Feasibility of an Online Acute Stressor in Preschool Children of Mothers with Depression

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Abstract

Maternal depression is a risk factor for future mental health problems in offspring, with stress-system function as a candidate vulnerability factor. Here we present initial validation of an online matching-task paradigm in young children exposed to maternal depression (N=40), a first in stressor-paradigm research for this age group. Investigations of stress-system reactivity that can be conducted online are an innovative assessment approach, accelerated by the COVID-19 pandemic. Results indicate high feasibility, with ~80% success across measures, similar-to or better-than in-person success rates in young children. Overall, the online matching task elicited significant HR but not cortisol reactivity. Individual differences in child mental health symptoms were a moderator of reactivity to the stressor such that children with lower, but not higher, behavioural problems exhibited the expected pattern of cortisol reactivity to the online matching task. Results are aligned with allostatic load models, which suggest down-regulation of stress-system reactivity as a result of experiencing adversity and mental health vulnerability. Consistent with in-person research, this suggests an early phenotype for the emergence of behaviour problems may be linked to altered stress-system reactivity. Results hold potential clinical implications for intervention development and the future of online stress-system research.

Keywords: acute stress, cortisol, young children, online assessment, behavioural problems

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Early childhood is a critical developmental period, with heightened sensitivity to adversity and programming of stress response systems (Loman & Gunnar, 2010). The COVID-19 pandemic has presented challenges in acute stress research, while also offering a unique opportunity to develop remote assessment techniques. Although online stress research has emerged in adults and adolescents, no studies to date examine childhood samples (Zimmer et al., 2019). Here, we present an initial evaluation of an online stressor paradigm in activating cardiac (i.e. heart rate, HR) and hypothalamic-pituitary-adrenal-axis systems (HPAA; i.e. cortisol) responses in young children exposed to maternal depression. We further consider the moderating role of children's own mental health symptoms.

The preschool age range is a notoriously challenging period for inducing cortisol reactivity, theorized to be linked to the downregulation of HPAA and limited developmentally appropriate tasks that include social evaluation, uncontrollability, unpredictability, and goal blocking (Gunnar et al., 2009). A challenging matching-task stressor is amongst the most widely used. Recent studies have had inconsistent results highlighting the importance of both task factors and individual differences in understanding stress-system reactivity and assessment contexts (Kryski et al., 2011; Roos et al., 2017).

Early relationships set the foundation for emotional development, with exposure to maternal depression in the infant - preschool years linked to the emergence of children's own mental health problems as well as altered stress-system reactivity (Letourneau et al., 2013).

Abnormal stress-system function has been linked with both internalizing and externalizing behaviour problems (Doom & Gunnar, 2013). There have been mixed findings regarding the pattern and direction of effects, where both heightened and blunted reactivity can indicate vulnerability. Blunted cortisol reactivity is particularly associated with children's mental health problems, following adversity exposure (Jaffee, 2015).

Studying stress reactivity in a sample that is broadly at risk for mental health problems is crucial for understanding to what HPAA and cardiac function may be linked to emergent child behaviour problems. The aim of the present study is to use the matching task stressor paradigm and pilot test it for

use as a virtually delivered paradigm through the Zoom online platform. It is predicted that the virtual task will be effective at eliciting stress-system responsivity (i.e., reactivity and recovery) across cardiac and cortisol indices. Individual differences in child behaviour problem symptoms were also explored as moderators in responsivity.

Methods

Participants and Procedure

Preschool aged children ($N = 40$, age 2.83–5.99 years, $M = 4.30$, 16 female) with a wide range of household incomes (median = \$50,001 –\$60,000; range \$<\$10,000–\$140,000+) and maternal education (median = college/technical school, range= high school to graduate/professional degree). Families completed this assessment as part of a mental health program; as such, mothers were required to meet criteria for a Major Depressive Episode (Roos et al., 2020).

Assessments were 1.5 hours, beginning between 8:30-10:30 am; children awoke at least one hour prior, and did not consume food at least half-an-hour, prior to assessment. Assessments occurred in participants' home via the secure Zoom platform while assessors presented a PowerPoint, which included a variety of tasks, both before and after the matching tasks (i.e. cognitive tasks, free play; not reported here). Saliva samples occurred before and following the matching task, and 15-, 30-, and 45-minutes post-task.

Matching Task

Task materials are available at: <https://osf.io/b6hz5/>. The matching task paradigm was modified from previous studies (Roos et al., 2017; Kryski et al., 2011). During the task, a new assessor entered the Zoom whose demeanor was neutral, non-reinforcing and “principal-like”. Mothers were asked to sit further away from the child and instructed not to intervene during task. The new assessor helped the child select a desired prize. Children were instructed to match different coloured stickers to five different picture types (30 total) in three minutes, which is insufficient time for young children to complete the task. A stoplight, accompanied by a ticking noise, was present on screen during each round which indicated the time remaining (i.e., “green means lots of time, yellow means time is running out, red means

time is up”). During each trial, the assessor said two negative feedback statements (e.g., “you’re too slow”). After three failed attempts, the assessor told the child they did not win their prize and left the call. Then, the familiar assessor returned.

Child Mental Health

Mothers reported on their children’s mental health symptoms using the Child Behavior Checklist, which has excellent psychometrics and is widely used (CBCL; Achenbach and Rescorla, 2000). Total problem scores were used in the present study and similar to population norms ($M = 47.26$, $SD = 25.21$).

Cortisol

Salivary cortisol was sampled throughout the visit using Salivette cotton swabs delivered to families with numbered labels (Sarstedt, Inc., Newton, NC). Assessors trained mothers to collect saliva. Samples were sent to University of Trier to be assayed in duplicate (inter-and intra-assay); values were averaged across duplicate assays with coefficients of variants not varying more than 10%. Due to data skew, cortisol values were natural log-transformed (Dettling et al., 2000). One participant’s cortisol results were not biologically possible, and their data was removed from the sample. Child refusal resulted in ten participants being excluded from cortisol reactivity analyses. Reactivity was characterized as the difference between 0- and 15-minutes post stressor.

HR

Mother and child HR was measured throughout the assessment via Fitbit watches. Data output was HR at 1-minute increments across the assessment. HR reactivity across blocks of time were averaged and examined for change relative to the baseline measures, which were the tasks immediately prior to and following the matching task. Child refusal resulted in nine participants being excluded from HR reactivity analyses. Descriptive data for all biological measures are presented in Table 1.

Results

Repeated-measures ANOVAS were used to examine effects of Time and Mental Health symptoms (i.e. CBCL scores) on stress-system reactivity. CBCL was first included as a continuous variable, with follow-up ANOVAs on dichotomised CBCL scores median split into higher and lower

groups (at a score of 50). Paired samples t-tests were used to examine cortisol reactivity between lower and higher CBCL groups. Bivariate and point-biserial correlations examined stress-system reactivity variables and potential covariates including child age, child sex, maternal education and household income.

Cortisol

Repeated-measures ANOVAs were used to assess the impact of the matching task on cortisol reactivity across time, with CBCL scores as a within-subjects factor. There was no significant main effect of time on cortisol levels [$F(2.57, 66.80) = .867, p = .45$]. There was a significant interaction between time and CBCL scores [$F(2.57, 66.80) = 3.15, p = .04, \eta p^2 = .12$], with within-subjects contrasts identifying a linear [$F(1, 26) = 6.22, p = .02$] trend. There were no significant between-subjects effects. Results indicate that the matching task did impact cortisol over time, contingent on CBCL scores.

A follow-up repeated measures ANOVA, with CBCL scores median split into higher and lower scores also indicated a significant interaction between time and CBCL scores [$F(2.53, 65.80) = 3.08, p = .04, \eta p^2 = .12$], with different linear trends as a function of CBCL score [$F(1, 26) = 4.70, p = .04$].

These effects reflect different patterns between groups (Figure 1a) such that children with lower CBCL scores had cortisol trajectories that produced a steep rise ~15-minutes post matching task, then recovery ~30-minutes post matching task. Children with higher CBCL scores had cortisol trajectories that continually decrease post matching task.

Post-hoc independent sample t-tests on the differential patterns examined cortisol reactivity (T3-T2), with significant differences between higher ($M = -.20, SD = .48$) and lower ($M = .28, SD = .43$) CBCL children in cortisol reactivity [$t(27) = 2.83, p = .01$]. Cortisol reactivity was not associated with any sociodemographic characteristics.

HR

Repeated-measures ANOVAs indicated a main effect of time on HR [$F(2.75, 79.77) = 2.822, p = .05, \eta p^2 = .10$]. No interaction between time and CBCL [$F(2.75, 79.77) = 1.6, p = .19, \eta p^2 = .06$] was

found for HR, but contrasts identified a cubic [$F(1, 29) = 4.88, p = .04$] trend. There were no between-subjects effects.

As with cortisol, CBCL scores were split into higher and lower conditions to determine if the level of score impacted HR. The interaction between time and higher and lower CBCL scores indicated a marginal difference in HR based on CBCL [$F(2.80, 81.24) = 2.50, p = .07, \eta p^2 = .09$], with a cubic [$F(1, 29) = 5.06, p = .03$] effect. A line graph illustrates this difference (Figure 1b).

Independent t-tests were used to examine if HR reactivity differed between high and low CBCL groups. The results showed a similar pattern as cortisol, with differences between the higher ($M = -4.51, SD = 7.25$) and lower ($M = 3.82, SD = 7.22$) CBCL conditions in HR reactivity [$t(29) = 3.21, p = .003$]. HR was not associated with any of the sociodemographic characteristics. Cortisol reactivity was associated with HR reactivity ($r = .40, p = .03$).

Discussion

Here we provide initial evidence for an online adaptation of the matching task stressor in a sample of preschool-aged children at-risk for mental health problems. Innovations in remote assessment techniques offer promise for research programs during the COVID-19 pandemic and future efforts towards a more accessible psychological science that reduces barriers to in-person research. Results highlight the feasibility of remote stress-system assessments in families of young children managing stressors such as parent mental illness.

Cortisol reactivity was linked to child mental health problems such that, children with lower but not higher mental health symptoms exhibited cortisol reactivity. HR exhibited more consistent reactivity to the matching task, with a main effect of time and only marginally significant associations with child mental health problems. The virtual matching task stressor is a promising task for assessing stress-system reactivity in young children. Important individual differences may also exist, particularly in samples with adversity exposure.

Findings regarding blunted cortisol reactivity in children with higher mental health symptoms are consistent with prior research in children exposed to early adversity. Maltreated or bullied children have

exhibited blunted cortisol reactivity, compared to controls, with blunted reactivity associated with more subsequent behavioural problems (Ouellet-Morin et al., 2011). Children who experienced a trauma and had parents who were less responsive exhibited both lower cortisol reactivity and increased incidence of mental health problems (Jaffee et al., 2015).

HR reactivity to the matching task was robust, with main effects of the stressor manipulation across participants. HR is considered a reliable measure of stress-system activation and represents in-the-moment reactivity more so than cortisol (Gunnar et al., 2009). The interaction between time and child mental health symptoms was marginally significant, with simple effects indicating that lower mental health symptom children exhibited significant reactivity, while the higher mental health symptom children did not.

Results are broadly consistent with allostatic load models, which suggest that following persistent early exposure to chronic stressors, such as reduced parenting sensitivity linked to maternal depression, the HPA axis down regulates to protect biological functions from excessive cortisol exposure. Maternal depression has previously been associated with blunted responsivity in offspring, with children of mothers with the most severe symptoms exhibiting the most blunted cortisol reactivity (Lawler et al., 2019). Blunted HR reactivity has also been found in samples of children exposed to environmental adversity such as low socioeconomic status and urbanicity (Evans et al., 2013). In adults, some research indicates adversity is linked to blunted cortisol, but not HR reactivity (Cărnăușă et al., 2015), while other work suggested that childhood adversity is linked to both lower HR and cortisol reactivity (Lovallo et al., 2012). More research is needed elucidate the relationships between stress-system profiles and mental health in at-risk samples.

Methodological strengths include standardization efforts (i.e. time of day, PowerPoint slides, assessor scripts). Limitations include the small sample and clinical specificity, which may limit generalizability. However, this is a meaningful sample in which to study stress-system vulnerability and mental health given that children are at risk for mental illness due to both genetic and environmental effects. Future research should examine the virtual stressor in a larger representative sample. Remote

assessments can increase accessibility and reduce novel aspects of the lab environment, but also limit control over factors such as parental involvement and room composition, despite research team efforts to manage possible confounders.

The preschool age has been identified as critically important for stress-system development and vulnerability to maternal depression. The development of effective stressor paradigms is crucial for understanding this effect and the extent to which stress responsivity is linked to child mental health. The present study found evidence to support the virtual matching task as an effective stressor, with stress-system reactivity varying in terms of identified mental health symptoms in an at-risk sample. This study aids in our understanding of the factors linked to stress-system reactivity and may inform interventions that promote mental and behavioural health in children exposed to adversity and their families.

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Table 1

Descriptive Statistics for Biological Measures Across Time

	Total <i>M</i> (<i>SD</i>)	Lower CBCL <i>M</i> (<i>SD</i>)	Higher CBCL <i>M</i> (<i>SD</i>)
Cortisol (LnT nmol/L)			
Baseline	1.33 (.75)	.96 (.55)	1.13 (.77)
0 min post MT	1.19 (.70)	.66 (.51)	.85 (.77)
15 min post MT	1.11 (.40)	.94 (.81)	.65 (.61)
30 min post MT	1.09 (.09)	.75 (.79)	.55 (.65)
45 min post MT	.87 (.36)	.83 (.64)	.60 (.69)
HR (BPM)			
Stroop average	105.58 (19.81)	104.57 (14.30)	108.87 (9.35)
MT first half	100.95 (22.69)	107.21 (13.94)	107.24 (12.09)
MT second half	108.13 (22.36)	109.44 (14.29)	104.15 (12.08)
MT reunification	108.60 (18.00)	108.89 (15.13)	105.95(14.67)

Note. LnT nmol/L = natural log-transformed nanomole per litre; BPM = beats per minute; MT = matching task; CBCL = Child Behaviour Checklist.

Figure 1

Effects of acute stressor task on biological levels across time. Error bars represent standard errors. LnT nmol/L = natural log-transformed nanomole per litre; BPM = beats per minute; MT = matching task; CBCL = Child Behaviour Checklist.