Relations among Childhood Trauma, Executive Control, and Induced Stress

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Abstract

The present study examined the relation of childhood trauma to executive control and executive control under stress. Participants (N=104) were students, ages 18-22 (M_{age}=18.97, SD=1.078), at Vanderbilt University. In the first session, participants completed a questionnaire about their experience of childhood trauma and a measure of executive control (the emotional n-back task). In the second session conducted a week later, participants were randomized to either a high or low stress induction. They again completed the executive control task. We hypothesized that: (a) greater levels of early trauma would be associated with worse executive control; and (b) the relation between stress and executive control would be stronger for individuals with high levels of childhood trauma. Results of the study were not consistent with the hypotheses, although post hoc exploratory analyses were in the expected direction. Limitations of the study included the small sample size and possible limited variability on the measures of trauma and executive control. Suggestions for future research are discussed.

Introduction

Executive control plays a central role in everyday life. From choosing what to eat to planning a schedule for the day, almost every decision we make involves some degree of executive control (EC). For this reason, individuals with impairments in EC can have difficulty functioning as compare to individuals with less impairment. Additionally, stress has been found to negatively affect executive control, such that when individuals experience increased stress, their executive control is diminished (Shields et al., 2017).

Although executive control during periods of acute stress, or state-based executive control, is impaired in most people, individuals differ in the amount their executive control is impaired under stress (Quinn & Joormann, 2015). Some individuals experiencing acute stress show minor problems in executive control, whereas others demonstrate a greater degree of impairment in executive control (Quinn & Joormann, 2015). State-based executive control impairments also are associated with higher levels of depressive symptoms (Quinn & Joormann, 2015).

Executive control can be influenced by both genetic and environmental factors (Bouchard & McGue, 2003). Environmental influences on executive control not only include elements of individuals' current environment– such as physical health or social support, but they also involve aspects of the individual's childhood environment. Experiences during childhood can profoundly affect cognitive, social, and emotional development (Gould et al., 2012). Childhood trauma is a particularly salient influence on development over time.

Childhood trauma is a broad term that encompasses neglect, maltreatment, or abuse that can be sexual, physical, or emotional in nature. Moreover, childhood trauma has been linked to lower levels of executive control (Blanchette & Caparos, 2016; Lu et al., 2017) and to the multiple other negative outcomes including depressive disorders, suicidality, and substance

abuse later in life (Merrick et al., 2017). Thus, trauma during childhood has enduring negative effects on cognitive functioning and mental well-being that often persist throughout life. The purposes of the current study were to examine the relation of childhood trauma to executive control and to test the extent to which childhood trauma moderates the relation between acute stress and executive control.

Executive Control

Executive control, or executive function, is composed of multiple cognitive processes, which are separate, but interconnected, and that actively direct behavior toward accomplishing a goal (Banich, 2009; Miyake & Friedman, 2012). Miyake and Friedman (2012) identified updating, shifting, and inhibition as three primary executive functions. Updating entails monitoring and revising the contents of one's working memory by deleting old information and adding new material. Shifting is the process of changing from one task or mental set to another. Inhibition involves actively overriding one's automatic response or reaction (Miyake & Friedman, 2012). These executive control abilities provide the cognitive foundation for planning, decision-making, goal-setting and completion, and a variety of other crucial tasks that are part of everyday life (Banich, 2009). Because of the centrality of executive control in achieving goals and completing tasks, impairments in executive functioning can have serious, deleterious effects.

Stress and Executive Control

Executive control is necessary for individuals to be able to actively cope with stress and successfully implement emotion regulation strategies (Quinn & Joormann, 2015). Individuals' executive control can significantly affect how stress affects them. A recent study by Shields, Moons, and Slavich (2017) found that stress had a negative effect on executive control. Among individuals exposed to a laboratory stress-induction, those with poor executive control showed a significant association between exposure to stress in their lives and their self-reported health

issues. In contrast, for those with better executive control, recent stress exposure was not associated with poor health. Shields and colleagues concluded that better executive control under stress mitigated the effects of recent life stress exposure on health in young adults. This finding highlights that individual differences in executive control exist and can affect how people respond to stress.

The experience of acute stress impairs working memory, cognitive flexibility, and cognitive inhibition, in part, because executive control may focus attention more on motor functions than on mental functions (Shields, Sazma, & Yonelinas, 2016). This attention redeployment response can be useful in some acute situations, such as when faced with an immediate threat of harm or violence. When stress exposure is more chronic, however, such as ongoing professional or interpersonal adversity, a reduction in executive control can become maladaptive. Therefore, Quinn and Joorman (2015a, 2015b) have been studying the effect of stress on executive control and on subsequent depression (e.g., Quinn & Joormann, 2015a, 2015b).

Quinn and Joormann (2015a, 2015b) have explored the associations among executive control, stress, and depression. In the study by Quinn and Joorman (2015a), participants completed the *n*-back test, which measures executive control by examining how quickly and accurately participants can update their working memory (Kirchner, 1958). Participants completed the *n*-back test and then returned a week later. During this second session, participants experienced a laboratory stress induction – the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), which asks them to complete a speech and mathematical task in the presence of the experimenter. Participants were told that the tests measured their intelligence and that other students would watch videotapes of the session and judge their performance. After the stress induction, participants completed the *n*-back test again. Whereas Quinn and Joormann

(2015a) found no correlation between performance on the initial *n*-back test and depressive symptoms, they did find a positive association between poor *n*-back task performance immediately after the TSST stress induction test and depressive symptoms. This association was moderated by trait rumination, suggesting that the association between executive control deficits under stress and depression was stronger among individuals who consistently engaged in rumination. Thus, the degree to which stress affected executive control was associated with depressive symptoms, indicating that depressed and nondepressed individuals may differ in their ability to cope effectively with stressors (Quinn & Joormann, 2015b).

Childhood Trauma and Executive Control

Childhood trauma and adverse life events that occurred early in life are widely believed to have detrimental effects on functioning and well-being (Gould et al., 2012; Kessler, 1997; Merrick et al., 2017). One consequence of childhood trauma is impaired executive functioning, particularly working memory (Blanchette & Caparos, 2016). A neuroimaging study by Lu et al. (2017) found a strong association between childhood trauma and abnormal resting-state neural networks in a nonclinical sample, and the abnormal neural functioning correlated significantly with executive control impairments. They also found that the severity of trauma correlated positively with the degree of executive control deficits and decreased neural connectivity (Lu et al., 2017).

In depressed patients, higher levels of childhood trauma have been found to be associated with greater severity of depression and more deficits in general knowledge, speed of processing, and executive control (Dannehl et al., 2017). In a study of patients with bipolar disorder, those who had experienced childhood trauma showed executive control impairments, specifically inhibitory control deficits, when compared to patients who had not experienced trauma (Marshall et al., 2016). Thus, executive control is impaired in individuals with a history of childhood

trauma and the more extensive the trauma, the greater the deficits in executive control.

Childhood Trauma, Executive Control, and Stress

Although evidence exists of a link between childhood trauma and executive control, less is known about the role of acute stress in this relation. Individuals who have experienced a stressor early in childhood such as trauma or abuse may be more vulnerable to disruption after exposure to an acute stressor (Gould et al., 2012). One construct that might be relevant here is allostatic load (McEwen & Stellar, 1993), which is the physiological result of the body working to adapt to a fluctuating environment over a prolonged period of time. When the body has to consistently function at a heightened level of stress, it adapts by increasing its neural activity to prepare for this heightened level of stress resulting in an increased allostatic load. A heightened allostatic load not only makes individuals susceptible to a variety of diseases and psychological disorders, but it also alters individuals' responses to acute stress (McEwen & Stellar, 1993).

In a review of research on the neurophysiological aberrations found in individuals who experienced chronic stress or abuse as children, Beauchaine et al. (2011) described abnormal trait adrenergic, dopaminergic, and serotonergic networks in adults who faced trauma early in life. Beauchaine and colleagues highlighted a study by Pruessner et al. (2004) that investigated the association between levels of parental care and neurological dopaminergic responses to acute stress. They found that individuals who reported lower levels of maternal care experienced a higher level of dopamine release after experiencing a lab-induced psychosocial stressor than individuals with higher levels of maternal care (Pruessner et al., 2004). Beauchaine et al. (2011) also examined animal studies and found that early childhood trauma or neglect was linked to altered neuronal functioning during instances of acute stress.

Childhood Trauma and Psychopathology

An extensive body of research has found associations between childhood trauma and the

subsequent development of various forms of psychopathology (Edwards et al., 2003; Kendler et al., 2004; Merrick et al., 2017; Pirkola et al., 2005). Though specific outcomes vary, rates of psychopathology in childhood trauma survivors are far greater than in those who experienced no trauma during childhood (Pirkola et al., 2005). Childhood trauma has been linked to post-traumatic stress disorder (PTSD), major depressive disorder, bipolar disorder, and schizophrenia (Gould et al., 2012). Moreover, the course of these disorders is generally more severe than the course of psychological disorders for those who did not experience trauma as children (Nemeroff, 2016).

The consequences of childhood trauma, such as cognitive or interpersonal impairments, could play a role in the development of psychopathology. One study found that trait impulsivity mediated the relation between childhood trauma and dissociative disorder (Somer et al., 2012). Another study reported that the association between childhood trauma and eating disorders was mediated by both emotion regulation impairments and dissociation (Moulton et al., 2015). A study of treatment-seeking women who had experienced childhood trauma found a significant relation between PTSD symptoms and impairments in both emotion regulation and interpersonal functioning (Cloitre et al., 2005).

In a review of the neurophysiological results of childhood trauma Nemeroff (2016) showed that hypothalamic-pituitary-adrenal (HPA) axis hyperactivity, which is associated with both mood and anxiety disorders, has been found in individuals with a history of childhood trauma. This association has been demonstrated in studies using an acute laboratory stressor – the Trier Social Stress Test – and analyzing cortisol levels, which are regulated by the HPA axis, in response to the stressor. Researchers also have found a variety of structural differences between brains of individuals with a history of childhood trauma and controls such as decreased brain volume of the prefrontal cortex and reduced volume of the hippocampus in depressed

patients with childhood trauma as compared to those with no trauma history (Nemeroff, 2016).

Several studies have examined the link between cognitive impairments from childhood trauma and the development of psychopathology. Gould et al. (2012) showed that disorders associated with a history of childhood trauma– PTSD, major depressive disorder (MDD), bipolar disorder, and schizophrenia – all had impairments in executive control. In particular, individuals diagnosed with MDD have deficits in executive control, memory, and psychomotor speed (Gould et al., 2012).

A primary motivation for research in the field of childhood trauma is to inform treatment. Studies have shown that individuals with a history of childhood trauma have lower levels of success with psychopharmaceutical therapies and traditional forms of psychotherapy such as cognitive behavior therapy (Nemeroff, 2016). Cognitive impairments associated with childhood trauma could be one reason that traditional psychotherapies are less successful with individuals with a history of childhood trauma. Exploring the association between childhood trauma and executive control might provide a guide to intervention development for patients with a history of childhood trauma.

Study Aims and Hypotheses

This study builds upon previous research on the relations among stress, executive control, and childhood trauma.

Specific Aim 1: To determine the association of childhood trauma with executive control.

Hypothesis 1: Higher levels of childhood trauma will correlate significantly with greater impairments in executive control.

Specific Aim 2: To examine the relation of childhood trauma to changes in executive control after exposure to acute stress.

Hypothesis 2: The association between childhood trauma and changes in executive

control will be stronger for individuals exposed to high versus low levels of stress.

METHOD

Participants

We used the SONA online research study tool to recruit undergraduate students, ages 18-22 (M_{age}=18.97, SD=1.078); 85.7% were female, at Vanderbilt University. The SONA tool allows students to search for research studies in which to participate. Participating students received partial course credit for completing the onsite sessions. A total of 104 participants were assessed as part of a larger study; 62 of these students were randomized to one of the two stress conditions (high-stress and low-stress).

Measures

To assess history of trauma, participants completed the Childhood Trauma Questionnaire (Bernstein et al., 2003). The CTQ is a 28-item self-report measure of 5 types of childhood neglect and trauma: emotional and physical neglect, and physical, emotional, and sexual abuse. Participants rated each item using a 5-point Likert scale ranging from “Never true” to “Very often true”. The CTQ has demonstrated reliability and validity (Bernstein et al., 2003).

To measure executive control, we administered the emotional N-back task. Sitting as a computer, participants are shown a string of words, such as “victim” or “happy,” which are a mixture of positive and negative words. Each word is shown one at a time, and participants are instructed to indicate whether the word they are currently viewing is the same as the word presented on the screen two words earlier. Each word is displayed for 500 milliseconds (ms), and then a blank screen is shown for 2500 ms. This process repeats for a total of 120 trials. Executive control performance on this task is measured by totaling the number of errors made; errors consist of missed and incorrect responses. Fewer total errors reflects better executive control.

Procedure

Session One. The researcher led the participant through the informed consent procedure. Then, the participant completed the Childhood Trauma Questionnaire (CTQ) on the computer survey. Next, the executive control N-back task was administered.

Session Two: One week later, participants returned to the lab, and were randomly assigned to either the high- or low-stress condition (described below). After the stress task, participants completed the N-back task again, which is a measure of executive control.

Stress Induction: The stress induction followed the Trier Social Stress Test protocol (Kirschbaum et al., 1993). Participants randomized to the high stress condition were instructed to prepare a 5-minute speech about why they are the best candidate for a job. They were given 3 minutes to prepare and make notes, but they were not permitted to use their notes during the presentation. Participants were told that they would be recorded while giving their speech and the recording would be shown to a panel of their peers to judge how their performance compared to other students. After the speech, participants completed an arithmetic task in which they count aloud backwards from 2083 to 0 in increments of 17. When a mistake was made, the researcher said, "Error, 2083" to prompt the participant to begin again. The task continued until the participant reached 0 or after 5 minutes elapsed.

Low-Stress Condition: Participants randomized to the low-stress condition received a version of the TSST that involved similar physical requirements as in the high-stress condition but without the social evaluative threat. In the low-stress condition, participants were instructed to think about a movie, novel, or trip for 3 minutes and then to stand in place while discussing the topic aloud for 5 minutes. For the arithmetic task, participants counted upward from 0 in increments of 15. There was no feigned recording of this task, and no researcher was present during the tasks to ensure that the potential for social evaluative threat was minimized.

Results

Descriptive statistics for each variable are presented in Table 1. Correlations between the variables are presented in Table 2. Data from all participants were included except if some of the participant's data were not collected or if the participant declined to participate in the TSST stress induction, which occurred with 10 participants. The Pearson correlation analyses conducted in SPSS revealed a significant correlation between pre-stress (T1) n-back errors and post-stress (T2) n-back errors ($r = 0.467$, $p < 0.01$). The correlation between Childhood Trauma Questionnaire (CTQ) scores and pre-stress (T1) n-back scores (Hypothesis 1) was not significant (see Table 2).

Table 1
Descriptive Statistics

Variables	N	Min	Max	Mean	S.D.
Stress Condition	105				
T1 N-back Errors	105	4	33	15.47	(6.98)
T2 N-back Errors	65	2	27	11.78	(5.90)
Child Trauma Questionnaire	102	25	82	36.54	(13.22)

Stress Condition	Variables	N	Min	Max	Mean	S.D.
Low Stress	T1 N-back errors	36	4	32	16.17	(7.11)
	T2 N-back errors	36	2	27	11.32	(5.95)
	CTQ Total Score	33	25	75	34.27	(10.96)
High Stress	T1 N-back errors	29	5	30	15.69	(7.10)
	T2 N-back errors	29	4	27	12.48	(5.93)
	CTQ Total Score	29	25	76	35.86	(13.19)

CTQ = Child Trauma Questionnaire; Min = Minimum; Max = Maximum;
S.D. = Standard Deviation

Table 2
Study Variable Correlations

	M (SD)	Age	Sex	Stress Condition	T1 N-back Errors	T2 N-back Errors	CTQ
Age		--					
Sex		-.018	--				
Stress Condition		.043	.184~	--			
T1 N-back Errors	15.47 (6.98)	-.170	.109	-.078	--		
T2 N-back Errors	11.78 (5.90)	-.166	.119	.107	.467**	--	
CTQ	36.54 (13.22)	.097	.005	.075	.010	.034	--

** Correlation is significant at the 0.01 level (2-tailed). CTQ = Child Trauma Questionnaire

To test whether the relation between childhood trauma and executive control was moderated by acute stress, we conducted a multiple linear regression in SPSS. In the regression analysis, childhood trauma (CTQ), stress condition assignment (0 = low stress, 1 = high stress)., and the interaction between CTQ and condition were the predictors, and executive control at the post-stress (T2) n-back scores– was the dependent variable (see Table 3).

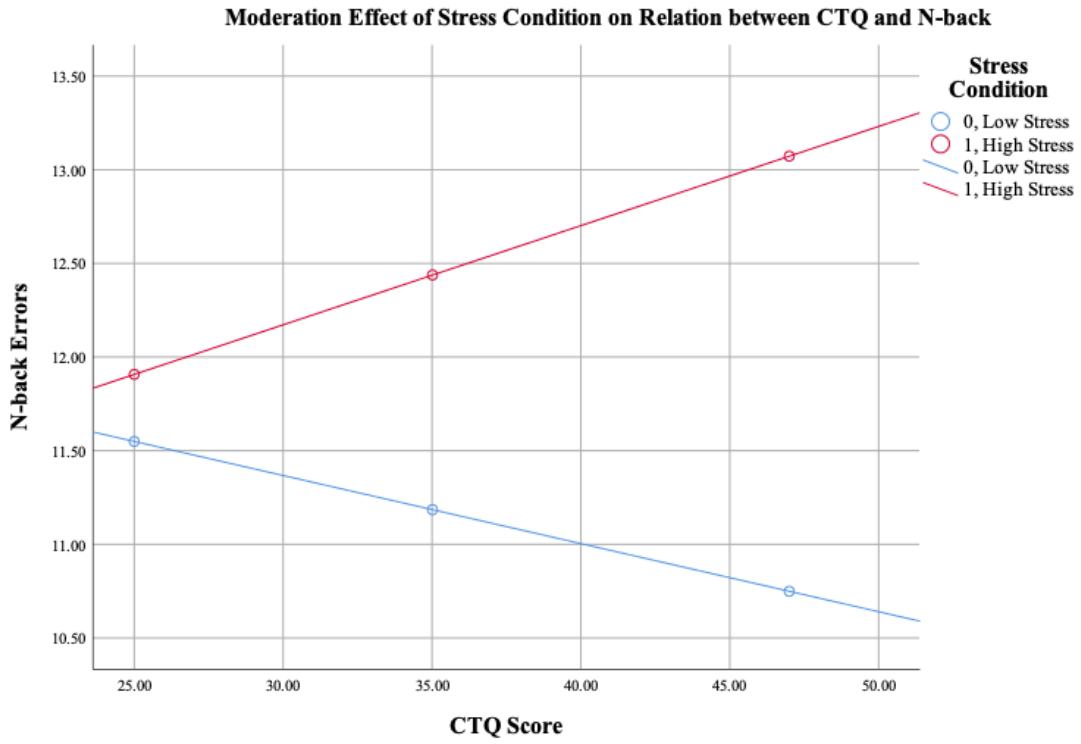
Table 3
Interaction of CTQ by Stress Condition Predicting N-back Errors after the Stress Induction

Variables	B	SE	t	p
Childhood Trauma Questionnaire (CTQ)	-.04	.10	-0.37	.711
Stress Condition	-1.88	4.83	-0.395	.699
CTQ * Stress Condition	.089	.13	0.683	.498

The overall model predicting T2 n-back scores was not significant, $F(3, 58) = .395$, $p = .757$, and the interaction term was not significant, ß = .089, $t(62) = .683$, $p = .498$. Thus, Hypothesis 2 was not supported. Nevertheless, we conducted a post hoc exploratory analysis in which we plotted the variables comprised in the interaction. Figure 1 shows that higher scores on the CTQ predicted more errors on the T2 N-back for those in the high stress condition, whereas the trend was in the opposite direction (i.e., lower CTQ scores were associated with fewer N-

back errors) for participants in the low stress condition.

Figure 1



Discussion

Childhood trauma is associated with significant long-term effects including increased risk of psychopathology such as PTSD, major depressive disorder, and bipolar disorder. People with a history of childhood trauma also are at greater risk for deficits in executive control (EC). The present study investigated the correlation between college students' reports of their experiences of trauma during childhood and their performance on a measure of executive control. In addition, we explored the extent to which the strength of the relation between trauma history and changes in executive control differed for those exposed to an acute high- versus low-stressor. The results did not support either hypothesis, however. Prior research has shown a significant association between trauma experienced as a child and executive control deficits in adulthood (Carrion &

Wong, 2012; Gould et al., 2012; Lu et al., 2017). The lack of a significant correlation between childhood trauma and EC impairments in the current study could have been due to several factors, particularly the small sample size and characteristics of the sample (see below for a discussion of study limitations).

Childhood Trauma and Executive Control under Stress

Experiencing childhood trauma has been linked to executive control impairments in adulthood. The second objective of this study was to test whether this association varied by exposure to acute stress. We predicted that the relation between childhood trauma exposure and executive control deficits would be stronger in participants who underwent the high stress induction as compared to those who were in the low-stress condition. Although stressor condition did not moderate the relation between childhood trauma and executive control, we conducted a post hoc analysis to explore if there was even a signal of this interaction. Although not statistically significant, this analysis yielded results that were in the right direction.

Strengths, Limitations, and Future Directions

One strength of the current study was the use of a well-validated experimental procedure for inducing stress – the Trier Social Stress Test. Limitations of the present study also should be noted as they provide directions for future research. First limitation was the small sample size. A larger sample would provide greater power to detect an effect if one was present. The reason for the small sample size was that this study was only a part of a larger project in which some people underwent a different set of procedures unrelated to the current study goals. In addition, we only were able to collect the sample for two semesters. The study was continuing into this spring semester until the University shut down due to the coronavirus (COVID-19).

Second, the information about trauma assessed with the self-report questionnaire might have missed some important details about trauma. In a review of methods and measures of

childhood trauma, including the CTQ, Roy and Perry (2004) noted several limitations of self-reports about a sensitive topic such as abuse and maltreatment. A primary concern is whether self-report questionnaires capture the complete narrative as participants may be reluctant to share such personal information due to concerns about confidentiality and laws about having to report abuse (Roy & Perry, 2004). In contrast, interviews may provide a better opportunity to sensitively probe for salient details about the trauma such as the individual's relationship to the perpetrator, age at which the trauma occurred/began, and the duration of abuse (Roy & Perry, 2004). This additional information likely would provide greater accuracy and variability on the measure. Future studies should consider using structured or semi-structured interviews to ensure that the extent and type of trauma is measured adequately.

Another concern regarding the measurement of early trauma may be the sample used here. Although child maltreatment occurs at all socioeconomic levels, undergraduate students at Vanderbilt University likely come from home environments characterized by support rather than neglect or abuse. It is possible that the amount and severity of abuse in this sample was not as extensive as has been found in other studies of the association between early trauma and executive functioning. Our sample's mean CTQ score of 36.54 was far lower than studies examining clinical samples. For example, in a study of depressed patients, the mean CTQ score was 47.8 (Kaczmarczyk et al., 2018). Furthermore, this sample's variation of childhood trauma severity was less than previous studies. Our sample's standard deviation was 13.22, which is lower than the depressed patient sample's standard deviation of 19.2 (Kaczmarczyk et al., 2018).

Another limitation of using a college student sample is that there might not have been sufficient variability on the measure of executive control. That is, students at Vanderbilt are generally highly intelligent and therefore might have shown a skewed distribution on executive functioning. Thus, the results may not generalize to a more representative sample of individuals

with a larger range in age and intelligence.

Also regarding measuring executive control, participant completed the measure twice, a week apart. The effect of the stress manipulation might not have been strong enough to overcome possible practice effects. Future studies should randomize participants to conditions that vary in the level of stress, and only administer the EC measure once. Moreover, without a way to validate the efficacy of the stress induction, we cannot be certain that it was sufficiently stressful enough. Conversely, it also is possible that the low stress control condition was stressful. In either case, potential differences between the two stress conditions would be reduced.

With an estimated 900,000 children in the United States experiencing abuse or maltreatment each year, research on the link between childhood trauma and the development of psychopathology is critical to efforts aimed at preventing abuse and minimizing its consequences (*Child Maltreatment 2005*, n.d.). Further research also is needed to determine the long- and short-term effects of both chronic and acute stressors on individual's executive functioning in relation to the onset and maintenance of psychopathology. Finally, investigators should aim to identify the neurobiological, genetic, and psychosocial mechanisms underlying the connections among early trauma, executive control, stress, and psychopathology

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