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Impact of maltreatment on depressive symptoms in young male adults: The mediating and moderating role of cortisol stress response and coping strategies

Christina Y. Cantave[a], Stephanie Langevin[a], Marie-France Marin[b,c], Mara Brendgen[c,d], Sonia Lupien[b,e], Isabelle Ouellet-Morin[a,b,*]

[a] School of Criminology, University of Montreal, Montreal, Canada
[b] Centre for Studies on Human Stress, Research Center of the Montreal Mental Health University Institute, Montreal, Canada
[c] Department of Psychology, University of Quebec at Montreal, Canada
[d] Sainte-Justine Hospital Research Center, Montreal, Canada
[e] Department of Psychiatry, University of Montreal, Montreal, Canada

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ABSTRACT

Background: Converging evidence suggests that maltreated children suffer from depression at an early age and experience recurrent episodes of depression that persist over longer periods of time. However, the stress-related mechanisms hypothesized to be implicated in these associations remain to be specified. The present study tested the mediating and moderating roles of acute cortisol response to stress and coping strategies in the association between child maltreatment and depressive symptoms in early adulthood.

Methods: Data from 156 men aged 18 to 35 years (n = 56 maltreated) were collected using self-reported questionnaires assessing child maltreatment, depressive symptomatology and coping strategies. Cortisol was measured in response to the "Trier Social Stress Test" (TSST).

Results: Although acute cortisol response to stress did not mediate the maltreatment-depressive symptoms association, a moderation effect was found. Child maltreatment was associated with higher risk of depressive symptoms among participants with a higher cortisol response to stress, but not for those with moderate-to-lower cortisol responses. Additionally, maltreated participants reported more depressive symptoms, an association that was partly explained by their higher use of emotion-oriented coping (mediation). Finally, maltreated individuals who reported using less task-oriented coping had greater depressive symptomatology than those who adopted this coping strategy more frequently (moderation).

Conclusion: These findings extend prior work examining the role of the hypothalamic-pituitary-adrenal (HPA) axis in the etiology of depression. The results draw attention to coping strategies, in addition to acute cortisol response to stress, as potential targets for mitigating the onset of depressive symptoms in adults maltreated as children.

1. Introduction

Converging evidence suggests that child maltreatment is a major risk factor for depression, contributing to a higher prevalence of recurrent and persistent episodes (Gilbert et al., 2009; Nanni et al., 2012). However, the relative importance of the stress-related mechanisms underlying this association requires more attention and their exact roles need to be specified. One potential risk pathway linking child maltreatment to depressive symptoms involves the hypothalamic-pituitary-adrenal (HPA) axis and its end-product cortisol (McEwen and Stellar, 1993). When individuals are exposed to stressful situations, the HPA axis triggers the secretion of cortisol to meet the metabolic needs of the individual. Under conditions of chronic and repeated stress, however, prolonged, excessive or insufficient mobilization of the HPA axis may lead to a cascade of physiological changes that could subsequently jeopardize mental and physical health (McEwen and Stellar,

* Corresponding author at: School of Criminology, University of Montreal, C.P. 6128, succursale Centre-ville, Montreal, QC, H3C 3J7, Canada.
E-mail addresses: yamiley.christina.cantave@umontreal.ca (C.Y. Cantave), stephanie.langevin@umontreal.ca (S. Langevin), marin.marie-france@uqam.ca (M.-F. Marin), brendgen.mara@uqam.ca (M. Brendgen), sonia.lupien@umontreal.ca (S. Lupien), isabelle.ouellet-morin@umontreal.ca (I. Ouellet-Morin).

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1993). Yet, how an individual physiologically responds to stress does not capture well the cognitive and behavioral processes also activated following the perception of stress. In this study, we tested the distinct, albeit potentially complementary roles of acute stress cortisol secretion and coping strategies in the association between child maltreatment and depressive symptoms. In particular, we examined whether these mechanisms explain (i.e., mediate) this association or whether they rather signal for whom this association occurs (i.e., moderation).

Acute cortisol response to stress has long been hypothesized as a mediator in the maltreatment-depression association. Specifically, child maltreatment is expected to induce atypical cortisol responses to stress, which subsequently lead to changes in the brain structures involved in the regulation of the HPA axis (e.g., amygdala, frontal lobes, hippocampus). In turn, disrupted cortisol responses to stress should increase later risk for depressive symptomatology (Shonkoff et al., 2012). Consistent with this hypothesis, previous investigations conducted among individuals maltreated as children have detected atypical cortisol responses to stress, which generally involve lower, but sometimes also higher cortisol responses to a psychosocial challenge (Harkness et al., 2011; Heim et al., 2000; Ouellet-Morin et al., 2018). Also consistent with a mediating role of acute cortisol response to stress, are the findings revealing higher (Heim et al., 2000; Powers et al., 2016) and lower (Zorn et al., 2017) responses to stress in depressed individuals. Part of these inconsistent findings may depend on measurement variations such as the timing of stressors (number of samples, morning versus afternoon testing) as well as sociodemographic sample differences (e.g., age, sex). However, these bivariate associations offer only circumstantial evidence that acute cortisol response to stress may partly explain higher levels of depressive symptoms in individuals who were victims of child maltreatment. To the best of our knowledge, only one study has directly tested this possibility (i.e., mediation), reporting that cortisol response to stress did not explain the association between childhood adversities (e.g., maltreatment and poverty) and internalizing symptoms among adolescent boys and girls (Busso et al., 2017). In sum, despite theoretical arguments suggesting that acute cortisol response to stress partly explains higher risk of depression following child maltreatment, empirical evidence supporting the mediation hypothesis remains scarce.

An equally plausible hypothesis is that acute cortisol response to stress may not serve as a mediator of the maltreatment-depressive symptoms association, but instead may signal a higher susceptibility to the depressogenic effect of child maltreatment (i.e., moderation). However, only a few studies have evaluated the moderating role of cortisol supporting, for the most part, this hypothesis, whereby maltreated individuals reported higher risks of depression if they showed a higher acute cortisol response to stress (Hagan et al., 2014; Kuhlman et al., 2018). For example, Hagan and colleagues reported that the association between maltreatment and internalizing symptoms was stronger among young adults who exhibited higher cortisol responses to a conflict role-play task (Hagan et al., 2014). Taken together, cortisol response to stress has been proposed to explain why (i.e., mediation) and for whom (i.e., moderation) exposure to child maltreatment increases later depressive symptoms. However, few studies to date have tested these propositions directly. Importantly, to the best of our knowledge, only one study has tested these distinct hypotheses (i.e., mediation vs. moderation) within the study to clarify the role of basal cortisol levels in the etiology of depression (Badanes et al., 2011). Their results supported the moderating role of cortisol, whereby adolescent boys and girls exposed to more stressors (e.g., family, school and friendship-related stress) and who secreted lower cortisol levels during a laboratory visit had higher levels of depressive symptomatology. Evidence for the mediating role of cortisol was not found. Given that these authors did not focus on maltreatment or cortisol response to stress, it remains unclear whether the latter plays a mediating or a moderating role in the maltreatment-depression association.

The cortisol stress response may not be the only stress-related mechanism involved in the maltreatment-depression association. The consideration of psychological-based processes such as coping strategies may be especially relevant in this context as they may shed additional light onto the cognitive and behavioral reaction to stress. Existing findings suggest that avoidance (distraction from the stressful encounter) and emotion-oriented coping strategies (regulating the emotional response) are associated with higher cortisol reactivity, whereas task-oriented coping strategies (altering or managing demanding situations) are related to lower cortisol reactivity (Endler and Parker, 1994; Janson and Rohleder, 2017; Lazarus and Folkman, 1984). In the context of maltreatment, children may adopt emotion-oriented and avoidance coping strategies more frequently considering their urgent need to rapidly reduce acute distress, shame and helplessness (Hager and Runtz, 2012; Lazarus and Folkman, 1984). Previous studies have also reported a greater use of avoidance and emotion-oriented coping strategies among sexually abused females as a way to deal with stressful situations (Walsh et al., 2010). However, a greater inclination to use avoidance and emotion-oriented strategies has been related to higher psychological distress and psychopathology (e.g., depression) in adults who were maltreated as children (Walsh et al., 2010). In contrast, the use of task-oriented coping strategies was found to predict fewer internalizing symptoms (Compas et al., 2001). Current conceptualizations thus suggest that maltreatment may increase later recourse to avoidance and emotion-oriented coping strategies and reduce the use of task-oriented strategies to deal with stress, which, in turn, may increase the risk of depression (i.e., mediation). Findings tend to support this hypothesis (Choi et al., 2015; McQuaid et al., 2015; Merrill et al., 2001; White Hughto et al., 2017). For instance, Choi and colleagues (2015) reported that adult women seeking antenatal care and who were maltreated as children were more inclined to adopt avoidance and emotion-oriented coping strategies, which were associated with higher levels of depressive symptoms. However, nonsignificant results regarding the mediating role of avoidance-oriented coping strategies have also been documented (Goodkind et al., 2009; McQuaid et al., 2015). Together, existing findings suggest that coping strategies may partly explain the maltreatment-depressive symptoms association, with the caveat that these studies have mainly focused on avoidance coping strategies.

Alternatively, coping strategies have also been hypothesized to serve as a moderator that signals for whom exposure to maltreatment may exacerbate (or mitigate) the risk for depressive symptoms. To the best of our knowledge, only one study has reported that avoidance-oriented coping strategies affected the association between child sexual abuse and psychological adjustment, including depression (Merrill et al., 2001). Given that the authors did not formally test the conditional effect of these strategies (i.e., sexual abuse x avoidance), it remains unclear if the higher levels of depression reported in abused women who use more avoidance coping are significantly distinct from those who rely less frequently on these strategies. Additionally, other studies reported higher risks for depression following trauma (e.g., bullying and terrorism) in individuals who use more emotion- and avoidance-oriented coping strategies (Aldwin and Revenson, 1987; Garnefski and Kraaij, 2014). In contrast, individuals who use more often flexible, optimistic and creative coping strategies following traumatic experiences showed lower risks of depression (Sinclair et al., 2016). Taken together, existing evidence suggests that coping strategies may mediate and/or modulate the association between child maltreatment and adult depressive symptoms, although stronger evidence has been observed for the former hypothesis. However, most studies have focused on sexually abused females, which limits the generalizability of findings to men and other forms of maltreatment (Walsh et al., 2010). Furthermore, only one study so far has simultaneously examined both the mediating and the moderating roles of coping strategies in that association (see Merrill et al., 2001).

This study aimed to extend current evidence suggesting that acute cortisol response to stress and coping strategies may play a role in the association between child maltreatment and adult depressive

symptoms. Specifically, two research questions were investigated. First, we tested whether acute cortisol response to stress and/or coping strategies partly explains the association between maltreatment and depressive symptoms (i.e., mediation). Second, we examined whether maltreated participants are more likely to report higher levels of depressive symptoms if they secrete higher (or lower) cortisol responses to stress or if they reported using more frequently avoidance and emotion-oriented coping strategies and fewer proactive strategies (i.e., moderation).

2. Methodology

2.1. Participants

The sample included 156 male participants aged between 18 and 35 years. The study sample was part of a larger project aiming to understand the biosocial roots of aggression. Given that men are more frequently engaged in these behaviors than women (Archer, 2004), the sample for the present study only included men, as we did not have the statistical power required to adequately test sexually dimorphic associations. Additionally, young adulthood was targeted considering that they are particularly at risk for mental health problems (Hagan et al., 2014) and because the study objectives are more rarely examined at this period of development than in childhood. To avoid learning effects, only participants who had never taken part in the TSST were included in the present study.

2.2. Procedures

Participants were recruited using ads posted online and on public billboards inviting them to participate in a study about early life experiences. Trained research assistants conducted a phone interview with interested individuals, screening for health and experiences of child maltreatment. Eligible participants were invited to the study, which lasted about 3 h 30 min. Upon their arrival at the laboratory, participants were once more informed about the study procedures after which they provided signed consent. The visit comprised the completion of the Trier Social Stress Test (TSST) 30 min following their arrival. The TSST is a well-established standardized stress paradigm that induces a social-evaluative threat, before and after which saliva samples were collected for cortisol measurement. Following instructions, participants were given 5-minutes to prepare for the test. They were later subjected to a 5-minute mock job interview in front of a "panel of behavioral experts," followed by 5-minutes of mental arithmetic. Participants communicated with the panel using an intercom and were filmed with a video camera in a stand-up position in front of a one-way window (Andrews et al., 2007). Both the "panel-in" and "panel-out" methods have been shown to elicit reliable cortisol responses in laboratory settings (Andrews et al., 2007). The TSST took place in the early afternoon for all participants (M = 13:41, SD = 0:53). Subsequently, participants responded to self-report questionnaires measuring coping strategies and depressive symptoms. Ethical approval was granted by the Research Center of the Montreal Mental Health University Institute Ethics Committee (Canada).

2.3. Measures

The short form of the *Childhood Trauma Questionnaire* (CTQ-SF) enquires about emotional, physical and sexual abuse and neglect that have occurred before age 18 (Bernstein et al., 2003). Participants responded to each of the 28 items of the CTQ-SF in the context of "when you were growing up"and answered using a five-point Likert scale ranging from "never true" = 1 to "very often true" = 5, leading to total scores of 5 to 25 on each subscale (plus three validity items). The CTQ-SF included items such as "People in my family said hurtful or insulting things to me" (Emotional Abuse) and "I was punished with a belt, a board, a cord, or some other hard object" (Physical Abuse). The CTQ has good internal consistency and criterion validity in clinical and community samples and a high convergent reliability with clinical assessments of abuse (Bernstein et al., 2003). We identified 56 men (35.9%) who reported experiences suggesting the occurrence of at least one type of maltreatment using the manual's recommended classification scores (Bernstein and Fink, 1998). The experiences of the remaining participants (n = 100) did not reach that threshold.

Acute cortisol response to stress was measured through the collection of five saliva samples via passive drool. The first two samples were collected 20 (T1) and 2 min (T2) before the TSST. The third (T3), fourth (T4) and fifth (T5) samples were obtained 15, 25 and 35 min after the beginning of the TSST. Saliva samples were stored in a −20 °C freezer and analyzed in a single batch with a high sensitivity enzyme immune assay kit (Salimetrics State College, PA, Catalogue No. 1-3102). The range of detection for this assay was between 0.012 and 3 ug/dL and the intra- and inter-assay coefficients of variation were 4.1% and 8.3%, respectively. All samples were assayed in duplicates, winsorized and log-transformed prior to statistical analyses. Of note, few individual samples were winsorized according to a cut-off score of 3 SD from the mean (T1: n = 2; T2: n = 0; T3: n = 3; T4: n = 4; and T5: n = 3).

The *Coping Inventory of Stressful Situations* (CISS) is a 48-item self-reported instrument assessing individuals' tendency to adopt coping strategies in response to stressful situations encountered in their daily lives (Endler and Parker, 1994). The CISS comprises three subscales of 16 items each, measuring task-oriented (e.g., coming up with different solutions to a problem), emotion-oriented (e.g., blaming myself for not knowing what to do), and avoidance-oriented coping strategies (e.g., going out for a snack or meal). Items were rated on a 5-point Likert-type scale with responses ranging from "not at all" = 1 to "very much" = 5. Subscale totals were derived by adding up the respective item scores. In this sample, the scores varied from 34 to 77 (M = 58.18, SD = 10.10) for task-oriented (α = .89), from 20 to 75 (M = 42.77, SD = 9.94) for emotion-oriented (α = .81) and from 18 to 69 (M = 39.13, SD = 11.09) for avoidance-oriented (α = .86) coping subscales, which parallel those reported in a normative sample of adults (Endler and Parker, 1999).

Participants reported about their depressive symptoms during the last two weeks with the *Beck Depression Inventory-II* (BDI-II; Beck et al., 1996), a widely used 21-item instrument adapted to clinical and non-clinical populations. Symptoms were rated on a 4-point Likert-type scale ranging from "not present" = 0 to "severe" = 3, with higher scores denoting more depressive symptomatology. The total scale was calculated by summing up all item scores (α = .87). Participants' responses varied from 0 to 44 (M = 10.48, SD = 8.79) in this sample, which is similar to those reported in a normative sample of young adults (Storch et al., 2004).

2.4. Statistical analyses

We conducted preliminary analyses to examine whether participants exposed to child maltreatment differed from those without maltreatment experiences in regard to their sociodemographic and lifestyle characteristics (Table 1). We asked about the participants' age, whether they were students or employed, their highest obtained educational degree, smoking, alcohol and drug consumption, and whether they had influenza in the past month. Results showed that maltreated participants were more likely than their nonmaltreated counterparts to have had influenza in the past month. This variable was thus controlled in all analyses. We derived participants' cortisol response to the TSST using a conditional latent growth model (LGM) in Mplus (Version 7.4; Muthén and Muthén, 1998–2012). LGM was selected because it allows the simultaneous estimation of two parameters: the baseline level (i.e., Intercept; sample taken two minutes before the TSST) and the response to the TSST (i.e., Slope). From this initial model, we identified – from a wide range of potential covariates (e.g., medication, cigarettes, drug

Table 1
Sociodemographic and lifestyle characteristics of nonmaltreated and maltreated participants.

Characteristics	Nonmaltreated n = 100	Maltreated n = 56		
	Mean (SD) or Percentage (n)	Mean (SD) or Percentage (n)	χ^2	*t*
Age	24.10 (3.78)	24.09 (3.60)		−.02
Single (vs married/common-law partner)	85% (85)	87.5% (49)	.18	–
Student (vs employed/unemployed)	62% (62)	69.6% (39)	.92	–
College or university degree (vs high school or vocational diploma)	82% (82)	74.1% (40)	1.34	–
Smoker (yes/no)	14% (14)	25% (14)	2.95	–
Alcohol consumption per week	3.27 (3.80)	3.75 (4.08)	–	−.74
Drugs consumption (yes/no)	23% (23)	18.6% (16)	.59	–
Had flu in the past month (yes/no)	17% (17)	33.9% (19)	5.79*	–
Cortisol (T1)	.15 (.10)	.17 (.11)	–	−1
Cortisol (T2)	.16 (.09)	.18 (.10)	–	−.95
Cortisol (T3)	.25 (.18)	.29 (.21)	–	−1.37
Cortisol (T4)	.27 (.20)	.32 (.22)	–	−1.42
Cortisol (T5)	.20 (.13)	.23 (.14)	–	−1.41
Depressive symptoms	8.82 (7.30)	13.44 (10.39)	–	−3.24***

Notes. * = p <0.05, *** = p <.001.

Table 2
Fixed, random, and covariance estimates of cortisol change during the baseline and response phases in the total sample (n = 156).

Parameters	Statistics		
	B	S.E.	Critical ratio
Fixed (means)			
Intercept (y_0)	0.66	0.03	19.21***
Slope (y_1)	0.09	0.01	8.35***
Random (variances)			
Intercept (σ_0)	0.09	0.01	6.55***
Response slope (σ_1)	0.01	0.01	6.01***
Covariances			
Intercept-response slope (y_0, y_1)	.01	.01	1.89
Intercept-smoking (y_0, c_1)	.08	.07	.11
Intercept-Flu (y_0, c_2)	.01	.07	.12
Response slope- smoking (y_1, c_1)	−.07	.02	−3.31***
Response slope – Flu (y_1, c_2)	−.04	.02	−2.16*

Notes. B = unstandardized beta estimates; S.E. = Standard error. The critical ratio refers to the ratio of the unstandardized beta estimate over the standard error (B/S.E.). Fit statistics: χ^2 = 350.97, degree of freedom = 20, CFI = .52, RMSEA = .33, SRMR = .18. * = p <.05; *** = p <.001.

use, awakening time, food and beverages intake) – those uniquely associated with the Intercept and the Slope. Two correlates were identified: having had influenza in the past month and being a smoker, which were statistically accounted for in the final model (Table 2). Following procedures used in other studies (Ouellet-Morin et al., 2018, 2011), the unstandardized Intercept and Slope parameters were then extracted to test the mediation and moderation models in the SPSS Process macro v2.16 (Hayes, 2013).

The main analyses were conducted in two steps. First, we tested whether cortisol response to the TSST (i.e., slope) and/or coping strategies could partly explain (i.e., mediate) the association between maltreatment and depressive symptoms using Model 4 in Process (Hayes, 2013). This procedure provides a formal test of mediation in the maltreatment-depressive symptoms association using bias-corrected bootstrap confidence intervals (BC; 95% CI) based on 10,000 bootstrap resamples. A mediation test is significant when the lower and the upper bounds of the bootstrap confidence intervals of the indirect effect between the predictor and the outcome do not include zero (Hayes, 2013). Second, we tested, in separate models, the moderating effect of cortisol response to stress and coping strategies on the association between maltreatment and depressive symptoms using Model 1 in Process. Significant interactions were probed using the Johnson-Neyman technique, which identifies the regions of significance of an association when the moderator is a continuous variable (Hayes, 2013). Significant interactions were also illustrated using the simple slope approach, which depicts the association between maltreatment and depressive symptoms (according to three equal groups; tertiles).

3. Results

Consistent with a prior examination of the data (Ouellet-Morin et al., 2018), but tested with a conditional LGM in the present study, we noted a significant increase of cortisol levels in response to the TSST [Slope (σ1): B(*SE*):0.01(0.01) = Critical Ratio: 6.01, p < .001] and sufficient variance within the sample to test our hypotheses (Table 2). The magnitude of the rise of cortisol secretion in response to the TSST was almost the double of the baseline level (1.8% increase). Bivariate correlation analyses revealed that a higher cortisol response to stress was marginally associated with fewer emotion-oriented (r = -.14, p = .07; Table 3) and with more task-oriented coping strategies (r = .17, p = .03). In contrast, no significant associations were found between the cortisol baseline level (Intercept) and each coping strategy. Emotion- and task-oriented coping were negatively correlated (Table 3). Moreover, there was a trend for positive associations between avoidance coping and task-oriented coping as well as between avoidance coping and emotion-oriented coping. Accordingly, we tested the mediating and moderating roles of cortisol response to stress while accounting for the potential effects of coping strategies (and vice versa).

3.1. Mediating effects

3.1.1. Does acute cortisol response to stress explain the association between maltreatment and depressive symptoms?

Maltreated participants reported higher levels of depressive

Table 3
Bivariate correlations between all continuous main variables.

	1	2	3	4	5	6
1 Acute cortisol response to stress (Slope)	1.0					
2 Cortisol baseline level (Intercept)	−.37**	1.0				
3 Emotion-oriented strategies	−.14†	.03	1.0			
4 Task-oriented strategies	.17*	.05	−.32**	1.0		
5 Avoidance-oriented strategies	−.08	−.04	.14†	.14†	1.0	
6 Depressive symptoms	−.16*	.11	.47**	−.49**	.06	1.0

Notes. * p <.05, ** p <.01, † p <.10.

symptoms [b = 3.6(*SE* = 1.22), *p* = .003] and had higher cortisol responses to the TSST compared to controls [b = .02(*SE* = .01), *p* = .04]. A higher cortisol response to stress was associated with lower levels of depressive symptoms [b = -15.95(*SE* = 8.27), *p* = .05]. The test of mediation, nevertheless, indicated that the direct effect of maltreatment on depressive symptoms remained significant [b = 4.02(*SE* = 1.23), *p* = .001] and that the indirect effect of maltreatment on depressive symptoms via cortisol response was not significant [b = -.39(*SE* = .230), BC 95% CI = -1.29 to -.01].

3.1.2. Do coping strategies explain the association between maltreatment and depressive symptoms?

Maltreated participants reported higher levels of depressive symptomatology [b = 5.23(*SE* = 1.25), *p* < .001] as well as a more frequent use of emotion-oriented coping strategies to deal with stressful situations compared to the control group [b = 3.98(*SE* = 1.57), *p* = .01]. In turn, the more frequent use of emotion-oriented strategies was related to higher levels of depressive symptoms [b = .25(*SE* = .06), *p* < .001]. Moreover, a significant indirect effect of maltreatment on depressive symptoms through emotion-oriented strategies was observed [b = 1.02(*SE* = .50), BC 95% CI = .24 to 2.20]. This indirect effect accounted for 20% of the total effect (i.e., the initial direct association) between maltreatment and depressive symptoms. The mediation was thus only partial, since maltreatment remained significantly associated with depressive symptoms [b = 4.21(*SE* = 1.21), *p* = .001]. Conversely, maltreatment was not associated with task-oriented strategies [b = 1.61(*SE* = 1.64), *p* = .33], although participants who adopted more task-oriented strategies reported fewer depressive symptoms [b = -.35(*SE* = .06), *p* < .001]. The formal test of the indirect effect, which ought to be performed despite the non-significant bivariate association between the independent variable and the hypothesized mediator (Hayes, 2013), further indicated that task-oriented strategies did not mediate the maltreatment-depressive symptoms association [b = -.56(*SE* = .58), BC 95% CI = -1.73 to .58]. Maltreated participants also did not differ from the controls in their use of avoidance strategies [b = -2.99(*SE* = 1.88), *p* = .11], nor were these strategies associated with depressive symptoms [b = .07(*SE* = .05), *p* = .17]. Avoidance coping strategies did not mediate the association between maltreatment and depressive symptoms [b = -.21(*SE* = .24), BC 95% CI = -.94 to .08].

3.2. Moderating effects

3.2.1. Does the association between maltreatment and depressive symptoms vary according to the acute cortisol response to stress?

We found that the association between maltreatment and depressive symptoms varied in magnitude according to the participants' cortisol response to stress [maltreatment x cortisol response: ΔR^2 = .02, *F* = 4.29, *p* = .04, b = 28.26, *t*(149) = 2.07, *p* = .04]. The overall model was significant [R^2 = .42, *F*(7,149) = 18.01, *p* = .04]. Post-hoc analyses were conducted using the Johnson-Neyman technique to identify at which cortisol concentration the association between maltreatment and depressive symptoms became significant (i.e., region of significance). Individuals who displayed moderate-to-higher levels of acute cortisol response to stress (i.e., ≥ .02, corresponding to a z-score of -.62) reported higher levels of depressive symptoms in association with child maltreatment. Inversely, child maltreatment was not associated with depressive symptoms among participants who had lower acute cortisol response to stress (i.e., < .02). To further illustrate these effects, the conditional effect of maltreatment on depressive symptoms was plotted at lower, moderate and higher cortisol responses to stress (Fig. 1 A). Among individuals with higher cortisol response to stress, maltreatment was associated with higher levels of depressive symptoms (β = .46, *p* = .001). The maltreatment-depressive symptoms association only showed a trend for significance for participants with a lower cortisol response to stress (β = .27, *p* = .06), and was non-significant for those who had a moderate cortisol response to stress (β = .10, *p* = .49). Moreover, maltreated participants with a higher cortisol response to stress reported depressive symptomatology that was only marginally higher than those who were also exposed to these experiences, but who exhibited moderate cortisol responses to stress [*Mean difference (MD)* = -7.35 (*SE* = 3.12), *p* = .06]. Alternatively, in absence of maltreatment, participants with a lower cortisol response to stress reported more depressive symptoms in comparison to those with moderate [*MD* = 4.28 (*SE* = 1.70), *p* = .04] or higher cortisol responses to stress [*MD* = 4.45 (*SE* = 1.73), *p* = .03].

3.2.2. Does the association between maltreatment and depressive symptoms vary according the use of coping strategies?

The overall model for avoidance [R^2 = .41, *F*(7,148) = 14.63, *p* < .001], emotion [R^2 = .41, *F*(7,148) = 14.63, *p* < .001] and task-oriented coping strategies [R^2 = .42, *F*(8,148) = 15.45, *p* < .001] accounted for a significant proportion of the variance in depression symptomatology, respectively. Avoidance-oriented [ΔR^2 = .002, *F* = .57, *p* = .45, b = -.08, *t*(148) = -.75, *p* = .45] and emotion-oriented coping strategies [ΔR^2 = .004, *F* = .94, *p* = .33, b = .12, *t*(148) = .97, *p* = .33] did not moderate the association between child maltreatment and adult depressive symptoms. Conversely, this association was moderated by the use of task-oriented coping strategies [ΔR^2 = .02, *F*(1,148) = 4.33, *p* = .04, b = -.23, *t*(148) = 2.08, *p* = .04]. Probing of this interaction using the Johnson-Neyman technique showed that participants who reported lower-to-moderate use of task-oriented coping strategies (i.e., ≤ 64) reported higher depression symptoms following maltreatment, whereas this association was not significant for those using task-oriented coping strategies on a moderate-to-frequent basis (i.e., > 64). To further illustrate this interaction, the maltreatment-depression association was plotted at lower, moderate and higher levels of task-oriented coping strategies (Fig. 1B). Specifically, maltreated participants reported more depressive symptoms compared to controls if they used task-oriented coping strategies at a relatively lower (β = .48, *p* < .001) or moderate (β = .36, *p* = .01) frequency, whereas maltreatment was not associated with depressive symptomatology for participants using these strategies more frequently (β = -.08, *p* = .57). Among the maltreated participants, those using task-oriented coping strategies frequently reported the lowest levels of depressive symptoms as compared to their maltreated counterparts reporting moderate [*MD* = -9.58(*SE* = 2.70), *p* < .001] or lower use of these strategies [*MD* = -15.51(*SE* = 2.73), *p* < .001]. In the absence of maltreatment, the only significant difference in depressive symptoms was noted between the participants who reported using more versus less often task-oriented coping strategies [*MD* = -5.25(*SE* = 1.74), *p* < .01].

4. Discussion

Despite the repeated calls for the adoption of a multiple level of analysis approach allowing to integrate information from molecular to broader social influences, and thus gain a more complete understanding of the etiology of depression, the exact contribution of these pathways remain uncertain. The present study tested the potential mediating and moderating roles of acute cortisol response to psychosocial stress and coping strategies in the association between child maltreatment and depressive symptoms to specify the relative importance of these processes in the etiology of depression following child maltreatment. Three features of our findings warrant attention. First, consistent with previous investigations (Badanes et al., 2011; Hagan et al., 2014; Kuhlman et al., 2018), this study revealed a positive association between maltreatment and depressive symptoms among participants with higher acute cortisol responses to stress, over and above individual differences in coping strategies, whereas no significant association was noted for those with lower-to-moderate responses. Our results thus offer additional support for the Biological Sensitivity to Context (BSC) theory (Boyce and Ellis, 2005) proposing that higher physiological reactivity may confer a greater sensitivity to detrimental environments, in this

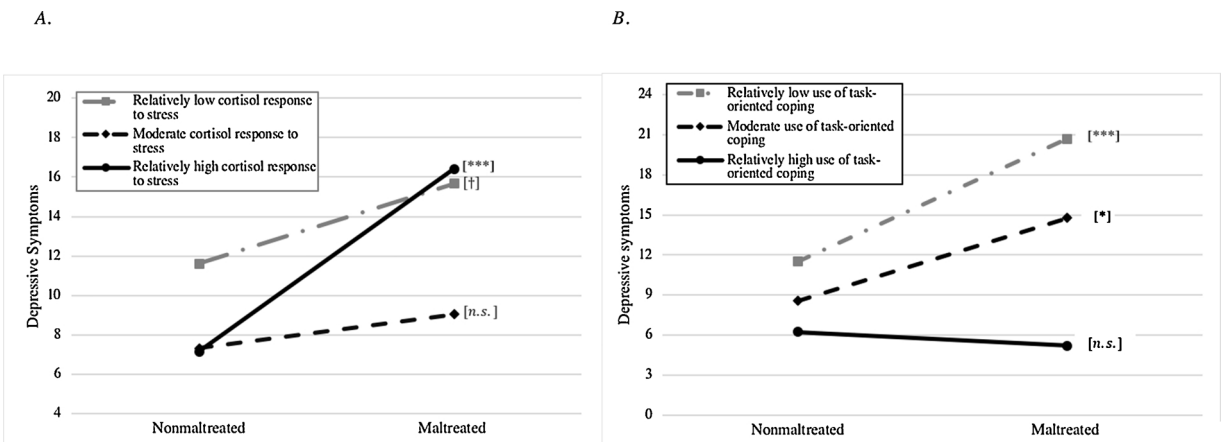

Fig. 1. A visual representation of the association between maltreatment and depressive symptoms according to the acute cortisol response to stress (Panel A) and the use of task-oriented coping strategies (Panel B).
Notes. Fig. 1 depicts the conditional effect of maltreatment on depressive symptoms according to three equal groups, each of which containing a third of the sample (i.e., tertiles). * * * $p \leq .001$; * $p < .05$; † $p = .06$; *n.s.* = nonsignificant.

case, child maltreatment. In contrast, participants who exhibited moderate-to-higher cortisol responses to stress reported the lowest levels of depressive symptoms in the absence of child maltreatment, which challenges the assumption that higher stress reactivity is a marker of vulnerability in all contexts, an idea also purported by the BSC theory (Boyce and Ellis, 2005). Additionally, the BSC theory posits that individuals with low physiological reactivity may be less affected by the environment, good or bad (Boyce and Ellis, 2005). This partly echoes our findings of higher depressive symptoms in participants with lower acute cortisol responses to stress regardless of their history of maltreatment. Future studies documenting the full spectrum of environments, from positive to detrimental, will be better positioned to fully examine these specific hypotheses.

Second, we found that maltreated participants who more frequently adopted task-oriented coping strategies to manage stress reported lower levels of depressive symptoms. The protective effects of task-oriented strategies relative to depressive symptoms were also observed among nonmaltreated participants. These findings are consistent with studies on other forms of adversities (e.g., bullying and trauma) that have reported fewer negative psychological symptoms among individuals who used more task-oriented coping strategies (Aldwin and Revenson, 1987; Garnefski and Kraaij, 2014), raising the possibility that these strategies may promote resilience. Of note, the moderating role of task-oriented coping strategies in the maltreatment-depressive symptoms association was independent of the moderating role found for cortisol response to stress. These findings thus suggest that both physiological and psychological systems may moderate the magnitude of the maltreatment-depression association despite their partial overlap. Physiological and psychological moderators thus should be considered simultaneously in future studies to refine our understanding of the role of stress in the etiology of depression.

Third, concordant with prior investigations (Choi et al., 2015; Goodkind et al., 2009; McQuaid et al., 2015), we found that maltreated individuals were more likely to adopt emotion-oriented coping strategies which, in turn, were related to higher levels of depressive symptoms. Active coping strategies are less likely to be used under conditions of repeated stress over long periods of time and when the situation seems uncontrollable and unpredictable (Lazarus and Folkman, 1984). Accordingly, when exposed to maltreatment, children may favor emotion-oriented coping strategies to reduce their emotional distress, shame and helplessness (Lazarus and Folkman, 1984). However, emotion-oriented coping strategies may become, over time, a predominant response to various stressors, regardless of their intensity (Hager and Runtz, 2012). This may inadvertently increase the daily level of perceived (i.e., subjective) stress in objectively harmless – in addition to more stressful – situations. The heavier reliance on emotion-oriented coping strategies may also eventually increase the exposure to stressful situations, because actions required to resolve these situations were not taken, thus increasing the risk for depression on the long run (Hager and Runtz, 2012).

Unlike emotion-oriented strategies, acute cortisol response to stress was not found to mediate the association between maltreatment and depressive symptoms. While this finding is consistent with prior investigations (Badanes et al., 2011; Busso et al., 2017), it nevertheless challenges the widely agreed-upon hypothesis of the HPA axis as a mechanism explaining the stress-disease association (McEwen and Stellar, 1993). Our findings also suggest that emotion-oriented coping may offer a more promising explanation of the higher risk of depressive symptomatology following child maltreatment. This does not, however, undermine the possible contribution that cortisol reactivity to stress may have in the onset and recurrence of depression. Indeed, and analogously to previous investigations (e.g., Zorn et al., 2017), we noted that participants who had lower cortisol responses to stress reported higher levels of depressive symptoms, over and above the main contributions of child maltreatment and coping strategies. In line with the Attenuation hypothesis (Susman, 2006), it is conceivable that prolonged exposure to child maltreatment resulted in chronically elevated activity of the HPA axis, subsequently leading to a shift from higher-to-lower cortisol responses to stress (Trickett et al., 2010). This may explain why previous research has found both higher and lower cortisol secretion in response to stress in adults who were maltreated as children (Ouellet-Morin et al., 2018). While lower secretions may protect the body from the persistent exposure to glucocorticoids, it is still unclear whether this pattern of response to acute stress mitigates the risk for internalizing problems in the long run (Trickett et al., 2010).

An overall main association between lower cortisol response to stress and depressive symptoms, however, contrasts with other studies that have reported a higher acute cortisol response to stress in depressed participants (Heim et al., 2000; Powers et al., 2016). In addition to child maltreatment, many factors could theoretically explain this divergence, including individual differences pertaining to the use of coping strategies, which were statistically controlled in the present study. Additionally, our study sample may have been composed of participants more inclined to adopt task-oriented strategies to cope with stress, which could have affected their cortisol responses to stress and, indirectly its association with depressive symptomatology. Consistent with this hypothesis, our participants reported a high endorsement of task-oriented coping strategies ($M = 58.18$; $SD = 10.10$) in contrast to comparable young adult men ($M = 23.30$; $SD = 5.07$; Cohan et al., 2006). The use of distraction and problem-solving responses have

indeed been found to be related to lower post-stressor cortisol concentrations during the TSST recovery in depressed participants (Stewart et al., 2013). Lower versus higher cortisol response to stress may also be differentially linked to the severity, the type and the clinical course of depression (Zorn et al., 2017). For example, a handful of studies reported higher acute cortisol responses to stress in individuals with mild/moderate depressive symptoms, whereas lower responses were noted for participants with moderate/severe depressive symptoms (Harkness et al., 2011). Higher cortisol levels have also been reported in melancholic depression (e.g., symptoms of insomnia, anorexia and motor agitation) as opposed to lower cortisol secretions in atypical depression (i.e., with hypersomnia, hyperphagia and leaden paralysis; Stetler and Miller, 2011). Transient depressive symptomatology was also associated with higher acute cortisol responses to stress, whereas more chronic depressive symptomatology co-occurred with lower acute cortisol responses to stress (Booij et al., 2013; Zorn et al., 2017). As no information was collected about the persistence and clinical presentation of depressive symptoms in our sample, these interpretations remain speculative in nature. Future studies assessing the severity along with the clinical feature and course of depression could further detail the hypothesized role of cortisol response to stress.

Unexpectedly, avoidance-oriented coping strategies were not related to either child maltreatment or depressive symptoms. These results contrast with those from past investigations highlighting the mediating role of avoidance strategies in the maltreatment-depression association (Choi et al., 2015; Walsh et al., 2010). Future studies should investigate whether distinct patterns of associations between child maltreatment, avoidance strategies and depressive symptoms may be detected between men and women, considering women's greater reliance on avoidance strategies in stressful situations compared to men (Cohan et al., 2006). Avoidance-oriented coping strategies were indeed found to be significantly associated with depressive symptoms in female, but not in male undergraduate students (Cohan et al., 2006; Endler and Parker, 1999). These findings emphasize the need to test, in adequately powered studies, sex-specific associations of the hypothesized role played by stress-related systems in the emergence and the clinical course of depressive symptoms in adults maltreated as children.

Our findings should be considered in light of several limitations. First, our sample consisted of young adult male participants. Sex and gender differences in relation to cortisol (Kudielka and Kirschbaum, 2005) and coping strategies (Cohan et al., 2006), particularly avoidance-oriented strategies, have been highlighted previously, suggesting that our findings may not be applicable to female participants or to younger or older populations (Trickett et al., 2010). Second, because our participants were recruited from the general population, rather than based on clinically meaningful levels of depression, only 4.5% of the sample reported severe levels of depression according to the manual's guidelines. This particularity of our sample thus limits the generalization of our findings to clinical populations. Third, our study relied on retrospective, self-reported child maltreatment experiences, which may be subject to recall biases. However, past research revealed that recollection of child maltreatment experiences seems to be reliable in adults (Bifulco et al., 1997), with recall bias explaining less than 1% of child maltreatment variance (Fergusson et al., 2011). Fourth, this study is cross-sectional, implying that the temporal sequence of events remains unclear. Fifth, in comparison to other studies (Höhne et al., 2014; Stewart et al., 2013), the magnitude of the association found between coping strategies and cortisol response to stress was small. While we reliably measured dispositional coping strategies (i.e., habitual ways of dealing with stress), we did not assess coping specifically in response to the TSST (i.e., situation-specific coping). Future studies investigating the role of situational and dispositional coping strategies are needed to increase our understanding of their associations with cortisol response to stress and depression.

Despite these limitations, our findings extend previous research on the hypothesized mediating versus moderating roles of cortisol response and coping strategies in the association between child maltreatment and depression in adulthood. Our study lends support to targeting coping strategies in interventions for depressed adults who were maltreated as children. More specifically, the less frequent use of emotion-oriented strategies to resolve stressful situations could, indirectly, be associated with less depressive symptomatology. In contrast, interventions should encourage a greater use of task-oriented strategies to buffer the impact of child maltreatment on depressive symptomatology. However, stronger evidence regarding the relevance of these strategies is needed before they become targets for intervention, including testing these hypotheses according to an experimental design (with randomization). More generally, our findings are compatible with cognitive-behavioral therapy, which is reported as particularly effective among depressed patients with severe maltreatment experiences (Harkness et al., 2012). Knowledge about the specific role that physiological and psychological stress responses may play in depression could eventually be translated into more targeted and efficient interventions promoting the well-being of adults maltreated as children.

Contributors

All authors have read and approved the final version of the manuscript.

The contributions of each author:

Christina Y. Cantave: analysis and interpretation of data; drafting the first version of the manuscript; final approval of the version to be submitted.

Stephanie Langevin: analysis of data; final approval of the version to be submitted.

Marie-France Marin: revising the article critically for important intellectual content; final approval of the version to be submitted.

Mara Brendgen: revising the article critically for important intellectual content; final approval of the version to be submitted.

Sonia Lupien: the conception and design of the study; revising the article critically for important intellectual content; final approval of the version to be submitted.

Isabelle Ouellet-Morin: the conception and design of the study; acquisition of data; analysis and interpretation of data; writing the manuscript; revising the article critically for important intellectual content; final approval of the version to be submitted.

Conflicts of interest

None.

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