00	105.77	12.27	82.00-132.00	1.37	.244	.01
	RTG	Parent-rated ADHD									
		Parent-rated QDQ	2.63	.52	1.40-4.00	3.11	.57	2.10-4.80	21.34	<.001	.16
	CDT	Performance	.11	.16	.00-.75	.21	.32	.00-1.50	4.17	.044	.04
		Activity measured	117.83	35.52	54.11-188.80	139.23	40.45	63.22-267.24	8.36	.005	.07
		Behavioural agitation	2.32	.84	1.13-4.00	2.78	.85	1.38-4.00	8.22	.005	.07
		Negative affect	1.09	.21	1.00-2.00	1.22	.30	1.00-2.00	7.19	.009	.06
	BDT	Performance	.15	.18	.00-.68	.24	.23	.00-.78	4.14	.045	.04
		Activity measured	93.92	41.24	25.45-227.16	106.67	49.69	46.99-340.97	1.92	.169	.02
		Behavioural agitation	2.58	.96	1.00-4.00	2.79	.91	1.00-4.00	1.21	.274	.01
		Negative affect	1.23	.47	1.00-3.00	1.39	.73	1.00-4.00	1.77	.186	.02
	P-DeFT	Performance	-.23	.96	-1.73-2.56	.19	1.00	-1.61-3.30	4.83	.030	.04
		Activity measured	135.05	55.94	40.39-270.26	164.31	50.95	74.93-346.20	8.08	.005	.07
		Behavioural agitation	1.94	.86	1.00-4.00	2.40	.92	1.00-4.00	7.57	.007	.06
		Negative affect	1.36	.48	1.00-2.67	1.58	.65	1.00-4.00	4.08	.046	.04
	PC	Performance	3.42	3.83	.27-18.04	3.73	3.25	.22-19.87	.20	.657	.00

		Activity measured	154.28	71.20	35.29-332.51	175.37	61.52	77.40-365.55	2.60	.110	.03
		Behavioural agitation	2.33	1.00	1.00-4.00	2.85	.81	1.17-4.00	8.60	.004	.08
		Negative affect	1.41	.54	1.00-3.00	1.74	.67	1.00-3.67	7.31	.008	.07
		Free play activity	204.53	47.71	108.74-319.58	196.31	42.25	71.93-302.28	.89	.347	.01
		Clean-up activity	211.60	69.12	117.73-401.40	227.02	52.23	111.12-338.17	1.63	.205	.02
T2		*N*	39			50					
	RTG	Parent-rated ADHD	14.56	6.38	2.00-34.00	23.88	6.79	6.00-35.00	43.46	<.001	.33
	RTG	Parent-rated QDQ	2.61	.46	1.70-4.10	2.97	.47	1.80-4.20	13.32	<.001	.13

Note: RTG = Ratings; BDT = Bee Delay Task; CDT = Cookie Delay Task; P-DeFT = Preschool Delay Frustration Task

Chapter 6 Parenting influences on pre-schoolers' attention-deficit/hyperactivity disorder symptom levels: A longitudinal study of the impact of their reactions to children's behaviour during waiting.

Chapter 5 showed the significant relationships between ADHD symptoms and children's waiting-related responses, supporting the delay aversion hypothesis. Chapter 6 presents further how we test the developmental origins of delay aversion and explore how parental and contextual effects exacerbate children's delay aversion and ADHD symptom levels over time. We also examine if parents from different cultures who vary in their parental expectation and perceptions of ADHD-related behaviours would differ in their reactions during waiting and whether there would be cultural invariance in its relationship to children's development of delay aversion and ADHD. Chapter 6 introduces the first longitudinal and cross-cultural findings that demonstrate how parents and children shape each other in their waiting-related behaviours.

Chapter 6 can be read as an individual study as well as a part of this whole work exploring the relationship between ADHD, delay aversion and waiting-related behaviours in a cultural context.

6.1 Summary

Attention-deficit/hyperactivity disorder (ADHD), a common neurodevelopmental condition, has been generally believed to be the result of deep-seated fixed deficits in cognitive processes

of bio-genetic origin. An alternative motivational hypothesis of the origins of ADHD was proposed by Sonuga-Barke (2005). First, he argued that ADHD during childhood could be exacerbated by the emergence of what he termed delay aversion - a motivation to reduce or avoid the exposure or experience of delay expressed through patterns of impulsiveness, overactivity and inattention. Second, he hypothesized that this delay aversion could develop overtime through a process of social conditioning when a child's behaviour during delay evokes, and comes to be associated with, the experience of negative affect associated with harsh or critical reactions by others, including parents. In this chapter we conducted a longitudinal study using the recently developed Parent-Child Delay Frustration Task (PC-DeFT) to test the prediction derived from this hypothesis that negative parental reactions at one point in development are associated with increases in ADHD symptoms one year, or so, later and whether these changes were mediated by delay aversion.

A community sample of 112 pre-schoolers (mean-age = 46.22 months) and their parents, recruited in London, UK, and Hong Kong, took part in a longitudinal study. At T1, dyads completed a new task designed to gauge parental reactions towards their child when they were required to wait unexpectedly for a reward (PC-DeFT) and control tasks that did not involve waiting. Children's performance, behaviour and emotional reactions during the tasks were recorded. Parents' reactions to their children's behaviour were observed and coded. At T2 (12 to 18 months later), teachers rated the children's ADHD symptoms and delay aversion levels.

At T1, children's ADHD symptoms and their levels of behavioural agitation and negative affect when waiting during the PC-DeFT (termed maladaptive waiting-related responses) were significantly correlated with each other and with their parent's negative reactions to them. Parental negative reactions during waiting at T1 significantly predicted children's levels of teacher-rated ADHD and delay aversion at T2 after controlling for both their T1 ADHD symptoms and maladaptive waiting-related responses. The pathway between T1 and T2 ADHD symptom ratings was mediated sequentially by children's maladaptive waiting-related responses, parental negative reaction during waiting, and teacher-rated delay aversion at T2. This pattern did not hold for non-waiting settings – where parents' T1 reactions in such were not related to T2 delay aversion nor ADHD outcomes. Results did not differ significantly between the UK and HK groups.

Our study provides the first empirical evidence that parental negative reactions, specifically in situations where their child have to wait, can influence ADHD symptoms via its impact on levels of delay aversion.

6.2 Introduction

6.2.1 Causal pathways to ADHD

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders. It is estimated to affect around 5% of the population (Polanczyk et al., 2007, 2015; Thaparet et al., 2013). It is characterised by age-inappropriate and pervasive patterns of hyperactivity, attentional difficulties and impulse control problems, which have a negative impact on daily functioning (American Psychiatric Association, 2013; Posner et al., 2020). Casual models of ADHD typically focus on its bio-genetic origins consistent with its high heritability (Faraone & Larsson, 2019; Faraone et al., 2005) and its association with genetic alterations (Banaschewski et al., 2010; Faraone & Mick, 2010). Evidence of complex and subtle abnormalities in brain structures, such as reduced grey matter volume, delayed cortical development, and lowered dopamine receptor density have also been found in individuals with ADHD – consistent with such a model (Sharma & Couture, 2014;

Tarver et al., 2014). Furthermore, causal pathways to ADHD are assumed to be mediated by core deficits in a range of cognitive and executive functions (Barkley 1997; Castellanos & Tannock 2002; Seidman 2006; Willcutt et al., 2005). In keeping with this model, while pre- and perinatal factors have also been implicated in the causes of ADHD pathways and trajectories, such bio-genetic pathways are considered impervious to post-natal social environmental influences such as those linked to parenting variations.

6.2.2 Delay aversion theory

Challenging this dominant view, Sonuga-Barke proposed an alternative socio-motivational hypothesis of ADHD development (Marco et al., 2009; Sonuga-Barke, 1994, 2005; Sonuga-Barke et al., 1992, 2010). It was developed in two stages. First, he argued that each of the core symptoms of ADHD, inattention, hyperactivity and impulsiveness, could be understood as manifestations of delay aversion: a motivation to reduce or avoid the exposure or experience of delay when waiting for valued outcomes or important events (Sonuga-Barke, 1994; Sonuga-Barke et al.,1992a, 1992b). In this conceptualisation, apparent impulsiveness represents a way to reduce delay in choice situations by choosing the least delayed among available options. Inattention and hyperactivity are conceptualised as ways to reduce the subjective experience of delay in non-choice situations, where delay cannot actually be reduced, by speeding up the passage of time (Zakay, 1992; Zakay & Tsal, 1989).

Support for the delay aversion hypothesis comes from numerous experimental studies. For instance, concerning impulsiveness, studies demonstrate that ADHD-related choice of small-sooner over large-delayed rewards was substantially greater in situations where delay-escape was possible compared to where it was not (i.e., where choosing the immediate reward reduced overall delay versus where it did not; Sonuga-Barke et al., 1992, 1994; Dalen et al., 2004, Marco et al., 2009). Concerning inattention and hyperactivity, studies showed that levels of ADHD-related behavioural agitation and distraction increased as a function of delay between target stimuli especially on long and boring tasks (Bitsakou et al., 2006; Mies et al., 2018); and that these effects can be reversed by adding extrinsic stimulation to a task (Antrop et al., 2000, 2006). The strongest direct evidence for delay aversion in ADHD comes from brain imaging studies showing the cues of inescapable delay are differentially associated with hyperactivation of brain systems that respond to aversive events (e.g., amygdala; Van Dessel et al., 2018).

6.2.3 Developmental origins of delay aversion

The second part of the hypothesis concerned the developmental origins of delay aversion and its potentially exacerbating effect on ADHD symptoms. Sonuga-Barke (2005) suggested that delay aversion could develop overtime through a process of social conditioning and that this could exacerbate ADHD symptoms. More specifically, that children's maladaptive behaviours during waiting (e.g., failure to wait, loss of concentration, acting up when bored) evoke negative responses from significant others so that the delay during these adverse waiting experiences produces negative affective states in the child. Over time, these waiting settings and the delay they embody become strongly associated with negative affective states (i.e., delay aversion). Impulsiveness, overactivity and inattention increase in intensity in these settings as a conditioned attempt to escape such emotional states.

This hypothesis of the developmental origin of ADHD as a response to delay aversion has not been tested. Of relevance, it has been observed that parents of children with ADHD are more reactive, punitive and controlling, and less rewarding and warm in their interaction (Johnson &Mash, 2001; Modesto-Lowe et al., 2008; Triguero Veloz Teixeira et al., 2015). Longitudinal studies looking at the effects of parenting style on the development of children with ADHD has produced mixed results (Hinshaw, 2002; Johnston & Mash, 2001; Keown, 2012; Liffordet et al., 2008; Seipp & Johnston, 2005). On one hand, there is little evidence that negative parenting increases levels of ADHD symptoms (Lifford et al., 2009; Tarver et al., 2014). On the other hand, negative parenting does appear to increase the risk of the development of comorbid conditions (Deault, 2010; Johnston & Mash, 2001). For instance, Pfiffner et al. (2005) found that negative parenting and ineffective discipline were associated with an increase in oppositional and defiant behaviour, while parental positive affect and praise have been shown to be associated with the opposite effect (Chronis et al., 2007). Furthermore, intervention targeting positive parenting skills have been found to help reduce conduct problems in children with ADHD (see meta-analyses in Daley et al., 2014). Context is a key prediction of the developmental delay aversion hypothesis, yet no studies have differentiated the effect of the context (e.g., waiting versus non-waiting) in understanding the relationship between parenting behaviours/responses and children's ADHD symptoms.

6.2.4 The current research

Here we tested this in a longitudinal study that examined whether parental reactions to children's performance during waiting and non-waiting settings at T1 when the children were three-to-four years old influenced the development of ADHD at T2 (12-to-18 months later) and whether these effects were mediated by the development of delay aversion. To address this, we developed a new experimental task – the Parent-Child Delay Frustration Task (PC-DeFT) to examine parents' reactions to their children's difficulties in managing delay. In this task, parents and children played a simple and enjoyable shopping game where the presentation of a Go-signal was sporadically and unpredictably interrupted with enforced periods of waiting.

The child's emotional and behavioural responses to these delay periods and their parent's reactions to the child were coded.

The study focused on the preschool years. Although most ADHD cases are not typically diagnosed until at least the age of six, it was consistently found that ADHD symptoms manifested in early years show persistence, and their factor structure, associated deficits and impact on children's functioning and wellbeing are comparable to school-aged children with ADHD (Biederman et al., 2010; Fantuzzo et al., 2001; Sonuga-Barke et al., 1997, 2003). We therefore recruited pre-schoolers between the ages of three and four as our participants to investigate early trajectories of ADHD and delay aversion. Our sample included families from two cultures with different attitudes to parenting and children's behaviour (Hong Kong and the UK). We did this to broaden the range of parental reactions to their child's response to delay. The culture in Hong Kong values efficiency and pragmatism; people there in general dislike waiting and live a fast-paced lifestyle (Hairon et al., 2018). Furthermore, the result-oriented tradition in the education system in Hong Kong may have also cultivated parents and children to emphasise productivity in task completion (Young, 2012). Moreover, it has been repeatedly noted that HK parents, compared to Western parents, have relatively high expectations on how their children should behave and tend to be more directive and controlling (Chao, 1994; Chen, 2005; Lam & Ho, 2010; Thompson et al., 2017).

In summary, we asked the following questions.

1. At T1, are children's ADHD symptoms and their waiting-related responses observed during the PC-DeFT correlated?
2. Are they related to parental negative reactions during waiting?

3. Do these parental negative reactions during waiting at T1 predict ADHD symptoms one year later? Does the association remain after children's baseline ADHD symptoms and maladaptive waiting-related responses have been controlled statistically?
4. Where a link between T1 parental reactions and T2 ADHD observed, is it mediated statistically by the children's delay aversion levels?
5. Are similar relationships seen for parental reactions in non-waiting tasks?
6. Are similar associations between parental responses and ADHD observed in HK and UK?

We predicted that -

1. T1 ADHD symptoms would be correlated with children's maladaptive waiting-related responses during the PC-DeFT and these would both be correlated with parental negative reactions during waiting.
2. Parents' T1 negative reactions during waiting would predict T2 ADHD symptoms one year later. These affects would persist after controlling for children's baseline ADHD symptoms and maladaptive waiting-related responses - a pathway mediated by children's levels in delay aversion.
3. These associations would not be seen for parental reactions in non-waiting settings.
4. Finally, although HK parents would be more reactive and negative during waiting, the association between parental reactions, delay aversion and ADHD symptom changes would be invariant across HK and UK samples.

6.3 Methods

6.3.1 Participants

Participants in this study were recruited via local nurseries, preschools and online parent groups using social media adverts in London, UK, and Hong Kong. At the initial screening stage, after being informed about the nature of the study and their right to participate and withdraw voluntarily, 189 preschool children and their parents agreed to participate in the screening and signed the informed consent form (UK: n=68, 51 % male; HK: n=121, 58 % male).

The screening questionnaires completed by teachers and parents provided basic demographic information of the child participants, whether the child had a diagnosis of special educational needs and/or pervasive developmental disorders (e.g., autism spectrum disorder), and their primary language spoken at home and at school. Thirty children (n^{UK}=13 and n^{HK}=17) were excluded on the following criteria— outside the age range; existing diagnosis; age-inappropriate level of comprehension abilities of spoken English (UK) or Cantonese (HK); teacher non-engagement; family not able to attend testing sessions. No participants had been formally diagnosed with ADHD and none were taking ADHD medications. Children were also screened for their level of ADHD symptoms using the five-item hyperactivity/inattention subscale of the *Strengths and Difficulties Questionnaire* completed by parents and teachers (SDQ, version T2-4). To ensure that we compared like with like across cultures, we oversampled participants and then excluded 47 in order to balance the degree of ADHD symptoms at a group level in HK and UK samples. The average SDQ subscale scores in the final UK and HK sample were not statistically different, $F(1, 110) = 2.33$, $p = .130$. Full T1 data was available for 112 parent-child dyads (n^{UK}=55 and n^{HK}=57). All parent participants in this sample were mothers, while the percentage of boys in the child sample was 56% (n = 63).

Families were contacted for T2 participation 11 months after their T1 testing session; 79.5% of them completed the follow-up (n^{UK}=39 and n^{HK}=50; females = 42 and males = 47). Reasons for drop-out included moving abroad, time constraint and inability to get in touch with. The mean age of child participants at T1 and T2 was 46.20 months (*S.D.* = 5.73; range = 36.92–59.24) and 60.85 months (*S.D.* = 7.76; range = 48.36–81.30) respectively. The mean IQ of participants was 106.95 (*S.D.* = 11.53; range = 82–132, i.e. all children met the inclusion criteria of IQ $\geq$ 80).

6.3.2 Procedures

Parent-child dyads were invited to attend in-person testing sessions which took place in quiet rooms either at King's College London or the University of Hong Kong. The testing was conducted by trained experimenters (one in each university). Participants were briefed that this was a longitudinal cross-cultural study exploring pre-schoolers' behaviours in tasks that require patience and waiting. After the introduction, the dyads completed eight minutes of free play time. Before moving on, parents were asked to instruct their children to tidy up their toys without assistance. The dyads then completed the PC-DeFT waiting task. The research team presented a certificate and book voucher to each participating dyad as a token of appreciation. The average time difference between T1 and T2 data obtained was 14 months ($\bar{x}^{\mathrm{HK}}$= 12 months; $\bar{x}^{\mathrm{UK}}$= 18 months). Parents and teachers completed sets of questionnaires at T1 (2019) and again 12 to 18 months later (2020/21, T2).

6.3.3 Measures

6.3.3.1 Screening measures

ADHD symptom screener: The parent and teacher versions of the Strengths and Difficulties Questionnaire (SDQ, version T2-4) are widely used psychometrically strong, brief screening questionnaire designed for research/clinical purposes (Goodman, 1997). The hyperactivity/inattention subscale consists of five items: two measuring inattention, two hyperactivity and one impulsivity. The original English language version was used in the UK. A validated Chinese translation was used in HK (Lai et al., 2010).

Intelligence: Children's IQ was estimated using the Block Design and Vocabulary subtests of Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler, 2003). The WPPSI measures the cognitive ability of pre-schoolers and young children between 2 years 6 months and 7 years and 3 months. The English (UK) and Traditional Chinese language versions were used in the UK and HK respectively.

6.3.3.2 Parent-child interaction task

We measured parents' reactions to their children's responses in three settings: one with sporadic unexpected delay (*PC-DeFT*), one with no delay but the need to comply with parent's request (clean-up) and one with no delay and no planned request (free play).

Parent-Child Delay Frustration Task (PC-DeFT): The PC-DeFT is a computerized task using programme similar to the Preschool Delay Frustration Task (P-DeFT; Chapter 3), with slight modification with regard to the role of participants in the task. The original P-DeFT was designed as a simple and enjoyable "shopping" game. The set up includes a traffic light system shown on a screen and a "crossing" button which can be pressed to change the red *Wait* signal to a green *Go*-signal. In each trial, participants are first shown the *Wait* signal, then they have to press the button to elicit the *Go*-signal. In the P-DeFT, the child participant can then visit the "toy supermarket" to get the target object as shown by the experimenter when they see the *Go*-signal. In this modified PC-DeFT version, the dyads are told to work together to complete the task—child participants are in charge of the button pressing while the parents are responsible for getting the target object from the "supermarket" when the red signal turns green. Children are reminded to stay at their seat all the time.

There is a total of 18 PC-DeFT trials. During the majority of trials (n=12), the *Go-signal* is shown immediately after the child presses the crossing button (i.e., no *pre-Go-signal* delay). In the remaining six trials, a *pre-Go signal waiting period* (either 5-secs or 10-secs; three trials each) is imposed in a pseudo-random order. Participants are not informed beforehand about the presence of these extra delay periods. In this task, four measures are used to assess the *children's* delay-related responses: (a) amount of button presses per second during the *pre-Go-signal* waiting period which reflects their intention to stop the wait; (b) activity level tracked using an unobtrusive wrist-worn triaxial actigraph unit accelerometer; (c) observed delay-related behavioural agitation (i.e., squirming/fidgeting) and (d) negative emotional responses (i.e., observed frustration) which are coded using a 4-point scale with 0="None/ Very rare", 1="A little"; 2="Quite a lot" and 3="A lot". The parents' reactions to their children are observed and coded using the Parent-Child Interaction System (PARCHISY; Deater-Deckard, 2000; Deater-Deckard, Pylas & Petrill, 1997). This coding system had been used extensively across cultures in research with both typically developing population and children with externalizing or internalizing behaviour problems (Aspland & Gardner, 2003; Funamoto &

Rinaldi, 2015). Codes used in this study included both positive and negative reactions to their child's behaviour: (a) positive content, (b) positive affect, (c) reciprocity, (d) negative content and (e) negative affect.

Free play and clean-up: Unstructured free play lasted eight minutes, during which the dyads were allowed to choose any activity or toys available and play together as they would in everyday life. After the eight-minute play session, the parents were asked to request their children to tidy up all the toys but were reminded not to give any actual assistance. There was no time limit for completing the tidy up; experimenters recorded the exact start and end time. The time used to complete clean-up ranged between 21 seconds and 6 minutes 12 seconds. Parental reactions are coded in the same way as for the PC-DeFT.

6.3.3.3 Teacher ratings

We used teachers' ratings of children's ADHD symptoms and delay aversion instead of parents' ratings as outcome variables at T2 to ensure independence of rating source and avoid shared method variance.

ADHD symptom rating: Teachers rated the children's frequency of occurrence of the 18 DSM-IV ADHD symptoms at T2 using the ADHD Rating Scale IV (DuPaul et al., 1998) adapted for preschoolers with a 4-point scale: 0="Never or rarely", 1="Sometimes", 2="Often" and 3="Very often" (ADHD-RS-IV-P; McGoey et al., 2007). A total score was computed by adding the scores of all the items.

Delay aversion rating: The Quick Delay Questionnaire (QDQ) was originally designed to measure adults' self-reported delay-related behaviours (Clare et al., 2010). Markomichali

(2015) adapted it to be used for pre-schoolers' and rated by teachers or parents. There are ten items in total tapping two aspects: (i) Delay Aversion (DA, e.g. "Hates waiting for things") and (ii) Delay Discounting (DD; "Often gives up on things he or she can't have immediately"). At T2, teachers rated children's behaviours on a 5-point Likert scale from 1="Not at all like him/her" to 5="Very much like him/her". The scale has high internal consistency (α =.84) and good test-retest reliability (r=.75).

6.3.4 Data Analysis

Preparatory analyses: A small proportion of the PC-DeFT data (5%) and actometer reading (4%) were missing due to technical issue (e.g. programme crashing, data storage error in actometer). Where data were missing, we used pairwise deletion to optimize data availability. To minimize the need for multiple testing, we reduced the number of variables by running two factor analyses to explore the relationships between the: (i) four measures of children's delay-related responses and (ii) the five indices of parents' reactions with their children's delay-related behaviours. Factor scores were calculated and used in the subsequent analyses. We then explored which demographic and background factors should be included in our models as covariates. We did this by examining which of these were associated with our main outcomes and mediators -T2 ADHD symptoms and delay aversion. Variable significantly associated with these outcomes were added as covariates into our models.

Core analyses: *Research question 1 & 2:* We first conducted T1 correlation analyses to examine the relationship between children's ADHD symptoms and maladaptive waiting-related responding and the relationship between these and parental reactions during PC-DeFT.

Research question 3, 4 & 5: We then explored the association between parental negative reactions in waiting/ non-waiting settings at T1 and children's ADHD symptoms at T2 using correlational and regression analyses, controlling for children's T1 ADHD symptoms and maladaptive waiting-related responses. Regression model 1 tested the prediction of children's teacher-rated ADHD symptoms and delay aversion ratings at T2 with parents' waiting-related reactions in waiting and non-waiting settings at T1 as predictors. Regression model 2 tested the prediction of T2 ratings with parents' negative reactions during waiting as predictors, controlling for children's T1 symptom ratings and waiting-related responses. To compare the predictive power of parental responses across settings on children's T2 ADHD symptoms, and to explore if these relationships were mediated by children's delay aversion, sets of PROCESS macro test of mediation (model 4; 5000 bootstrap samples) were run with parental responses during waiting and non-waiting settings as predictors, while controlling for children's waiting-related performance and ADHD symptom levels at T1. An exploratory test of serial mediation was then run to test if the relationship between T1 and T2 ADHD symptoms was mediated by children's maladaptive waiting-related responses, parental responses during waiting and children's levels of delay aversion using PROCESS macro model 6.

Research question 6: We ran ANOVAs to explore whether there were any significant differences between UK and HK participants on their waiting-related responses and reactions and ratings on delay aversion and ADHD symptoms. We then compared the correlations between children's waiting-related responses, parental negative reactions during waiting and the levels of children's delay aversion and ADHD symptoms at T2 in the UK and HK samples. PROCESS macro test of moderated mediation (model 59, 5000 bootstrap samples) was also run to test if national group would moderate the relationship between parental responses during waiting and ADHD symptoms at T2 via the children's delay aversion ratings.

6.4 Results

6.4.1 Descriptive statistics

Table 6-1 presents the demographic characteristics of the UK and HK participants at both T1 and T2**.** The two samples did not differ significantly in any aspects, except that more UK parents had higher levels of education than HK parents. UK and HK children's age at T1 testing was not statistically different. The original plan was to invite participants to participate in another in-person testing session with the same set of tasks administered 12 months later. However due to COVID-19 school closures and lockdown, in-person testing was suspended and thus the follow up T2 data could only be obtained using parent and teacher questionnaires. Contacting parents and teachers during the pandemic was challenging and a large number of parents and teachers, especially those in the UK, needed additional time to complete the questionnaires due to the extra childcare and online teaching support in that period. UK children's average age at T2 when their parents and teachers completed the questionnaire (M = 65.1, $S.D.$ = 8.8) was greater than that of HK children (M = 57.6, $S.D.$ = 4.8), $F(1, 87) = 26.37$, $p < .001$.

Table 6-1 Demographic characteristics of participants in UK and HK at T1 and T2

	T1		**T2**		Statistical comparison & effect size	
	UK (*n* = 55)	HK (*n* = 57)	UK (*n* = 39)	HK (*n* =50)	T1	T2
Child characteristics						
Age (months) – mean (SD)	46.55 (6.49)	45.86 (4.91)	65.06 (8.79)	57.56 (4.80)	$F(1, 110) = .41, p = .526.$	$F(1, 87) = 26.37, p < .001.$
Female – *n* (%)	25 (45.45)	24 (42.11)	19 (48.72)	23 (46.00)	$\chi^2(1) = .13, p = .721$	$\chi^2(1) = .07, p = .799$
IQ – mean (SD)	108.72 (12.20)	105.26 (10.69)	/	/	$F(1, 109) = 2.53, p = .114$	/
Parent characteristics *n* (%)						
Full-time employment	18 (32.73)	27 (47.37)	12 (30.77)	24 (48.00)	$\chi^2(1) = 2.50, p = .114$	$\chi^2(1) = 2.70, p = .100$
Age group:						
25-34	11 (20.00)	22 (38.6)	4 (10.26)	11 (22.00)	$\chi^2(2) = 4.71, p = .095$	$\chi^2(2) = 2.90, p = .235$
35-39	30 (54.55)	23 (40.4)	24 (61.54)	23 (46.00)		
Over 40	14 (25.45)	12 (21.2)	11 (28.21)	16 (32.00)		
Highest education level:						
Secondary	1 (1.82)	15 (26.32)	0 (0)	13 (26.00)	$\chi^2(3) = 26.07, p < .001$	$\chi^2(3) = 27.27, p < .001$
Higher education	3 (5.45)	11 (19.30)	2 (5.13)	9 (18.00)		
Bachelor	22 (40.00)	21 (36.84)	12 (30.77)	20 (40.00)		
Master or above	29 (52.72)	10 (17.54)	25 (64.10)	8 (16.00)		
Monthly household income:						
Below £2000	4 (7.27)	6 (10.53)	2 (5.13)	9 (18.00)	$\chi^2(3) = 5.33, p = .149$	$\chi^2(3) = 5.28, p = .152$
£2000-2999	1 (1.82)	7 (12.28)	2 (5.13)	6 (12.00)		
£3000-3999	8 (14.55)	8 (14.04)	5 (12.82)	6 (12.00)		
Above £4000	42 (76.36)	36 (63.16)	30 (76.92)	29 (58.00)		
Ethnicity:						
White	40 (72.73)	0 (0)	31 (79.49)	0 (0)	*Not applicable*	
Asian	8 (14.55)	57 (100.00)	7 (17.95)	50 (100.00)		
Black/ mixed	7 (12.73)	0 (0)	1 (2.56)	0 (0)		

6.4.2 Data reduction

Table 6-2 shows the intercorrelations between child's waiting-related responses and parent's reactions to child's behaviours during PC-DeFT. The four measures on children's waiting-related responses (activity level, amount of button presses per second, observed behavioural and emotional agitations) were positively correlated (rs $\geq$ .21; ps $\leq$ .027). Factor analyses supported a single latent factor for these four variables which explained 60.8% of their variance. This factor was termed ***child maladaptive waiting-related responses***. Parents' use of positive content, positive affect and reciprocity were positively correlated (rs $\geq$ .31; ps $\leq$ .001), while their use of negative content significantly correlated with negative affect (r = .70; $p \leq$ .001). Factor analysis gave a two-factor solution explaining 72.1% of their variance. The two factors were termed ***parental positive reactions during waiting*** and ***parental negative reactions during waiting***.

Table 6-2 Intercorrelations between (i) children's waiting-related responses and (ii) parents' reactions in PC-DeFT

			1	2	3	4	5	6	7	8
1	Child's waiting-related responses in PC-DeFT	Activity level								
2		Amount of button presses	.45**							
3		Behavioural agitation	.54**	.41**						
4		Emotional agitation	.48**	.21	.69**					
5	Parent's reactions in PC-DeFT	Positive content	.05	.07	.11	.06				
6		Positive affect	-.07	.05	-.06	-.17	.31*			
7		Reciprocity	-.14	-.07	-.18	-.29*	.32**	.67**		
8		Negative content	.52**	.42**	.48**	.48**	-.02	-.05	-.10	
9		Negative affect	.60**	.48**	.49**	.49**	-.01	-.07	-.21	.70**

Note: * $p < .01$; ** $p < .001$.

6.4.3 Covariates

Table 6-3 shows that child participants' age (both T1 and T2) and IQ were not significantly correlated with teacher-rated ADHD symptom and delay aversion levels at T2 (*rs* ≤ .28, *ps* ≥ .013) – these were therefore not included as covariates in subsequent analyses.

Table 6-4 shows the analyses testing the participants' characteristics and household income group differences in teacher-rated ADHD symptom and delay aversion levels. ADHD and delay aversion ratings did not differ by (i) child's sex (*Fs* ≤ 3.55, *ps* ≥ .062), (ii) parent's age (*Fs* ≤ 1.34, *ps* ≥ .266), (iii) parent's ethnicity (*Fs* ≤ 1.17, *ps* ≥ .313), (iv) parent's educational level (*Fs* ≤ 2.83, *ps* ≥ .042), or (v) household income (*Fs* ≤ .43, *ps* ≥ .733). These factors were not included in subsequent analyses.

Table 6-3 Correlations between children's IQ, age, ADHD and delay aversion ratings at T1 and T2

		IQ	**Age at T1**	**Age at T2**
1	ADHD symptom ratings at T1	-.24	-.16	-.13
2	ADHD symptom ratings at T2	-.20	-.24	-.22
3	Delay sensitivity ratings at T2	-.14	-.28	-.28

Note: * $p < .01$; ** $p < .001$ (adjusted *p* values based on Bonferroni correction).

Table 6-4 Child's sex, parent characteristics and household background differences in ADHD and delay aversion ratings at T1 and T2

		Difference between				
		Child's sex	**Parent's age group**	**Parent's ethnic group**	**Parent's education level**	**Household income group**
1	ADHD symptom ratings at T1	$F^{a} = 3.55$, $p = .062$.	$F^{b} = 1.34$, $p = .266$.	$F^{b} = 1.17$, $p = .313$.	$F^{c} = 2.83$, $p = .042$.	$F^{c} = .43$, $p = .733$.
2	ADHD symptom ratings at T2	$F^{d} = 2.75$, $p = .101$.	$F^{e} = .45$, $p = .642$.	$F^{e} = .65$, $p = .523$.	$F^{f} = 1.01$, $p = .393$.	$F^{f} = .11$, $p = .956$.
3	Delay sensitivity ratings at T2	$F^{d} = 3.01$, $p = .087$.	$F^{e} = .96$, $p = .387$.	$F^{e} = .44$, $p = .643$.	$F^{f} = 2.26$, $p = .088$.	$F^{f} = .31$, $p = .820$.

Note. The *df* of variables for *t* statistics are *a* = (1, 110); *b* = (2, 109); *c* = (3, 108); *d* = (1, 78); *e* = (2, 77); *f* = (3, 76) respectively.

6.4.4 Association between ADHD symptoms and child's and parent's responses during waiting at T1

Table 6-5 shows the correlations between children's teacher-rated ADHD symptoms, their maladaptive waiting-related responses and parents' reactions during waiting in the PC-DeFT at T1. Children's T1 ADHD symptoms as rated by teachers were positively correlated with their maladaptive waiting-related responses during the PC-DeFT (r = .60, p <.001). Parental negative reactions during waiting, but not their positive reactions, were correlated with both their children's T1 ADHD symptoms (r = .41, p <.001 vs r = -.23, p =.017) and maladaptive waiting-related responses (r = .70, p <.001 vs r = -.05, p =.602). More parental negative reactions during waiting were associated with higher levels of ADHD and more maladaptive waiting-related responses.

Table 6-5 Correlations between children's teacher-rated ADHD symptoms, their maladaptive waiting-related responses and parents' reactions during waiting in PC-DeFT at T1

			1	2	3
1	Child measures (T1)	ADHD symptoms rating			
2		Maladaptive waiting-related responses	.60**		
3	Parent measures (T1)	Negative reactions during waiting	.41**	.70**	
4		Positive reactions during waiting	-.23	-.05	.00

Note: * p < .01; ** p < .001 (adjusted p values based on Bonferroni correction).

6.4.5 Association between parental reactions in waiting and non-waiting settings at T1 and children's ADHD symptom and delay aversion levels at T2

Table 6-6 shows the correlations between the parents' reactions during waiting and non-waiting settings and their children's teacher-rated ADHD symptom and delay aversion ratings at T2, with children's ADHD symptom ratings at T1 being controlled for. Parental negative reactions during waiting in PC-DeFT were significantly correlated with children's ADHD symptoms and delay aversion at T2, even after T1 ADHD ratings were controlled for (r = .44, p <.001 & r = .30, p =.008 respectively).

On the other hand, parental negative reactions in non-waiting settings (free play and clean-up) were not significantly correlated with children's teacher-rated ADHD symptoms and delay aversion at T2 ($rs \leq .15$, $p \geq .204$). One finding to note, parental negative reactions during waiting significantly correlated their negative reactions during clean-up, r = .40, p <.001.

Table 6-6 Partial correlation between parental reactions during waiting and non-waiting settings and the children's teacher-rated ADHD symptoms and delay aversion at T2, controlling for baseline ratings at T1

			Outcome variables at T2	
			ADHD symptoms	Delay aversion
T1 measures				
1	Parental positive reactions during	Waiting in PC-DeFT	-.03	.03
2	Parental negative reactions during	Waiting in PC-DeFT	.44**	.30**
3		Free play	.15	.09
4		Clean-up	.15	.09

Note: Controlling for T1 baseline data. * p < .01; ** p < .001 (adjusted p values based on Bonferroni correction).

Table 6-7 shows the regression analyses with children's teacher-rated ADHD symptoms and delay aversion ratings at T2 as outcome variables. Parental negative reactions during waiting in PC-DeFT was a significant predictor of children's teacher-rated ADHD and delay aversion ratings at T2 ($\beta s \geq .35$, $ps \leq .008$), while parental negative reactions in the two non-waiting settings were not significant predictors ($\beta s \leq .18$, $ps \geq .089$) (model 1).

Parental negative reactions during waiting remained a significant predictor ($\beta = .39$, $p < .001$ & $\beta = .42$, $p = .001$ for T2 ADHD and delay aversion ratings respectively) after children's ADHD symptoms and maladaptive waiting-related responses at T1 were added as covariates (model 2).

6.4.6 The prediction of children's T2 ADHD symptoms from parental negative reactions during waiting and non-setting settings at T1 via delay aversion as a mediator

With children's T1 ADHD ratings and maladaptive waiting-related responses controlled for as covariates, PROCESS macro test of mediation showed that the prediction of T2 ADHD symptoms from parental negative reactions during waiting at T1 was fully mediated by children's delay aversion (**Figure 6-1**). The indirect effect was found to be significant ($\beta = .17$, 95% CI = .06, .31).

On the other hand, both the direct and indirect effects in the relationship between parental negative reactions during non-waiting settings (free play and clean-up) and children's T2 ADHD symptoms were not significant (see **Figure 6-3** in supplementary information).

Table 6-7 Regression models of children's teacher-rated ADHD symptoms/ delay aversion ratings at T2, with (Model 1) parents' waiting-related reactions at T1 as predictors and (Model 2) parental negative reactions during waiting in PC-DeFT as predictor, controlling for children's ADHD symptoms and maladaptive waiting-related responses at T1

		Outcome variables at T2			
		Teacher-rated ADHD symptoms		Teacher-rated delay aversion	
	Predictors (T1)	*β*	*t*	*β*	*t*
Model 1	Parental positive reactions during waiting in PC-DeFT	-.13	-1.22	-.03	-.28
	Parental negative reactions during waiting in PC-DeFT	.48	4.25**	.35	2.74*
	Parental negative reactions during free play	.18	1.73	.13	1.12
	Parental negative reactions during clean-up	.18	1.65	.17	1.32
	R^2	.41		.24	
	F	9.92**		4.41*	
Model 2	Parental negative reactions during waiting	.39	3.44**	.42	3.32*
	Children's T1 ADHD symptoms	.45	4.64**	.57	5.37**
	Children's maladaptive waiting-related responses in PC-DeFT	.06	.48	-.19	-1.30
	R^2	.54		.45	
	F	28.91**		20.20**	

Note. * $p < .01$; ** $p < .001$.

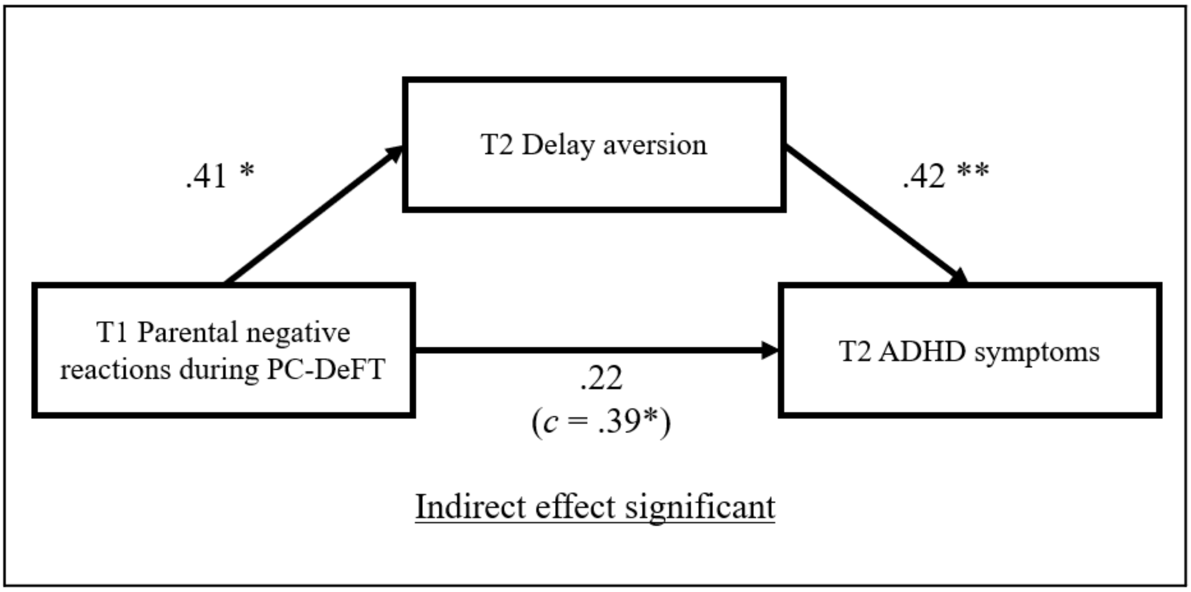

Figure 6-1 The mediating role of delay aversion in relationship between parental negative reactions during waiting at T1 and children's teacher-rated ADHD symptoms at T2, controlling for T1 ADHD ratings and waiting-related responses

Note. Standardized coefficients shown. * $p < .01$; ** $p < .001$

6.4.7 A serial mediation pathway between children's T1 and T2 ADHD symptoms via children and parents' waiting-related responses and reactions

An exploratory test of serial mediation was run to test if the relationship between T1 and T2 ADHD symptoms was mediated by children's maladaptive waiting-related responses, parental responses during waiting and children's levels of delay aversion using PROCESS macro model 6. The subsequent findings necessitate cautious interpretation, as they arise from an exploratory analysis owing to the constrained sample size. The exploratory test of serial mediation showed that the pathway between children's T1 and T2 teacher-rated ADHD symptoms was significantly and serially mediated by children's maladaptive waiting-related responses, parental negative reactions during waiting and teacher-rated delay aversion (**Figure 6-2**). The goodness of fit of the model was evaluated using Comparative Fit Index (CFI); the calculated value of 1.00 indicated a good fit. The indirect effect of T1 symptom ratings on T2 symptom rating via the three mediators was significant (β = .08, 95% CI = .02, .14).

Altering the order of the children's maladaptive waiting-related responses and parental negative reactions during waiting in the serial mediation model resulted in an indirect effect that was not significant (β = -.02, 95% CI = -.04, .01) (see **Figure 6-4** in supplementary information).

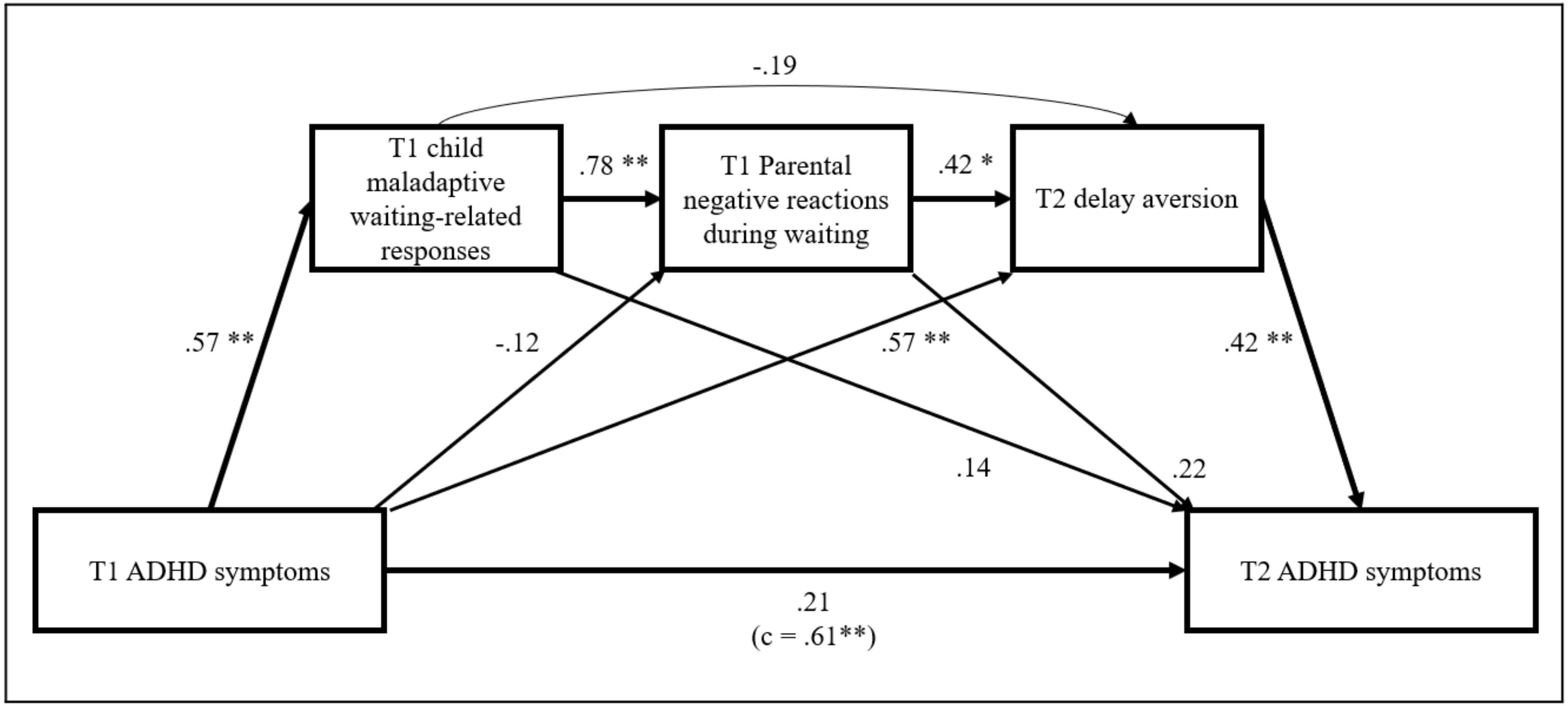

Figure 6-2 The serial mediation model of child and parent waiting-related responses and reactions at T1 and child's delay aversion as mediators in the relationship between child's teacher-rated ADHD symptoms at T1 and T2

Note. Standardized coefficients shown. * $p < .01$; ** $p < .001$

6.4.8 Cross-cultural differences

Table 6-8 Main effects of national group on all child and parent measures at T1 and T2shows the between national-group differences in child's ratings, task responses, and parents' responses and parental reactions in waiting and non-waiting settings. There were no significant differences between UK and HK participants on most of the T1 and T2 measures. A small group difference was found in children's maladaptive waiting-related responses, with UK children being more active and agitated during the waiting in PC-DeFT than HK children, $F = 4.09$, $p = .046$, $\eta^2 = .04$. UK parents showed higher level of reactions, both positive and negative, during waiting than HK parents, but the differences were not statistically significant ($Fs \leq .02$, $ps \geq .339$, $\eta^2 s = .01$).

Split-sample correlational analyses were conducted (**Table 6-9**). The patterns of association between parental reactions in waiting and non-waiting settings and children's levels of teacher-rated delay aversion and ADHD symptoms at T2 were similar in the UK and HK samples. Correlation coefficients between variables in the two samples were compared using Fisher's *Z*-transformation. The *Z*-tests showed that there were no significant differences between the correlation coefficients in the UK and HK samples ($Zs \leq 1.21$, $p \geq .226$).

PROCESS macro test of moderated mediation analysis (model 59) also demonstrated that mediating role of delay aversion in the relationship between T1 parental negative reactions during waiting and their children's levels of ADHD symptoms was not statistically different for UK and HK participants (Index of moderated mediation = -.07; 95% CI = -.22, .07).

Table 6-8 Main effects of national group on all child and parent measures at T1 and T2

		UK			HK			Statistical comparison		
		M	S.D.	*n*	*M*	S.D.	*n*	*F*	*p*	η^2_p
Child measures										
1	Children's maladaptive waiting-related responses at T1	.21	1.06	49	-.19	.91	54	4.09	.046	.04
2	Teacher-rated ADHD symptom at T1	-.07	1.13	55	.06	.86	57	.46	.498	.00
3	Teacher-rated ADHD symptom at T2	-.25	.94	33	.17	1.02	47	3.51	.065	.04
4	Teacher-rated delay sensitivity at T2	2.13	.96	33	2.38	.62	47	1.94	.167	.02
Parent measures (T1)										
5	Parental positive reactions during waiting in PC-DeFT	.10	.97	50	-.09	1.02	56	.92	.339	.01
6	Parental negative reactions during waiting in PC-DeFT	.08	1.07	50	-.07	.93	56	.63	.430	.01
7	Parental negative reactions during free play	-.13	.87	55	.12	1.10	57	1.71	.194	.02
8	Parental negative reactions during clean-up	.08	1.11	47	-.09	.85	38	.60	.441	.01

Table 6-9 Comparison of the partial correlation between parental reactions during waiting and non-waiting settings and the children's teacher-rated ADHD symptoms and delay aversion at T2 between UK and HK participants, controlling for baseline ratings at T1

		Outcome variables at T2			
		ADHD symptoms		Delay aversion	
T1 measures		UK	HK	UK	HK
1	Parental positive reactions during waiting in PC-DeFT	-.13	-.02	.09	-.01
2	Parental negative reactions during waiting in PC-DeFT	.12	.40*	.29	.16
3	Parental negative reactions during free play	.26	-.05	.04	.07
4	Parental negative reactions during clean-up	-.02	.19	-.08	.22

Note: Controlling for T1 children's ADHD symptom ratings and maladaptive waiting-related responses. * $p < .01$; ** $p < .001$ (adjusted p values based on Bonferroni correction).

6.5 Discussion

Existing aetiological models of ADHD focus on the genetic and biological factors in the development of ADHD (Banaschewski et al., 2010; Faraone & Mick, 2010; Sharma & Couture, 2014; Tarver et al., 2014), largely ruling out the contribution of post-natal social factors. Sonuga-Barke (1992, 2005) proposed a socio-motivational hypothesis of ADHD development in which hyperactivity, inattention and impulsiveness could be seen as the behavioural manifestations of delay aversion, a motivational drive to avoid or escape from situations that involved waiting. He argued that the development of delay aversion can emerge from parental negative reactions during waiting which can exacerbate ADHD symptoms.

6.5.1 Summary of main findings

Here we report the findings of the first study designed specifically to test the predictions derived from this hypothesis about the socio-developmental origins of delay aversion and its effect on ADHD symptom levels over time. To do this we developed a new parent-child waiting task, PC-DeFT, to measure parental reactions to their children's behaviour when they were required to wait. We then followed up dyads using a longitudinal design to see whether this measure predict children's ADHD symptom levels at T2 and whether this relationship was mediated by children's delay aversion. We also tested if the parental negative reactions in non-waiting tasks would have the same effect. There were a number of findings to note.

First, our results were consistent with the prediction that parental negativity are related to children's difficulties dealing with delay: *Children's maladaptive waiting-related responses* on the PC-DeFT at T1 were significantly correlated with *parental negative reactions during waiting* cross-sectionally. Previous research showed a linkage between general parental negativity and children's ability to wait but the effect size was small in magnitude (see Karreman et al., 2006 for a review; Mauro & Harris, 2000). Here we found a correlation moderate in strength: the more behaviourally and emotionally agitated a child was in the PC-DeFT, a higher level of parental negativity specifically during waiting was observed.

Second, the primary developmental prediction of the delay aversion model was supported – that parental negativity associated with children's waiting-related difficulties can, over time, lead to delay aversion and this can exacerbate levels of ADHD symptoms. In support of this, we found that a strong association between children's *maladaptive waiting-related responses* and *parental negative reactions during waiting* at T1 and that high levels of parental negative reactions during waiting at T1 predicted more ADHD symptoms at T2. The fact that this effect remained significant after controlling for T1 ADHD symptoms and children's PC-DeFT responses suggests that the influence of parental reactions at T1 was developmental - affecting changes in ADHD symptoms over time. With regard to this point – it appeared that this path between parental reactions and ADHD symptoms was mediated statistically by teacher ratings of delay aversion. How does this effect occur? The delay aversion hypothesis focuses on the notion that delay aversion is a conditioned affective state that arises through the pairing of the experience of delay with the negative affect that social censure and criticism create. An alternative view is observation learning or modelling: children observe parents showing negative emotions during waiting and reproduce a similar negativity towards waiting settings and are motivated to avoid comparable situations. In future this could be tested by exposing children to their parents' performance when waiting without any direct involvement themselves, to explore how the parents' waiting performance relate to their own responses in a similar situation using a longitudinal design.

Third, the effects described above seemed to be very specific to parental responses in delay situations. Even though there was a significant correlation between parental negativity during waiting and during clean-up, parental negative reactions during the free play and clean-up tasks did not appear to be related to children's ADHD symptoms nor delay aversion levels longitudinally. This finding suggests a contextual specificity of parental negative reactions in waiting tasks in the prediction of children's ADHD symptoms and delay aversion. This may help explain why previous research on the impact of parenting practices on children's development of ADHD symptoms has given mixed results (Tarver et al., 2014). It is not the generally strict and punitive parenting that counts, but the parents' negative reactions specifically during waiting that show an impact on children's delay aversion and ADHD symptom levels. Further aetiological research should consider the context-specificity and explore if children's ADHD-related behaviours and its trajectories are context specific.

Fourth, no significant differences were found between UK and HK children and parents at a number of levels: first, in their rated ADHD symptoms and delay aversion levels; second, contrary to our hypothesis, UK and HK parents did not differ significantly in their observed reactions during waiting and non-waiting tasks. Although HK parents have been shown in the past to be more controlling and impatient, it was found that HK parents in this study displayed less positive and less negative reactions during waiting than UK parents. This could be partly due to the cultural expectation and Confucianism beliefs in HK, particularly in non-private settings, to display calmness and restraint of emotional expression (Chan et al., 2021). Finally, the effect of parental negative reactions during waiting on children's ADHD symptoms via the development of delay aversion was invariant across cultures.

6.5.2 Strengths and clinical implications

The current study had a number of strengths including the use of a longitudinal design and the relatively large sample in two cultures. Parental reactions were observed and coded in both waiting and non-waiting settings which made the test of their specific effects on children's delay aversion and ADHD symptoms possible. Our findings have a number of clinical implications, in that they highlight the potential value of incorporating a delay-related focus into parent training programmes and the potential value of interventions targeting parent-child interaction specifically during context of waiting – perhaps providing both parents and children with strategies to better deal with delay and waiting. In his research on self-regulation, Kopp (1989) suggested young children needed their parents to help externally regulating their behaviours and emotions before intrinsic self-regulatory abilities fully emerge. However, previous studies showed that, without prior instruction, parents in general did not have sufficient knowledge of effective waiting strategies and tended to encourage children focusing on the waiting or the delayed reward, which were found to be associated with a decrease in children's ability to wait (Hom & Knight, 1996; Mauro & Harris, 2000; Mischel & Baker, 1975; Mischel & Ebbesen, 1970). In contrast, children with parents who explained to them, helped them to emotionally cope with the waiting-related stress and frustration and/or taught them behavioural or cognitive distraction strategies did better in the delay-of-gratification task (LeCuyer-Maus & Houck, 2002; Peake et al., 2002). To support children's development of the ability to cope with delay, parents could be equipped with skills and strategies to effectively manage delay themselves so as to minimize the possibility of displaying negative reactions during the waiting. Parents can then demonstrate calmness and self-regulatory strategies through the interaction with their children. Children's any successful waiting behaviours should be reinforced so as to associate waiting with a more peaceful state and neutral if not positive affect.

6.5.3 Limitations and future directions

However, there were also limitations. First, the originally planned follow-up at T2 involved children and parents participating in all the waiting tasks and interaction activities once again one year later – it however was not implemented due to COVID-19 lockdown. The data we obtained from parent and teacher questionnaires at T2 nevertheless still provided us valuable information to test the hypotheses. Second, the duration of the unexpected delay in PC-DeFT was relatively short. The task was designed so as to be age-appropriate for pre-schoolers and the fact that parental negative reactions during waiting, but not their reactions in non-waiting settings, were significantly associated with children's ADHD symptoms and delay aversion supported its validity. Future research may have a wider range of waiting duration to explore if parents and children would react more intensively in even longer delays. Third, there was a lack of individuals with clinical levels of ADHD. This reduced power to explore associations between parental reactions during waiting and children's ADHD symptoms and delay aversion in the clinical range. These should be included in future studies.

In our exploratory serial mediation analysis, we found that the pathway between children's T1 and T2 ADHD symptom levels was mediated by children's maladaptive waiting-related responses, parental negative reactions during waiting and children's delay aversion sequentially and that altering the order of children's and parents' waiting-related responses/ reactions resulted in an insignificant model. These analyses seem to support the hypothesis that children's maladaptive responses during delay provoked parental negative responses which in turn contributes to the development of children's delay aversion and ADHD-related difficulties. It however has to be noted that data reflecting participants' waiting-related response were collected concurrently, further longitudinal studies are needed to examine how children's waiting-related responses predict parental reactions in waiting and non-waiting settings later years. Randomized control trials can also be conducted to explore if intervention targeting positive waiting behaviours in children can have an effect on parental reactions during waiting and in general and compare its effects against intervention that helps parents understand and manage children's waiting-induction frustration.

6.5.4 Conclusion

In summary, the present findings suggest the importance of parents' reactions during waiting situations on children's development of delay aversion and ADHD symptoms and highlight the potential value of targeting parent-child interaction and strategies in managing waiting positive in the intervention for children at risk of developing ADHD.

Supplementary information

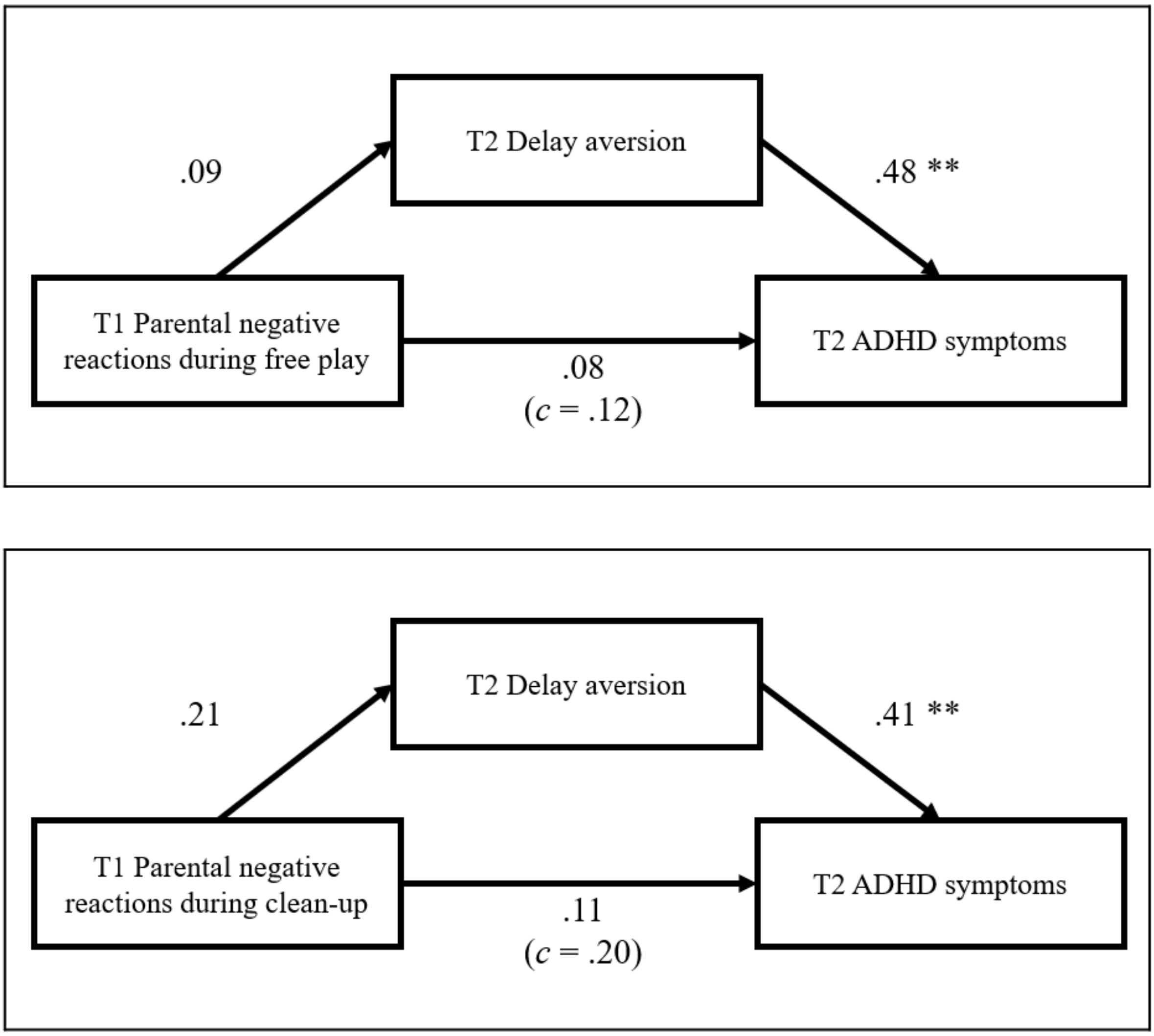

Figure 6-3 The mediating role of delay aversion in relationship between parental negative reactions during free play (above)/ clean-up (below) at T1 and children's teacher-rated ADHD symptoms at T2, controlling for T1 ADHD ratings and waiting-related responses

Note. Standardized coefficients shown. * $p < .01$; ** $p < .001$

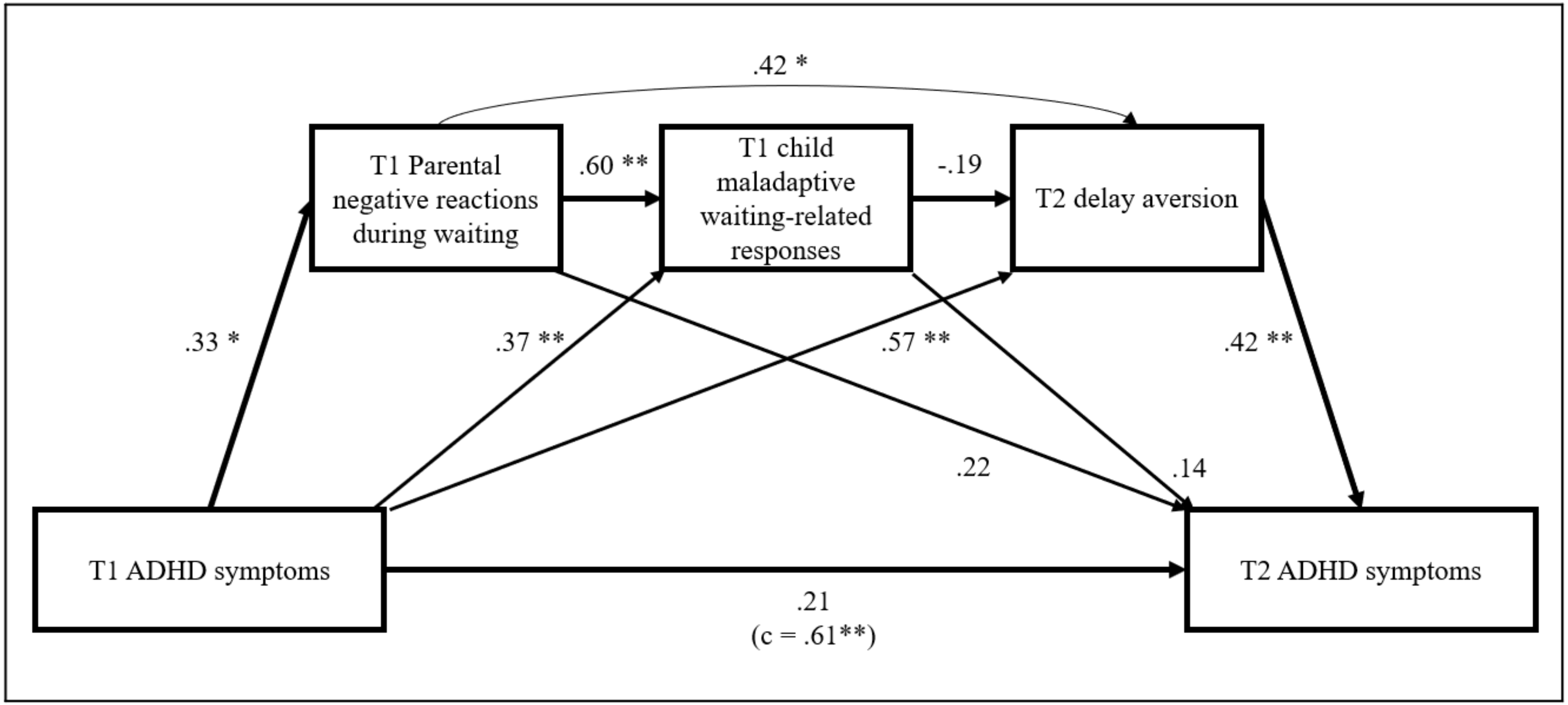

Figure 6-4 The serial mediation model of parent and child waiting-related responses and reactions at T1 and child's delay aversion as mediators in the relationship between child's teacher-rated ADHD symptoms at T1 and T2

Note. Standardized coefficients shown. * $p < .01$; ** $p < .001$

Chapter 7 Discussion

7.1 Aims of thesis

Research on preschool ADHD is gaining more and more attention in the last decades, as it is commonly agreed that early identification and intervention is the key to support children at risk of developing neurodevelopmental disorders. It was found that preschool ADHD was associated with poor wellbeing and functioning outcomes in a similar way as with ADHD found in school age (Biederman et al., 2010; Cole et al., 2011; Fantuzzo et al., 2001; Graziano et al., 2007; Ryan-Krause, 2017; Smith et al., 2017; Sonuga-Barke et al., 1997, 2003, 2005). Despite the increased popularity in preschool ADHD research, meta-analyses showed that most of the existing waiting tasks used with preschool children either measured their ability to inhibit impulses and wait for delayed rewards or their preference for small-immediate over larger-delayed rewards (Marx et al., 2021; Patros et al., 2016; Pauli-Pott & Becker, 2011). The limited nature of waiting tasks designed for the preschool population has not supported the understanding of pre-schoolers' waiting-related frustrations in different contexts (e.g., pre-announced versus expected delay; with and without parent's presence) and how they vary as a function of delay duration.

Although the delay aversion model, which explains ADHD as functional expressions of conditioned avoidance of delay, has been tested and supported in the preschool population, it has rarely been explored in a cross-cultural context, with most existing research being conducted in the Western cultures. In addition, the developmental origins of delay aversion are yet to be explored - how the interaction between children's and parents' responses during waiting associates with the development of preschool delay aversion and ADHD symptoms over time remains an unanswered question.

The aims of the current research are thus to fill the above literature gaps by exploring preschool ADHD symptoms in relation to delay aversion and waiting behaviours in a cultural and familial context. One-hundred-and-twelve preschool children from UK and HK, two cultures known to have very different expectations on children's behaviours, participated in our studies. We first developed a new delay frustration task and examined pre-schoolers' behavioural and emotional frustrations during and after the presentations of unexpected delay (Chapter 3). We then examined delay aversion and ADHD in a cultural context by comparing how parent ratings of children's delay sensitivity and ADHD symptoms related to their children's actual waiting-related responses and objectively measured activity level in UK and HK (Chapter 3 and 4).

The two parts of the delay aversion model were tested in Chapter 5 and Chapter 6. Chapter 5 specially tested if children's maladaptive waiting-related responses at T1 could independently predict their ADHD symptom ratings at T2, controlling for their baseline ratings. Chapter 6 explored how parental reactions during waiting at T1 could affect children's delay aversion and ADHD symptom levels at T2. In both, we also examined if national groups moderated the relationship between waiting-related responses and ADHD symptoms. This study is the first to employ a longitudinal and cross-cultural design in exploring how parents and children shape each other in their waiting-related behaviours.

7.2 Summary of findings

7.2.1 Strong evidence that parents' perceptions and reports of ADHD-related behaviours are culturally determined

Our findings in chapters 3, 4 and 5 supported the hypothesis that UK and HK children behaved differently in situations that involved waiting of different nature (i.e., unexpected waiting, waiting for delayed rewards and choice delay). UK children were observed to have more intensive negative reactions, behaviourally and emotionally, during the waiting tasks than HK children. However, HK children were rated by their parents as showing more ADHD symptoms than their UK counterparts. These findings add value to previous research findings that showed cross-cultural differences in parental ratings and children's behaviours, as most of those studies did not make direct comparisons between cultures but rather relying on data that were collected at different times and often for different purposes (Ho et al., 1996; Lai et al., 2010; Luk et al., 2002; Meltzer et al., 2000). Furthermore, this work examined the relationship between informant ratings and measured activity concurrently.

This cultural discordance found between ADHD ratings and measured/ observed waiting-related responses is compelling evidence that UK and HK parents operated at different ADHD symptom endorsement thresholds, with the former having a higher rating threshold, i.e., more maladaptive waiting-related responses are required for UK parents before they consider them to be indicative of ADHD symptoms. It is striking that the average activity level associated with UK parent ratings made at the 80th percentile equated to the ratings at the 93rd - 98th percentile of HK parent ratings. This means that nearly all HK children rated in the clinical range by HK parents, if transported to the UK and rated by UK parents, would be in the normal range. Further, we found no evidence that these rating threshold differences operated only at the high end of rating severity, meaning that HK parents were differentially more sensitive to activity across the full distribution of ratings not just to hyperactivity of potential clinical significance. This suggests a general shift in cultural perceptions of a linear nature with the whole rating distribution being transposed rather than just the tail extended.

In addition, our findings in chapter 4 showed that child behaviour-related stress fully mediated the association between national group and the ADHD rating thresholds, suggesting that the cross-cultural variations in rating thresholds could be related to differences in the levels of parenting stress experienced between UK and HK parents. We also found that the between-nation differences in children's reported ADHD symptoms did not hold for teacher ratings.

Overall, the work provided the strongest evidence to date that parents in HK operate at different rating thresholds when endorsing ADHD symptoms when compared to the UK. It also suggested that these effects are accounted for by cultural differences in parenting stress.

7.2.2 Delay aversion as a neuropsychological explanation of ADHD

7.2.2.1 Waiting-related behavioural and emotional agitations increased as a function of delay duration

Consistent with the delay aversion theory, findings in Chapter 3 showed that children's ADHD-related behaviours like hyperactivity and impulsiveness increased as a function of delay duration. In the P-DeFT, children's behavioural agitation and negative affect was greater on trials with imposed pre-*Go*-signal delay than on those without it. The agitations also increased in intensity as waiting periods were increased only by five seconds (from 5-sec to 10-sec).

These results highlight how sensitive preschool children are to delay that a slight change in the delay intervals can result in an increase of frustration.

7.2.2.2 Waiting-related frustration observed both during and after delay

Chapter 3 provided the first evidence that preschool children did not only express frustration during the waiting period differentially as a function of the delay duration and individual differences in delay sensitivity, but they also exhibited higher levels of physical activity and lower task completion efficiency after the longer than shorter waiting period. Findings also suggested that the higher the level of rated delay sensitivity, the more the children were affected in the post-delay period. The relationship was less salient with the during-delay measures.

7.2.2.3 Strong association between ADHD symptom levels and waiting-related behavioural and emotional agitations

Findings in Chapter 5 showed that there was a strong cross-sectional correlation between children's ADHD symptom ratings and their delay aversion ratings. A moderate correlation was also found between children's ADHD symptom ratings and their waiting task performance as well as their waiting-related behaviours and reactions. In addition, regression analyses showed that participants' waiting-related responses at T1 significantly predicted their ADHD symptoms and delay sensitivity ratings at T2, even after controlling for their baseline ratings at T1. The current findings are consistent with previous research showing children with higher level of ADHD symptoms had a higher tendency to terminate waiting period sooner and exhibited more intense reactions (Bitsakou et al., 2006; Bitsakou et al., 2009; Antrop et al., 2000; Mies et al., 2018; Pauli-Pott & Becker, 2021; Van Dessel et al., 2018).

Our findings supported the delay aversion hypothesis that individuals with elevated ADHD symptoms find the pre-reward delay emotionally aversive thus would take actions to avoid or escape from it if possible (Sonuga-Barke et al., 1992a, 1992b; Sonuga-Barke, 1994). The significant prediction of T2 ADHD ratings suggests that children's negative behavioural and emotional reactions during waiting situations may be a risk marker of high levels of ADHD symptoms over time. The potential process explaining the exacerbation of ADHD symptoms via development of delay aversion was thus tested and discussed in Chapter 6.

7.2.3 First evidence supporting the socio-developmental origin of the delay aversion and its exacerbation of ADHD symptoms

Chapter 6 presented the first findings that tested the socio-developmental origin of delay aversion and its exacerbation of ADHD symptoms. The first part of the findings showed that children's maladaptive waiting-related responses on the PC-DeFT at T1 were significantly associated with their parents' negative reactions during waiting cross-sectionally; the correlation found was strong in magnitude. It is acknowledged that correlation does not imply causation, but our results are consistent with the prediction that parental negativity can be evoked by children's difficulties dealing with delay - the more behaviourally and emotionally agitated a child was in the PC-DeFT, a higher level of parental negativity specifically during waiting was observed.

The second part of the Chapter 6 findings showed that high levels of parental negative reactions during waiting at T1 predicted more delay aversion and ADHD symptoms at T2 even after controlling for children's ADHD symptoms and PC-DeFT responses at T1. Further mediation analyses suggested the relationship between parental negative responses during waiting at T1 and children's ADHD symptoms at T2 was mediated by their levels of delay aversion. These results provided the first evidence to support the developmental prediction of the delay aversion mode, which suggested that the parental negativity associated with children's waiting-related difficulties can, over time, affect changes in delay aversion and thus exacerbate ADHD symptoms over time.

In addition, Chapter 6 also tested the specificity of parental responses in delay situation, with findings highlighting that parental negative reactions during non-waiting settings did not appear to be related to children's ADHD symptoms nor delay aversion levels longitudinally.

7.2.4 Cultural invariance found in delay aversion model

Cultural differences were found in (1) children's waiting-related responses and (2) parents' ADHD symptom rating thresholds. Despite these differences in absolute terms, the analyses in Chapter 3 and 5 exploring the relationship between delay aversion/ ADHD symptom levels and children's waiting-related responses was not moderated by national group. This suggests that within both UK and HK, ADHD symptoms are correlated with waiting-related performance and responses in a similar way – that, in this regard, ADHD symptoms have the same neuropsychological signature across cultures.

The test of national grouping as a potential moderator in the socio-developmental model of the delay aversion in Chapter 6 also suggested that the parental negative reactions during waiting at T1 predicted children's ADHD symptom levels at T2 to a similar degree in the UK and HK sample. In sum, these findings supported a cultural invariance in the understanding of delay aversion as a neuropsychological explanation of ADHD and an acquired characteristic.

7.3 Implications of the findings

7.3.1 ADHD rating threshold and parenting stress

This work provides strong evidence that parents' perceptions and reports of ADHD-related behaviours are culturally determined. It seems to suggest that the similar ADHD prevalence across different regions and cultures do mask marked differences in actual levels of children's ADHD behaviour – at least regard HK and UK. For instance, our findings in Chapter 3 suggested if a standardized norm is employed, HK children being rated in the clinical range on the ADHD Rating Scale by HK parents would be within the normal range if transported to the UK. The between-nation difference found in the ADHD symptom rating threshold appeared to be related to the higher level of parenting stress seen in HK parents. The culture in HK emphasizes self-control and restraints of disruptive behaviours and emotional expression – and this seems to create a lot of pressure for parents who are assumed the responsibility to ensure their children conform to the cultural expectations and behavioural standards. Given the very different perceptions of ADHD-related behaviours and their impacts on parental functioning, it is therefore necessary to have cross-cultural validation of ADHD assessment tools and culturally specific norms which are especially crucial for rating scales. Establishing measurement invariance of the ADHD symptom rating scales between cultures is thus as important in cross-cultural research and comparison. Although the current sample size was insufficient for conducting meaningful factor analyses with the desired level of statistical power, we found high internal consistencies for the full scale and two subscales in both the current UK (Cronbach's $\alpha s \geq .81$) and HK sample (Cronbach's $\alpha s \geq .80$). Furthermore, the split-sample correlation analyses showed the hyperactivity-impulsivity ratings correlated significantly to children's actometer-measured activity level in a similarly way in the two subsamples (r^{UK} = .41., p = .004; r^{UK} = .44., p < .001).

Having seen the significant relationship between parenting stress and ADHD rating threshold, it appears that the elevated parenting stress experienced by HK parents has influenced how they perceive the children's behaviours. It is of concern given that we know from previous research that stress can manifest as parental mental ill-health and also increase the risk for child maltreatment. Interventions need to be developed that are culturally adapted to address the problem of parenting stress in HK.

Despite the cultural relativity of ADHD symptom endorsements, our findings suggested cultural invariance in the neuropsychological correlates of ADHD. There seem to culturally common processes that drive the relationship between ADHD ratings and behavioural outcomes as observed in waiting situations, i.e., although children with elevated ADHD symptom levels in different cultures may be distinctive in terms of intensity and quantity of their actual behaviours, they do appear to have more maladaptive waiting-related responses than children with lower level of ADHD symptoms within the same culture. This cultural invariance may infer that intervention efforts with the same focus are likely to be useful across cultures (more will be discussed in section 7.3.3).

7.3.2 Parental factors in the development of delay aversion

The role of parental negative responses during waiting in the prediction of children's delay aversion and ADHD symptom levels over time was found to be significant and independent of children's initial symptom level and maladaptive responding during delay. Here we found a correlation moderate in strength, which appeared to be stronger than previous research which showed a small effect size between general parental negativity and children's ability to wait (Karreman et al., 2006; Mauro & Harris, 2000). This difference may be perhaps due to the specificity in terms of context in our research on parental influences. Our findings suggested a contextual specificity of parental negative reactions in waiting tasks in the prediction of children's ADHD symptoms and delay aversion. The parents' positive reactions during delay and negative reactions during non-delay settings were not significantly correlated with children's delay aversion and ADHD symptom levels. Even though there was a significant correlation found between parental negativity during waiting and clean-up, the two did not associate with children's symptom levels in the same way. These findings imply that future parenting and ADHD aetiology studies should consider the context-specificity and explore if children's ADHD-related behaviours and its trajectories are context specific.

7.3.3 Early Intervention efforts

Although a growing number of research has supported the validity of preschool ADHD, most ADHD cases are still not typically diagnosed until the children started formal education at the age of five or six (Arnett et al., 2013; Lahey et al., 2004; O'Neill et al., 2017). Non-pharmacological interventions such as parent training programme and behavioural interventions for children are necessary and recommended for children at risk of developing ADHD and/or awaiting formal diagnosis (American Academy of Pediatrics, 2011; Fabiano et al., 2009; Sattler & Hoge, 2006). The findings of this work highlight two risk markers of high levels of ADHD symptoms over time: (1) children's maladaptive behavioural and emotional reactions during waiting situations and (2) parental negative reactions during waiting situations. These findings echo the socio-developmental origin of the delay aversion – that the original neutral waiting environment comes to be paired with the negative affect induced by the unfavourable feedback from others as well as the internal feelings of failure, which subsequently triggers conditioned avoidance of delay exhibited through an increase in ADHD-related behaviours. There is a potential value to include strategies that can help minimizing the negative affect associated with waiting in future interventions for preschool children at risk of developing ADHD. Further, the cross-cultural invariance found in the delay aversion model suggested that these early intervention efforts could be useful in different cultures.

To enhance children's delay tolerance and adjust their behavioural and emotional reactions during waiting situations, it was previously shown that distracting the children from the anticipated outcome could reduce their waiting-related frustration, for instance, cognitive distractions such as asking the children to think of fun things produced pleasant affection, and the children were more willing to wait voluntarily for a delayed reward (Mischel et al., 1972). Through teaching children distraction techniques like self-directed speech and redirection of attention to other objects or tasks such as drawing and relaxation exercise, children's ADHD-related symptoms during waiting reduced (Feldman et al., 2011; Peake et al., 2002).

The predictability of parental negativity during waiting on children's ADHD symptoms over time provide insights for early intervention efforts targeting parent-child interaction specifically during the context of waiting. A delay-related focus can be incorporated into existing parent training programmes and provide parents the strategies to enhance delay tolerance. It has been suggested in early years self-regulation research that young children needed their parents to help externally regulating their behaviours and emotions before intrinsic self-regulatory abilities fully emerge (Kopp, 1989). However, previous studies also showed that parents in general did not have sufficient knowledge of effective waiting strategies and tended to encourage children focusing on the waiting or the delayed reward, which were found to be associated with reduced waiting duration (Hom & Knight, 1996; Mauro & Harris, 2000;

Mischel & Baker, 1975; Mischel & Ebbesen, 1970). With prior instructions to parents to employ distraction strategies or acknowledge children's waiting-related stress during the delay, positive outcomes in terms of increased waiting time and reduced negative behaviours were found (LeCuyer-Maus & Houck, 2002; Peake et al., 2002). We recommend that parents can be guided to (1) understand that the development of pre-schoolers' self-regulatory skills, especially in situations involving waiting, takes time and needs parents' explicit guidance and support; (2) learn to use strategies like distraction and relaxation that can enhance children's ability to copy with delay; (3) practice skills to effectively manage delay and demonstrate calmness and self-regulatory strategies when interacting with their children and (4) reinforce any successful waiting behaviours in their children, so as to associate waiting with a more peaceful and/or positive state.

7.3.4 New measures of delay behaviours

Chapter 3 presented the use of a newly developed tool, Preschool Delay Frustration Task (P-DeFT) to assess preschool children's waiting-related frustration. This age-appropriate and easy to use task objectively measures children's performance and reactions during the presentation of unexpected delay periods. Findings showed that preschool children behaved differently in trials with and without delay and they are sensitive to delay intervals only differed by 5 seconds; even small changes in waiting duration are possible to bring about significant differences in young children's performance and reactions. This highlights how important it is for researchers to take into account even small differences in delay when interpreting findings in this age group.

During the administration of all the four waiting tasks, we did not only record participants' performance (i.e., retrieval of prohibited reward before waiting time ends in Cookie Delay Task, number of rewards and waiting time chosen and experienced in Bee Delay task and amount of button presses during P-DeFT and PC-DeFT), we also recorded and coded their behavioural agitation and negative emotional reactions/ affect during the waiting period. Our findings in Chapter 5 showed that ADHD symptoms and delay sensitivity ratings appeared to have a stronger association with the behavioural-emotional indicators than with the performance scores, suggesting the need to include multiple measures of waiting-related behaviours and emotions in future research on inhibition control and delay aversion.

Apart from measuring children's delay-related behaviours, we designed the PC-DeFT to examine parent-child interactions specifically during the context of waiting. The comparison of parental responses during waiting and non-waiting situations enabled us to testify the specificity of context in the relationship between parental factors and children's development of delay aversion and ADHD symptoms over time. Although further validation is needed, our findings with the use of PC-DeFT suggested a potential value of examining parents' behaviours and interaction with children during waiting in preschool ADHD research. There is also a potential benefit of introducing parental involvement in young children's delay tolerance training.

7.3.5 Extension of the delay aversion model: Spill-over effect of waiting-related frustration

Participants' performance in DeFT supported the delay aversion model by showing waiting-related behavioural and emotional agitations increased as a function of delay duration, it also extended the model by showing the first evidence of an aftereffect of waiting-related frustration - participants' frustration experienced during a delay appeared to spill over to effect subsequent activities after the delay had finished. The increased activity and reduced efficiency in the post-delay task were found to be linked to the duration of waiting experienced prior to task commencement.

In the past, the delay aversion model has focused exclusively on children's responses during delay. The current findings demonstrated that the negative effects of delay extend to after the imposed delay is terminated. From a delay aversion perspective, the reason why children took longer to complete the task and returned to their seat later maybe because they were trying to avoid going back to the frustrating delay situation by postponing the start of the next trial. Future studies are needed to test this hypothesis and examine factors that may contribute to some children's difficulty in recovering from waiting-related frustrations.

7.4 Strengths

This work has a number of methodological strengths. First, we explored ADHD, delay aversion and waiting behaviours in preschool children using a cross-cultural and longitudinal experimental design.

Second, the relatively large sample recruited in two cultures known to have very different expectations on children's behaviours provided us important findings and insights for early intervention efforts.

Third, this work employed a battery of classic and novel tasks that involved waiting of different intensity and nature. Apart from objectively measured performance, we also observed and coded participants' behavioural and emotional reactions specifically during the waiting periods. As predicted, there were significant positive correlations in participants' reactions across the waiting tasks.

Fourth, the development of the P-DeFT provides researchers tools to measure pre-schoolers' waiting-related frustrations both during and after the presentation of unexpected delay with varied duration, while the PC-DeFT can be used to examine parent-child interactions specifically in the context of waiting.

7.5 Limitations

Despite having the methodological strengths, this work also has a number of limitations.

Frist, we acknowledged the significance of establishing measurement invariance of rating scales in cross-cultural research, as our findings in Chapter 4 indicated that parents from different nations might interpret ADHD symptoms differently, reflected by the varying rating thresholds in our sample. Initial evidence from internal consistency analyses suggested that the items in each of two subscales of the ADHD-RS-IV-P were measuring the same underlying construct reliably and consistently in both the UK and HK samples. The current sample size was insufficient for conducting meaningful factor analyses with the desired level of statistical power, future studies may benefit from a larger sample size to further assess the psychometric properties of the ADHD-RS-IV-P across different cultures and in particular, explore using factor analyses to test if the factor structures of the rating scale in parent groups known for their different attitudes to children's behaviour and self-regulation would be similar. While acknowledging the importance of establishing measurement invariance, we are confident in our findings as parent ratings were significantly correlated with the children's objectively measured activity level to a similar degree in both subsamples. This correlation provided additional support for the validity of our results, despite the potential for between-nation differences in rating thresholds to be confounded by measurement bias.

Second, we tried to match participants in the UK and HK sample using the parent and teacher ratings on the five-item hyperactivity/inattention subscale of SDQ. However, our findings in Chapter 4 showed that parent ratings were subject to cultural bias, with parents in HK tended to rate children with the same level of physical activity higher than parents in the UK. The two cultural groups appeared to differ in their objective levels of activity although being rated by parents as being the same. Chapter 6 however showed that teacher ratings on ADHD symptoms did not differ significantly between nation groups. Whether teacher ratings can better capture children's actual activity levels requires further examination – for instance to compare teachers' ADHD rating threshold across cultures.

Third, in the study of rating threshold (Chapter 4), we computed a ratio of measured activity level to impulsivity/hyperactivity rating. This work lacks an objective measure of children's level of inattention. It therefore remains unclear whether the findings with regard to hyperactivity generalise to less obtrusive behaviours such as inattention. The cultural differences found in the rating threshold appeared to be related to the elevated parenting stress related to children's behavioural problems reported by HK parents. It is possible that the less disruptive problems may trigger less marked parental reactions and result in a reduced or no between-culture difference in rating threshold on inattentive symptoms. On the other hand, it is also possible that HK parents may perceive attention abilities as remarkably important given its strong correlation with academic performance and achievement, resulting in an even bigger gap between HK and UK parents' rating threshold on inattentive symptoms.

Fourth, to examine the specificity of context in the association between parental responses and children's ADHD symptoms, we observed and coded parents' interaction with their children in waiting and non-waiting situations. However, this study lacked a non-waiting task that allows us to measure and compare UK and HK children's behavioural and emotional expressions of frustration in situations without delay, for instance, during a task with high difficulty level or a game that involves frequent instances of losing. Further testing is needed to explore whether UK children are more emotionally expressive generally or only specifically in the presence of waiting-induced frustration.

Fifth, the current findings supported a statistical mediational relationship between children's T1 and T2 ADHD symptom levels via children's rated and actual delay aversion, as well as parental negative responses during delay. It is of interest to explore whether parental responses at T1 would have an independent effect on children's waiting responses at T2 or that children's maladaptive responses at T1 would predict parents' waiting-related negative responses at T2 and how these two paths relate. The original follow-up plan that involved children and parents participating in all the waiting tasks and interaction activities once again one year later however was not implemented due to COVID-19 lockdown.

Moreover, there are also potential limitations of using teachers' report of children's ADHD symptoms during the pandemic. As discussed, our original plan to measure children's task-based performance and objectively measured actometer reading was suspended due to the COVID restrictions. The only available source of follow-up data was questionnaires and the reasons to use teachers' ratings of children's ADHD symptoms and delay aversion instead of parents' ratings as outcome variables at T2 were to ensure independence of rating source and avoid shared method variance. We endeavoured to ensure that teachers familiarized themselves with the children before completing the questionnaire. Emphasizing voluntary participation, a few teachers (n=5) expressed to us that they did not feel adequately acquainted with the child and decided not to complete the questionnaire. Moreover, in the UK, out of the 33 completed questionnaires, 21 of them were completed by teachers between June and August 2020. As lockdown only started in late March, teachers had been teaching the participating children in person for at least six months before the online lessons started. The other 12 questionnaires were completed between June and July 2021, and those were children in their second year of primary education, which teachers could have known them for nearly two years, if not, at least three months in person and six months of online interaction before the completion of questionnaires. On the other hand, in Hong Kong, children were mandated to wear their uniforms and maintain a high level of discipline during online classes, with teachers making concerted efforts to replicate a classroom atmosphere as closely as possible. Students were required to keep their video on, and teachers continued to provide constant feedback and report on students' behaviours and performance. Similarly, all teachers completed the questionnaires only after having known the children for more than six months.

7.6 Future direction

7.6.1 Intervention research

Like most of the other environmental risk factors, it is not always possible to establish a cause-and-effect relationship between parental influences and ADHD in children (Thapar et al., 2013). Interventions studies targeting positive parenting skills and strategies however did found to be effective in enhancing the functioning of families with children with ADHD, providing strong evidence supporting the important role of parenting in the symptom development of children with ADHD (Charach et al., 2013; Sonuga-Barke et al., 2001, 2018).

As suggested in section 7.3.3, future early intervention can include teaching children strategies to enhance delay tolerance and guiding parents to practice and demonstrate effective delay management skills through the interaction with their children during waiting situations. Waitlist controlled trials could be designed to explore the effectiveness of intervention with a delay tolerance aim on children's rated delay aversion and their responses during delay settings. Participants can be randomly assigned into groups receiving different parenting skills training, for instance, a group receiving intervention on general parenting skills, a group on effective and positive waiting strategies, a group on both the general and delay-specific parenting skills and a waitlist group. Stronger conclusions can be made on the socio-developmental origin of delay aversion if the children with mothers in the delay-specific intervention groups show a stronger decrease in delay aversion than the general parenting and control groups.

7.6.2 Cultural differences within the same national groups

In our samples, it was noted that the UK group had a more diverse ethnic composition, with around one quarter of the participants being of black or Asian ethnicity. Although the different ethnic groups within the UK sample did not differ significantly in their ADHD rating threshold ratios, it was found the within-ethnic-group variance was particularly high in the White (n=40) and Black/mixed (n=7) ethnic groups, whereas the variance in Asian group (n=7) was similar to the HK participants. This result needs to be interpreted with caution as the numbers of participants in each ethnic group are small. Yet, this preliminary analysis raises interesting issues of migration and enculturation for future studies – whether immigrants have a set of perceptions and report patterns of ADHD-related behaviours similar to individuals in the same ethnic group or to individuals in the current local community, and how this difference or similarity changes as a function of the years of residence in their new domicile. For instance, it was suggested the elevated parenting stress experienced by HK parents was related to the cultural expectations on children's self-regulated behaviours; it would be particularly relevant to explore how HK parents who have migrated to the UK, where behavioural standards are more relaxed, will change in their parenting style, parenting stress and perceptions of children's behaviours.

On the parenting measures in our work, we found the UK and HK parents only differed significantly in their self-rated authoritarian control, the two samples however did not show significant differences in their observed negative responses to children both during waiting and non-waiting setting. Looking into details, despite having lower ratings on the authoritative domain than UK parents, overall HK parents still rated themselves on balance as more authoritative than authoritarian. It could be possible that there is a gradual change in HK parents' way to education and discipline their children following the growing attempts to promote positive parenting approaches in recent decades in HK (Chan et al., 2021). This observation suggests that the dynamic nature of parenting style and practice. Future longitudinal research can explore how changes in social policy and expectation influence parental factors and whether such shift has an impact on parents' perceptions on children's behaviours.

7.6.3 Father as participants

In this work, all the parent participants in both our UK and HK samples were mothers. The role of fathers in families is agreed to be very important but often receives much less attention than the role of mothers in the research of children's neurodevelopment.

There are a number of ways that paternal factors may differ from maternal factors in their association with children's development and expression of ADHD-related symptoms. First, it was found that mothers' own ADHD symptoms, but not the fathers', predicted children's future ADHD symptoms after controlling for their early years' symptomatology (Breaux et al., 2017).

Other research however found that both maternal and paternal ADHD symptoms had similar significant associations with children's adverse neurodevelopmental outcomes (Agha et al., 2013).

Second, our findings showed cross-cultural differences in parental perceptions of ADHD-related behaviours. It would be of interest to explore whether the same patterns can be seen in fathers from different cultures. Previous research on parents' attribution for child behavioural problems tended to show that mothers tended to perceive children's ADHD-related behaviours more negatively (i.e. attributing ADHD symptoms to internal and stable factors) than fathers did (Chen et al., 2008). In another longitudinal attribution study, Williamson and Johnston (2015) found that, comparing to family of children without ADHD, maternal attributions for child behaviours were more negative than the controls, but paternal attributions were not significantly different from the controls. Regarding the predictive value of parental attributions, they however found that both the maternal and paternal attributions predicted children's behavioural problems seven months later. For the ratings on children's ADHD symptoms, it was found in both Western and Eastern-based studies, that fathers tended to have lower ratings and reported problems as less serious than mothers did (Ma & Lai, 2016; van der Veen-Mulders et al., 2017), and that fathers' report on ADHD symptoms appeared to have higher levels of correspondence with teachers' report than that between mothers' and teachers' reports (Sollie et al., 2013). It is not difficult to imagine why mothers' ratings and attribution of ADHD symptoms are different from the fathers' – it is still the society's expectation in many cultures that mothers assume greater childcare responsibilities (Bianchi et al., 2012; Moore, 2008) and a study in HK found that mothers of children with ADHD did report experiencing higher level of parenting stress than fathers did (Ma & Lai, 2016).

Third, it would be insightful to explore if the associations we found between parental negative responses during delay and children's development of ADHD symptoms over time are applicable to father-child interactions during delay. Previous studies found that fathers of children with ADHD were more authoritarian and showed less affection than fathers of children without ADHD (Alizadeh & Andries, 2002; Chang et al., 2013). Fathers' lack of responses and emotional engagement during infancy and toddlerhood was also found to predict children's ADHD symptoms years later in middle childhood (Aquino et al., 2023). Instead of jumping into conclusion whether paternal or maternal parenting factors have more impact on children's development of ADHD, it has been suggested that the two parental factors predict children's behaviours differently (Ellis & Nigg, 2009; Keown, 2012), with some found children's ADHD diagnosis specifically correlated with mothers' inconsistent discipline and fathers' low involvement, while others found maternal sensitivity and paternal hostility particularly predictive of future ADHD symptoms. On the other hand, the temporal relationships between parent-child rejection and child ADHD symptoms also appeared to be different for fathers and mothers, with ADHD symptoms increasing tension between child and mother, but father-child rejection increasing levels of child ADHD symptoms (Lifford et al., 2008).

Fourth, it was found that fathers and mothers felt differently on the effectiveness of ADHD interventions (Chen et al., 2008). A systematic review on parent training for ADHD found that fathers in general had very little participation in interventions (Fabiano, 2007); but positive outcomes such as reduced negative responses and increased positive interactions were observed in fathers' interaction with children upon the completion of a parenting program for ADHD (Fabiano et al., 2012). This work proposed the inclusion of delay-managing strategies in the parenting training as an intervention for children at risk of developing ADHD. It would be essential to examine the effectiveness of such early intervention efforts with different parent groups.

It is therefore critical for future ADHD research to include fathers as participants, particularly in the cross-cultural examination of parents' ADHD rating threshold and the effects of parental responses during delay on children's development of ADHD and delay aversion.

7.6.4 Follow on participants and include a wider range of participants

Participants in this work were pre-schoolers with a range of hyperactivity and inattention symptoms, but none of them had an ADHD diagnosis. Given the strong associations found between waiting-related responses and children's ADHD symptoms in this sample, it would be worthwhile to have a follow-up a few years later to see if waiting-related responses can predict future neurodevelopment and discriminate participants with and without ADHD. In addition, the socio-developmental origin of the delay aversion and its exacerbation of ADHD symptoms can also be further testified in longitudinal studies by comparing the predictions of parental' responses during delay on children's performance and the prediction of children's performance on parental responses over time.

To further explore if the cross-cultural differences found in children's waiting-related responses and parents' rating threshold extend to other developmental periods, future studies can have the waiting tasks modified and include school-aged children with and without neurodiverse conditions. Non-waiting frustration tasks are recommended to explore the specificity of delay on children's expression of frustration in different cultures. Objective measures of hyperactivity (e.g. tracking of physical activity) and inattention (e.g. eye-tracking techniques) are recommended.

Findings of this work show that children behaved differently both during and after the short versus long delay trials. Given the young age of the preschool participants in this sample, the number of delay trials and the variation of waiting times were limited. For further testify how the different indictors of waiting-related frustration change in magnitude and direction as the length of delay increases, future research can vary the delay duration to a larger extent.

Future research can also include children with diverse needs and explore if the waiting-related performance and frustrations exhibited in children with elevated level of ADHD symptoms in our study will be seen in children with other neurodevelopmental or behavioural and emotional disorders such as autism spectrum disorder (ASD), conduct disorder (CD) or Oppositional Defiant Disorder (OCD). Previous research demonstrated that although children with ASD showed deficits in executive functioning similar to children with ADHD, Antrop et al. (2006) found that children with ADHD showed stronger preference to avoid delay than both typically developed children and children with ASD. There has not been much research exploring the relationship between ASD and delay aversion specifically, with only one study indicating that adults and adolescents with ASD valued future rewards less than their typical counterparts (Warnell et al., 2019). On the other hand, findings from structural equation modelling showed that ODD symptoms were uniquely predicted by delay aversion, even after accounting for ADHD. Future studies including a wider range of participants can therefore examine if the predictability of parents' negative reactions in waiting situations is specific to ADHD-related symptoms or applicable to other developmental difficulties.

7.7 Conclusion

This work provides the first findings that examine the relationship between pre-schoolers' ADHD, delay aversion and waiting behaviours in a familial and cultural context. We first found strong evidence that parents' perceptions and reports of ADHD-related behaviours are culturally determined, with HK parents appeared to have lower rating threshold than UK parents, that is, less waiting-related activity is required for HK parents before considering it as an ADHD symptom. Second, our findings supported the delay aversion model by showing that children's maladaptive waiting-related responses increased as a function of delay duration and significantly associated with their levels of ADHD symptoms. Third, the socio-developmental origin of the delay aversion was also justified as we found a strong positive correlation between children's maladaptive waiting-related responses and parental negative responses during delay at T1 and that parental negative responses during delay independently predicted children's delay aversion and ADHD symptom levels at T2, even after controlling for their baseline ratings at T1. Fourth, despite the cultural differences found in parents' rating threshold, our findings suggested that there was cultural invariance in the relationship between pre-schoolers' ADHD, delay aversion and waiting behaviours which provided insights for early intervention efforts that could be effective across cultures.

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Appendix A

Descriptive statistics of PARCHISY codes observed and scored in the three parent-child interaction tasks.

Table A1 Descriptive statistics of PARCHISY codes observed and scored in free play

Variables	N	Min	Max	Median	Mean	SD	Skewness	Kurtosis
Mother codes								
Positive content	112	1	7	5	4.68	1.58	-.62	-.65
Negative content	112	1	3	1	1.21	.47	2.16	4.04
Positive affect	111	1	7	3	2.85	1.06	1.05	3.23
Negative affect	112	1	4	1	1.06	.34	6.89	54 .49
Responsiveness	105	4	7	6	6.30	.75	-.83	.24
Verbalisations	112	3	7	5	5.31	1.17	-.22	-.76
Child codes								
Positive affect	112	1	7	3	2.70	1.15	1.46	4.17
Negative affect	112	1	3	1	1.02	.19	10.58	112.00
Responsiveness	109	2	7	5	5.06	.97	-.38	.19
Noncompliance	112	1	2	1	1.04	.21	4.47	18.31
Autonomy/ independence	112	1	7	6	4.85	1.89	-.75	-.79

Activity	112	4	7	6	5.56	.73	-.08	-.23
Verbalisations	112	2	7	5	4.63	1.45	.12	-1.18
Dyadic codes								
Reciprocity	112	1	6	3	2.74	.97	.36	.57
Conflict	112	1	1	1	1.00	/	/	/
Cooperation	112	1	2	1	1.11	.31	2.57	4.71

Table A2 Descriptive statistics of PARCHISY codes observed and scored during clean-up

Variables	N	Min	Max	Median	Mean	SD	Skewness	Kurtosis
Mother codes								
Positive content	65	1	6	4	3.82	1.58	-.15	-1.11
Negative content	85	1	3	1	1.28	.53	1.71	2.12
Positive affect	85	1	3	2	1.75	.65	.30	-.70
Negative affect	85	1	3	1	1.16	.40	2.38	5.18
Responsiveness	43	3	7	6	5.81	.98	-.87	1.29
Verbalisations	85	1	6	3	3.56	1.25	.32	-.46
Child codes								
Positive affect	85	1	3	1	1.52	.65	.88	-.28
Negative affect	85	1	3	1	1.12	.36	3.17	10.30
Responsiveness	49	2	7	5	4.57	1.24	-.20	-.41
Noncompliance	85	1	3	1	1.27	.52	1.80	2.45
Autonomy/ independence	85	1	7	5	5.01	1.46	-.47	-.33
Activity	85	3	6	5	5.09	.75	-.33	-.61
Verbalisations	85	1	6	3	2.80	1.24	.73	.45
Dyadic codes								

Reciprocity	85	1	4	1	1.58	.71	1.03	.51
Conflict	85	1	2	1	1.02	.15	6.40	39.90
Cooperation	85	1	2	1	1.01	.11	9.22	85.00

Table A3 Descriptive statistics of PARCHISY codes observed and scored during PC-DeFT

Variables	N	Min	Max	Median	Mean	SD	Skewness	Kurtosis
Mother codes								
Positive content	106	1	7	2	2.67	1.82	.75	-.61
Negative content	106	1	4	1	1.54	.76	1.14	.19
Positive affect	106	1	4	2	2.42	.74	.16	-.21
Negative affect	106	1	4	1	1.3	.59	2.11	4.65
Responsiveness	68	2	7	5	5.24	1.25	-.18	-.72
Verbalisations	106	1	7	3	3.53	1.36	.59	.16
Child codes								
Positive affect	106	1	5	3	2.48	.94	.09	-.23
Negative affect	106	1	5	1	1.71	.95	1.31	1.09
Responsiveness	79	2	7	4	3.92	1.27	.15	-.76
Noncompliance	106	1	4	1	1.38	.77	1.99	2.94
Autonomy/ independence	106	2	7	6	5.77	1.25	-1.16	1.06
Activity	106	4	7	6	5.64	1.10	-.08	-1.33
Verbalisations	106	1	7	3	3.25	1.17	.82	1.00
Dyadic codes								

Reciprocity	106	1	4	2	1.96	.89	.40	-.94
Conflict	106	1	2	1	1.03	.17	5.77	31.90
Cooperation	106	1	1	1	1.00	/	/	/

Appendix B

Operational manual of the Preschool Delay Frustration Task (P-DeFT)

B1. Task description

The Preschool Delay Frustration Task (P-DeFT) is developed based on the Delay Frustration Task (DeFT) created by Bitsakou et al. (2006). It is designed for a preschool aged population to measure children's responses when continuous presentation of a simple rewarded task was unexpectedly interrupted.

This task will be introduced to child participants as a fun and straightforward "shopping" game where they have to cross the road to visit a toy supermarket. In each trial of the game the participants will be

- presented with a red *Wait* signal and then asked to
- complete a two-stage task –
    - (a) to press a "crossing" button positioned at the side of their chair to change that signal to a green *Go-signal* and then to
    - (b) complete a shopping task at the toy supermarket which involves locating an object shown by the experimenter on a shopping card (with one grocery item pictured on it).

The only rule of the game for participant was to wait for the red *Wait* signal to change to a green *Go*-signal before going to find the item.

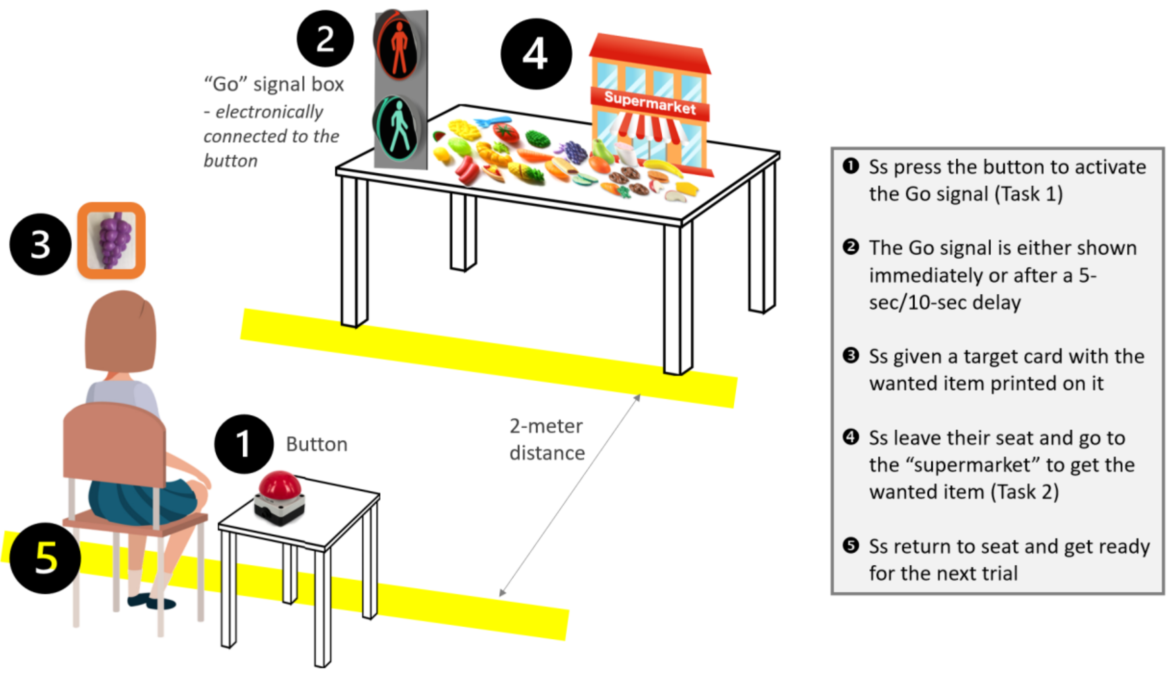
There is a total of 18 trials, with 3 conditions: no-delay, 5-sec delay and 10-sec delay. In the majority of trials (N=12), the green *Go-signal* will be shown immediately after the child presses the crossing button (i.e. no *pre-Go-signal* delay). In six trials, presented in a pseudo-random order, a *pre-Go-signal* waiting period will be imposed (either by 5-sec or 10-sec; three trials each). During this period, the *Wait* signal will continue to be shown until the waiting time is up and subsequently a green *Go-signal* will be shown. The number of remaining trials is displayed on the screen. Participants are not informed before the start of the task about the presence of these waiting periods but can be told that the crossing button is rather old and may occasionally be a bit slow to work. The measures of delay intolerance will be explained in the following.

B2. Task set-up

The P-DeFT should be conducted in a child-friendly room equipped with small furniture, including table and chairs. A computer/ laptop with the P-DeFT programme installed is required. A large monitor should be set to show the traffic light system clearly to the participants.

Opposite to where the child sits (2 meters away), researchers need to set a table with plastic toy food and groceries on it – an A4-sized "SUPERMARKET" sign should be put on the table. Next to the supermarket shows the traffic light system that is displayed on a monitor/ computer. Next to the where the child sits, a "crossing" button should be set on a side table in a way that the child can easily reach it.

Note that both the crossing button (USB port) and the traffic light system (HDMI/USB/Display port) have to be linked to the experimenter's laptop. Ensure the wire is secured in place to prevent slip and trips hazards.



B3. Materials needed

- Activity tracker
- Food and grocery toys
- USB 'crossing' button
- Shopping cards
- Computer program
- Large monitor (traffic light system) & cable
- Masking tape
- Manual and record forms

B4. Series of events during a trial

- Child participant must stay seated before the start of each trial.
- Child presses the crossing button to activate the green *Go-signal*
- The green *Go-signal* on the traffic system is either shown
    1. Immediately
    2. After a 5-sec *pre-Go-signal* delay

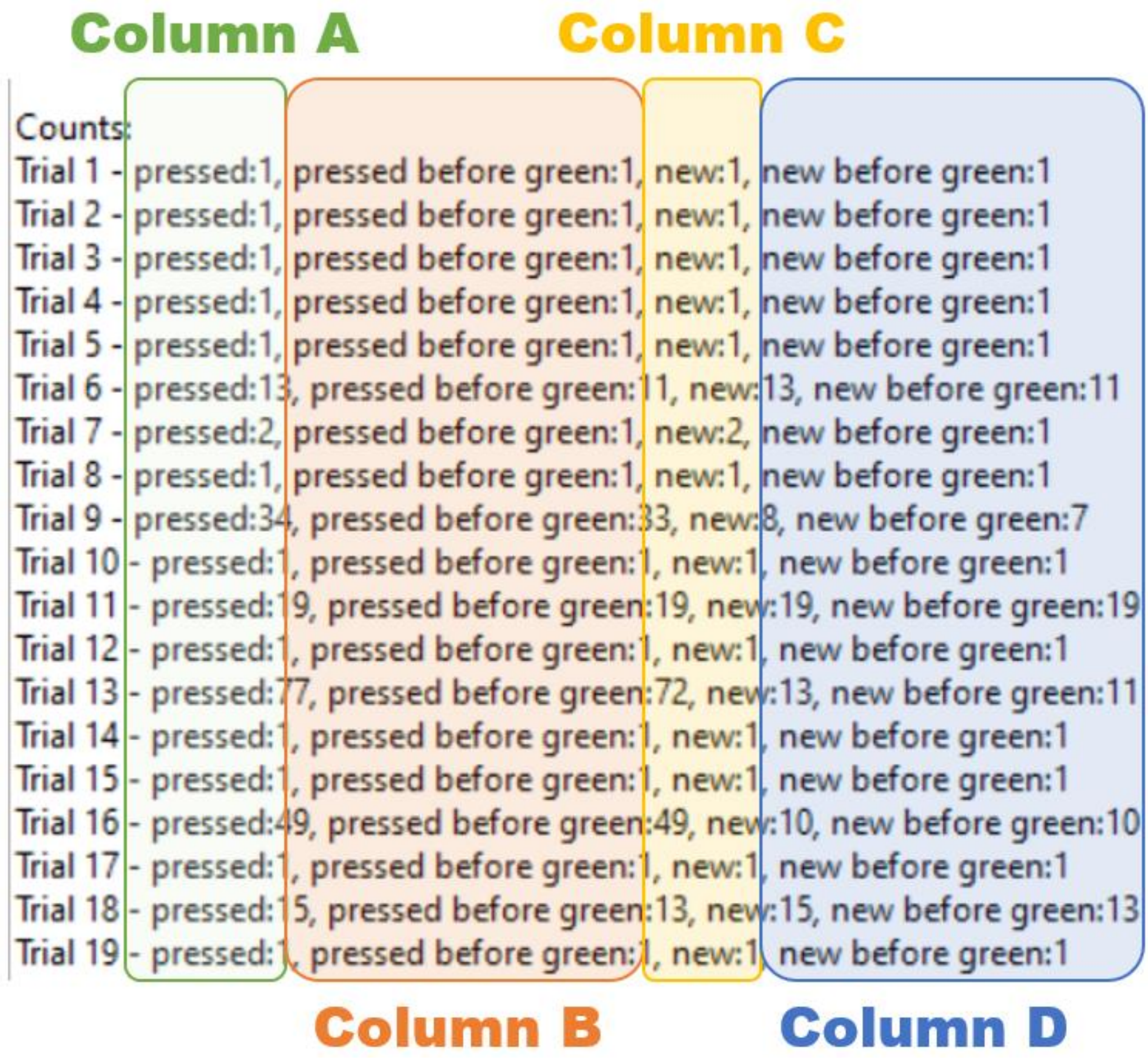
3. After a 10-sec *pre-Go-signal* delay

- During the *pre-Go-signal* delay, the green light will not appear no matter how hard/ frequent the child presses the button. All responses are recorded.
- After the green *Go-signal* appears, the experimenter will hand a shopping card (with target item on it) to the child
- Child then takes the corresponding item from the supermarket and gives it to the experimenter (it is not needed for experimenter/ child to put the items back to the supermarket)
- Child returns to his/her seat
- Experimenter presses *Space* key (to RESET the traffic light system to red) to proceed to next trial <u>once the child is seated</u>

B5. Presentation order (pseudo-random order)

Trial	Amount of delay (seconds)
1 (Demonstration)	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	5.0
7	0.0
8	0.0
9	10.0
10	0.0
11	5.0
12	0.0
13	10.0
14	0.0
15	0.0
16	10.0
17	0.0
18	5.0
19	0.0

B6. Program output file of P-DeFT (.Txt or .xlsx file)



Counts:
Trial 1 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 2 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 3 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 4 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 5 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 6 - pressed:13, pressed before green:11, new:13, new before green:11
Trial 7 - pressed:2, pressed before green:1, new:2, new before green:1
Trial 8 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 9 - pressed:34, pressed before green:33, new:8, new before green:7
Trial 10 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 11 - pressed:19, pressed before green:19, new:19, new before green:19
Trial 12 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 13 - pressed:77, pressed before green:72, new:13, new before green:11
Trial 14 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 15 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 16 - pressed:49, pressed before green:49, new:10, new before green:10
Trial 17 - pressed:1, pressed before green:1, new:1, new before green:1
Trial 18 - pressed:15, pressed before green:13, new:15, new before green:13
Trial 19 - pressed:1, pressed before green:1, new:1, new before green:1

- **Column A & B: Duration of button pressing during the delay trials**
- By default (typical computer settings), when you hold down a key on your keyboard, the key will be repeated until you release the key. Based on our complete data set, abundant testing shows that a held-down key is repeatedly emitted at an average rate of 1 per 30 milliseconds (26-55ms). The program records the number of emitted keys, i.e. if the child keeps pressing the button, the program will record the multiple key emittance, reflecting how <u>long</u> the child presses the button
- "Pressed before green" (column B) denotes the duration of button pressing *during* the pre-*Go* green signal. As some children did not release the key even when the signal turned green (or they didn't realise the key turned green), "Pressed" (column A)

denotes the duration of button pressing during the whole period before children leave their seat for the shopping task. Column B should be used if data DURING the delay is wanted.

- **Column C & D: Number of new/discrete button pressing**
  A new press is only counted when the children release the button before pressing the button again. New press can be counted by observations or by the program calculation. Repeated testing suggests that in the program output, if the time difference between two recorded emitted keys is more than 100 milliseconds (0.1s), the latter key should be counted as a new press.
- "New before green" (column D) denotes the number of discrete button pressing *during* the pre-*Go* green signal, while "New" (column C) denotes the number of button pressing during the whole period before children leave their seat for the shopping task. Column D should be used if data DURING the delay is wanted.

- For illustration, using the following spreadsheet as an example, during the 10s delay period, the child pressed the button for the first time at 20:38:13, then pressed another time after 1s72ms. On the child's third press, he/she was observed holding the key and the time difference between entries on the output is around .032 to .033s. Experimenters do not need to look at the time difference between presses manually, the output file (second figure as shown above) summarised the duration and number of presses during the delay period (column B, D).

20:38:12.684	16	Examiner	_: Reset with 10.0s delay		Time difference	Pressed	Pressed before green	New	New before green
20:38:13.115	16	Child	Pressed					1	1
20:38:14.187	16	Child	Pressed		00:00:01.072	125	120	2	2
20:38:14.682	16	Child	Pressed		00:00:00.495			3	3
20:38:14.714	16	Child	Pressed		00:00:00.032				
20:38:14.747	16	Child	Pressed		00:00:00.033				
20:38:14.780	16	Child	Pressed		00:00:00.033				
20:38:14.813	16	Child	Pressed		00:00:00.033				
20:38:14.845	16	Child	Pressed		00:00:00.032				
20:38:14.878	16	Child	Pressed		00:00:00.033				

- User can also calculate "Time used in the shopping task" to investigate if children perform differently in the post-*Go*-signal shopping task in trials with and without delay
- "Time used in the shopping task" = time between "System - Turned traffic light GREEN" and "Reset with n.0s delay"

09:45:57.719850 - 3 - System - Turned traffic light GREEN
09:47:07.372057 - 4 - Examiner - _: Reset with 0.0s delay
09:47:11.191066 - 4 - Child - Pressed
09:47:11.244608 - 4 - System - Turned traffic light GREEN
09:48:24.351138 - 5 - Examiner - _: Reset with 0.0s delay
09:48:29.598994 - 5 - Child - Pressed
09:48:29.665472 - 5 - System - Turned traffic light GREEN
09:49:37.924829 - 6 - Examiner - _: Reset with 5.0s delay
09:49:43.895065 - 6 - Child - Pressed
09:49:44.751016 - 6 - Child - Pressed
09:49:47.878886 - 6 - Child - Pressed
09:49:48.630999 - 6 - Child - Pressed
09:49:48.916751 - 6 - System - Turned traffic light GREEN
09:51:00.844945 - 7 - Examiner - _: Reset with 0.0s delay

- Experimenters have to be very precise about when exactly to press "Reset" – experimenters should press Reset (space key) once the child returns to his/her seat and gets seated

B7. Task instructions

"In this game, if you want to win points, you need get the right things from the supermarket over there (point to the table with food and grocery toys). *The points will let you win stickers.*

But look, there is a traffic light there with a red man (point to the monitor display). *You can only leave your seat and go to the shop when that turns green. To do this, you have to press this big white crossing button.*

You may try to press it now (let child press the crossing button once; the traffic light turns green). *See, it turns green.*

When the light turns green, I will give you a card like this (show the card). *You can then go there and get the right thing for me. You will get one point if you do that.*

You may try to go there and get the right thing for me now (hand the card to child and let him/her go).

Good job/ good try (child gets the right/ wrong item). *Please come back and sit down immediately each time after you give it to me and get ready for the second round* (reset the traffic light to red).

One last thing, we are sorry that this button is bit old, but don't worry, although sometimes it works a bit slowly, it should turn green after you have pressed it. BUT please remember, YOU CAN ONLY LEAVE THE SEAT until you SEE THE GREEN LIGHT.

Do you understand what you have to do?

Shall we start the game now?"

**Remember to reset the traffic light to red after the child returns to his/her seat.*

If the child attempts to leave the seat before seeing the green light, stop him/her and remind:

"Please stay in the seat until you see the green light"