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Working Memory Performance Is Related to Childhood Trauma but Not Psychotic-Like Experiences in a Nonpsychiatric Sample

Arielle Ered[1, 2], Charlotte A. Chun[1], Kathleen J. O'Brien[1], Gina M. Creatura[1], and Lauren M. Ellman[1]
[1] Department of Psychology and Neuroscience, Temple University
[2] Department of Psychiatry, Perelman School of Medicine, University of Pennsylvania

Objective: This project seeks to clarify the impact of childhood trauma and psychotic-like experiences (PLEs) on working memory (WM) and explore gender differences in these relationships. The effect of childhood trauma on WM performance has yet to be explored in individuals with PLEs, despite consistent associations between trauma, psychosis spectrum symptoms, and WM performance. ***Method:*** In 466 undergraduates, positive PLEs (Prodromal Questionnaire) and trauma (Childhood Trauma Questionnaire) were examined to determine contributions to WM performance on a spatial n-back task. We conducted hierarchical linear regressions on the total sample and stratified by gender to examine the effects of childhood trauma, positive PLEs, and their interaction on WM performance. Supplemental analyses explored attenuated negative and disorganized symptoms. ***Results:*** Controlling for age, there were no significant main effects of positive PLEs, childhood trauma, their interaction, or three-way interaction including gender in predicting WM. After stratifying by gender, childhood trauma was significantly associated with poorer WM in females only. Post hoc analyses revealed that in the full sample, physical neglect predicted WM performance and was a trend for females, while sexual abuse trended toward predicting WM in males. Supplemental analyses of attenuated negative and disorganized symptoms revealed childhood trauma significantly predicted WM in the full sample and females only for negative symptoms. ***Conclusions:*** Females who have experienced childhood trauma may be at greater risk for WM problems, irrespective of co-occurring PLEs, suggesting that cognitive difficulties may be partially attributable to history of trauma. These findings have potential implications for intervention strategies in trauma-exposed individuals.

Clinical Impact Statement
In a sample of diverse undergraduates experiencing a range of psychotic-like experiences (PLEs), childhood trauma, PLEs, and their interaction were not related to performance on a task that assessed spatial working memory (WM). After examining males and females separately, childhood trauma significantly predicted worse WM performance in females only. These findings have implications for cognitive deficits in females who have experienced childhood trauma, and that these individuals may be at particular risk for the development of cognitive difficulties. Clinically, assessment of cognitive deficits in females with a history of childhood trauma should be considered, and interventions such as cognitive remediation may be warranted.

Keywords: gender differences, cognition, psychosis spectrum, childhood trauma

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Traumatic life events have been found to be related to symptom severity across the psychosis spectrum, including in individuals diagnosed with schizophrenia (Ciufolini et al., 2014; Pruessner et al., 2013), at clinical high risk (CHR; Loewy et al., 2019; Mayo et al., 2017), and in nonclinical samples of individuals with attenuated, subthreshold versions of positive psychotic symptoms, or psychotic-like experiences

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Arielle Ered https://orcid.org/0000-0002-8386-4423
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Correspondence concerning this article should be addressed to Lauren M. Ellman, Department of Psychology and Neuroscience, Temple University, 1701 North 13th Street, Philadelphia, PA 19122, United States. Email: ellman@temple.edu

(PLEs; Ered & Ellman, 2019; Ered et al., 2017; Gibson et al., 2014). Studies of individuals prior to the onset of frank psychosis are crucial for efforts at early identification and prevention of psychosis, aimed at decreasing the duration of untreated psychosis, which is associated with poor treatment response, more severe course of illness, and lower school and work performance (Breitborde et al., 2017). PLEs are common, impacting approximately 5%–8% of the general population, usually transient (Nelson et al., 2012; van Os et al., 2009) and are usually assessed using self-report questionnaires. In nonclinical samples, 8% of individuals who reported one PLE were diagnosed with a psychotic disorder at 2-year follow-up, and individuals who reported more than one PLE had a 21% conversion rate to a psychotic disorder (Nelson et al., 2012).

Childhood trauma is of particular relevance for psychosis risk given that childhood is a critical period for brain development and traumatic events occurring during this time are associated with long-term changes in brain structure, function, and stress reactivity. Large, population-based studies reveal that childhood trauma predates the onset of psychotic symptoms (Read et al., 2005) and is associated with more positive symptoms in individuals with schizophrenia (Üçok & Bıkmaz, 2007). These findings indicate that early trauma may constitute a marker of psychosis risk, suggesting a point of early intervention.

Reported rates of childhood trauma differ by gender. Female undergraduates report significantly higher rates of sexual abuse on the Childhood Trauma Questionnaire (CTQ; Paivio & Cramer, 2004). Similarly, in the general population, females report significantly higher rates of sexual abuse while males report higher rates of physical abuse (Briere & Elliott, 2003). However, trauma differentially affects males and females, both in individuals on the psychosis spectrum and the general population. In recent-onset psychosis, higher CTQ scores in females only were associated with greater severity of positive symptoms, negative symptoms, depression, and functioning (Garcia et al., 2016). In fact, one study found that females with psychotic disorders were more likely to report physical or sexual abuse in childhood than unaffected females, while this relationship was not present in male participants (Fisher et al., 2009). This relationship was stronger in females who experienced both physical and sexual abuse in childhood.

Exposure to traumatic events can have adverse effects on a range of executive functioning abilities including working memory (WM) performance (Kelder et al., 2018; Majer et al., 2010). For example, previous findings from our lab showed that participants with a history of traumatic life events have trauma-specific attentional biases, as demonstrated by slower reaction times to trauma-related stimuli on an emotional Stroop task (Gibson et al., 2019). Meta-analyses indicate that: (a) both childhood and lifetime trauma exposure are associated with WM impairment in adults, independent of posttraumatic stress disorder symptoms (Blanchette & Caparos, 2016) and (b) childhood trauma is related to WM dysfunction in both clinical and nonclinical samples (Goodman et al., 2019), including in individuals with psychotic disorders (Vargas et al., 2019). Furthermore, there appears to be a dose-dependent effect such that greater exposure to childhood trauma is associated with worse WM performance on lab tasks (Majer et al., 2010). Early life trauma may have particularly deleterious effects on cognitive outcomes because it can interfere with normative neural development during sensitive periods (Pechtel & Pizzagalli, 2011). For example, childhood trauma has been associated with volumetric brain changes, such as reduced prefrontal cortex and orbitofrontal cortex volumes (Hanson et al., 2010; Tomoda et al., 2009), and these changes mediate the relationship between life stress and spatial WM (Hanson et al., 2012). These findings suggest a potential pathway through which early trauma can affect later WM functioning.

Additionally, WM impairments have been found in individuals across the psychosis spectrum. Studies have found that children (Karcher et al., 2018; O'Brien et al., 2020), adolescents (Rossi et al., 2016), and adults (Mollon et al., 2016) with PLEs show worse performance on WM tasks. Similar impairments in WM have been found in individuals at CHR (Zheng et al., 2018). While general cognitive deficits are commonly found during this stage, Pflueger et al. (2018) found that other cognitive deficits, such as verbal memory encoding, are secondary to primary WM impairment in emerging psychosis. Furthermore, longitudinal studies have found that deficits in WM have been associated with higher delusional ideation at follow-up (Broome et al., 2012), as well as progression to frank psychosis (Seidman et al., 2016). These impairments continue to be found throughout first-episode psychosis (FEP) and chronic schizophrenia (Bosnjak Kuharic et al., 2019; González-Ortega et al., 2013). Importantly, individuals at CHR and those experiencing frank psychosis seem to show WM deficits to a similar extent (Carrión et al., 2018; Pflueger et al., 2018). These findings suggest that WM impairments do not worsen as the illness progresses, but are present prior to illness onset, indicating a potential marker of psychosis risk.

In individuals across the spectrum of psychotic experiences (including those with psychotic disorders, at CHR for psychosis, and in nonpsychiatric controls), childhood trauma is associated with poorer WM performance, in particular on trials with higher WM load (Quidé et al., 2017; Üçok et al., 2015; Velikonja et al., 2019). In FEP, childhood trauma is associated with worse WM performance even after controlling for premorbid IQ, suggesting a specific impact on WM (Campbell et al., 2013). Although WM differences are a common risk factor, they are not always found across the psychosis spectrum and may be better accounted for by other factors, such as childhood trauma (Begemann, Daalman, et al., 2016; Kilian et al., 2018).

To date, most studies examining WM and trauma within the psychosis spectrum have focused on frank psychosis or CHR for psychosis. Few studies have examined the relationship between childhood trauma and WM in adolescents/young adults with PLEs (Begemann, Daalman, et al., 2016), and none to our knowledge have examined the interaction of childhood trauma and PLEs on WM. By examining PLEs and childhood trauma as correlates of WM performance, we can help disentangle the effects of childhood trauma and PLEs on WM and examine if these factors act individually or interactively to contribute to WM dysfunction. Furthermore, we will test a three-way interaction of gender, childhood trauma, and PLEs on WM performance in the full sample, as well as stratify by gender to determine if there are gender-specific effects in these relationships, given that gender differences in the effects of childhood trauma in individuals with positive PLEs have previously been found (Gibson et al., 2014).

We hypothesized that greater childhood trauma exposure and PLEs would both be associated with lower WM performance. Furthermore, we hypothesized that the interaction of childhood trauma and PLEs would predict poor WM, that is, the combination of greater childhood trauma and higher PLEs would be associated with lower WM scores. Additionally, we hypothesized that, consistent with findings from the schizophrenia literature, these relationships would be even stronger in females than males. This study

will clarify the relationship between PLEs, childhood trauma, and WM performance in a community sample of diverse undergraduates. These findings have implications for the mechanisms through which cognitive dysfunction develops in psychosis spectrum disorders and will help to identify targets for intervention prior to the onset of the disorder.

Method

Participants

Study participants were 466 undergraduate students at a large, racially, ethnically, and socioeconomically diverse, urban university, and were aged 18–36, since this period is when subthreshold psychotic symptoms typically emerge. Participants were recruited through the university's online psychology subject pool, which was open to all students at the university. Participants selected the current study from a list of available studies and reviewed a short description of the study, which was described as focusing on psychological symptoms and life events. All participants received course credit for completing questionnaires and cognitive tasks. The study was approved by the university's Institutional Review Board (Protocol #13359, Psychotic-like Experiences in a Non-Clinical Young Adult Student Population) and informed consent was obtained prior to research activities being conducted.

Measures

Questionnaires

CTQ (Bernstein et al., 1994). The CTQ was used to assess traumatic life events occurring before the age of 16. This inventory, validated for ages 12 and older, assesses five types of childhood maltreatment (emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect). The CTQ shows good sensitivity and specificity, internal consistency, and convergent validity in both clinical and community samples (Bernstein & Fink, 1998). The total score including all trauma types was used, and the five subscales were also utilized.

Prodromal Questionnaire (PQ; Loewy et al., 2005). The full-length, 92-item PQ (Loewy et al., 2007) was used to measure PLEs. Positive PLEs were evaluated using the 45-item positive scale. Supplemental analyses of attenuated negative and disorganized symptoms utilized the 19-item negative scale and 19-item disorganized scale, respectively. Individuals are asked whether they have experienced symptoms in the last month (outside the influence of drugs, alcohol, or medications). Endorsing eight or more distressing positive PLEs has been validated against the structured interview for prodromal syndromes (SIPS) in predicting psychosis risk syndromes with 90% sensitivity and 49% specificity (Loewy et al., 2005, 2007). The variable of interest was the total number of positive PLEs endorsed and supplementary analyses utilized the total number of attenuated negative and disorganized symptoms endorsed.

Cognitive Task

Spatial n-Back (Callicott et al., 1998): The spatial n-back assesses WM. Each trial displays a stimulus inside one of four circles fixed in a diamond pattern. Participants are instructed to report the location of the stimulus in the current trial (0-back condition), the preceding trial (1-back condition), or two trials prior (2-back condition). The stimulus duration was 400 ms and the interstimulus interval was 1,400 ms. After a set of practice trials, participants completed six blocks of seven critical trials per condition, for a total of 126 critical trials. Participants scoring below chance (25% accuracy) on any of the three conditions were excluded. A sensitivity index of performance accuracy was calculated as $d' = Z_{\text{hits}} - Z_{\text{false alarms}}$, as d' is the most appropriate metric of WM in studies of schizophrenia (Haatveit et al., 2010). A WM index was computed by controlling 2-back d' scores for 0-back d' scores.

Data Analysis

First, we examined the moderating effect of total childhood trauma on the relationship between positive PLEs and WM. Next, as trauma has been found to impact individuals differentially by gender, we stratified the sample into males and females (via self-reported gender) and examined the same moderation model in both genders. Effect sizes are reported in terms of f^2, with 0.02 representing a small effect, 0.15 a medium effect, and 0.35 a large effect (Cohen, 1988). First, the dependent variable (WM) was examined visually and statistically for normality. Next, bivariate relationships were examined between all variables of interest. Linear regressions were conducted predicting WM performance from childhood trauma and PLEs separately, and then together to examine the additive relationship of the two variables on WM performance. The interaction of childhood trauma × PLEs predicting WM was also examined. Finally, given evidence that trauma has differential effects on males and females, a three-way interaction including gender was run. As the sample was drawn from the community and was anticipated to experience a reduced range of psychopathology and WM dysfunction compared to a clinical or high-risk sample, thus limiting power for detecting an interaction, we then ran an exploratory analysis stratified by gender and the hierarchical model was run for males and females separately. Because there was a significant difference in mean age between males and females in our sample, $t(465) = 2.92$, $p = .004$, we controlled for age in all analyses. Post hoc analyses examining the relationship between childhood trauma subtypes (physical abuse, emotional abuse, sexual abuse, physical neglect, and emotional neglect) and WM were examined. Finally, supplementary analyses of the hierarchical model using attenuated negative and disorganized symptoms as independent variables were conducted, but should be interpreted with caution as these scales have either not been validated (attenuated disorganized symptoms) or have poor convergent and divergent validity (Pierce et al., 2021).

Results

Participant demographics are presented in Table 1 and bivariate correlations between study variables of interest are presented in Table S1 in the online supplemental materials.

Primary Analyses

In the full sample, positive PLEs and childhood trauma were not significantly associated with WM performance. The interaction of childhood trauma and positive PLEs on WM performance was not significant, and the three-way interaction of gender × PLEs × trauma did not significantly predict WM. In the exploratory analysis

Table 1
Demographics and Clinical Features of Total Sample (N = 466), Females (n = 335), and Males (n = 131)

Measure	Total sample	Females only	Males only	Difference (t or χ^2, p)
Age (years), *M* (*SD*) [range = 18–36]	**20.43 (2.77)**	20.19 (2.57)	21.03 (3.18)	2.92, **.004****
Gender, % (*n*)—male	**28% (131)**	—	—	—
Ethnicity, % (*n*)—Hispanic	**4% (20)**	5% (15)	4% (5)	.10, .75
Race, % (*n*)	—	—	—	7.02, .14
Asian	**14% (67)**	13% (44)	18% (23)	—
African American	**12% (57)**	14% (47)	7% (10)	—
Caucasian	**62% (290)**	60% (202)	67% (88)	—
Multiracial	**4% (19)**	5% (16)	2% (3)	—
Unknown	**7% (33)**	7% (24)	6% (9)	—
Born in the United States, % (*n*)	**85% (396)**	86% (287)	83% (109)	.45, .50
PQ positive scale, *M* (*SD*) [range = 0–37]	**9.05 (7.13)**	8.60 (7.02)	10.18 (7.34)	2.15, **.03***
PQ positive distressing items endorsed, % (*n*)	—	—	—	.159, .69
0–7 items	**88% (410)**	88% (296)	87% (114)	—
8+ items	**12% (56)**	12% (39)	13% (17)	—
PQ negative scale, *M* (*SD*) [range = 0–19]	**6.85 (5.08)**	6.67 (4.97)	7.30 (5.34)	1.15, .25
PQ disorganized scale, *M* (*SD*) [range = 0–5]	**1.02 (1.29)**	1.05 (1.32)	0.95 (1.21)	−.70, .48
CTQ total trauma, *M* (*SD*) [range = 25–85]	**36.52 (12.17)**	36.90 (12.92)	35.55 (9.99)	−1.08, .28
CTQ emotional abuse subscale, *M* (*SD*) [range = 5–25]	**8.11 (3.99)**	8.33 (4.21)	7.56 (3.33)	−2.05, **.04***
CTQ physical abuse subscale, *M* (*SD*) [range = 5–20]	**6.59 (2.63)**	6.59 (2.70)	6.59 (2.44)	.10, .99
CTQ sexual abuse subscale, *M* (*SD*) [range = 5–25]	**6.13 (3.47)**	6.36 (3.89)	5.54 (1.93)	−3.03, **.003***
CTQ emotional neglect subscale, *M* (*SD*) [range = 5–25]	**9.09 (4.50)**	9.16 (4.55)	8.89 (4.23)	−.61, .27
CTQ physical neglect subscale, *M* (*SD*) [range = 5–18]	**6.61 (2.52)**	6.47 (2.40)	6.97 (2.79)	1.82, .07
Working memory index, *M* (*SD*) [range = −1.9–1.8]	**0.11 (0.92)**	0.05 (0.91)	0.25 (0.96)	2.09, **.04***

Note. Bolded values indicate significant result. PQ = Prodromal Questionnaire; CTQ = Childhood Trauma Questionnaire.
* $p < .05$. ** $p < .01$.

stratifying by gender, childhood trauma significantly predicted WM above and beyond the effect of PLEs in females only ($p = .03$); however, the effect size was small ($f^2 = .02$). Notably, females did not experience significantly more childhood trauma overall compared to males but did report significantly more childhood sexual abuse and emotional abuse (see Table 1). PLEs were not associated with WM in either gender. Furthermore, there was no significant interaction of PLEs and childhood trauma on WM in either females or males (see Table 2).

Post Hoc and Supplemental Analyses

Given our finding that childhood trauma trended toward predicted WM performance above and beyond the impact of positive PLEs in females, we conducted a linear regression examining subtypes of trauma (physical abuse, emotional abuse, sexual abuse, physical neglect, and emotional neglect) in the full sample, as well as males and females separately. In the full sample, WM performance was predicted by physical neglect ($p < .05$) and trended toward predicting WM in females only ($p = .051$); however, in males, sexual abuse trended toward predicted WM performance ($p = .052$); see Table 3 for results. Finally, we explored additional subtypes of PLEs (negative and disorganized) as independent variables within the hierarchical model (see Table S2 in the online supplemental materials). We found a similar pattern of results to positive PLEs, such that in the full sample, childhood trauma significantly predicted or trended toward predicting WM performance (attenuated negative symptoms $p < .05$, attenuated disorganized symptoms $p = .09$). Again, after stratifying by gender, we found that CTQ significantly predicted WM for females but not males over the effect of attenuated negative symptoms ($p = .01$) and trended toward significance over the effect of disorganized PLEs ($p = .05$).

Discussion

These results indicate that, in a nonpsychiatric sample of individuals experiencing a range of PLEs, childhood trauma was a significant predictor of lower WM performance in females only. Positive PLEs were not associated with WM performance in the full sample, as well as males and females separately. Although these findings are consistent with our previous work (Chun et al., 2020; see Appendix A1), which found no association between PLEs and WM, others have found that PLEs are associated with poorer WM performance (Mollon et al., 2016; Rossi et al., 2016). However, these studies did not assess for sex differences in their samples, were recruited from the general population compared to university settings, and consisted of a sample of adolescents rather than young adults. As PLEs are consistently higher in younger individuals, both in community and help-seeking settings (Brandizzi et al., 2014; Scott et al., 2008), these studies may have had higher prevalence and/or severity of PLEs compared to our relatively older ($M_{age} = 20.43$ years) sample.

Our primary hypothesis that childhood trauma and PLEs interact to produce WM dysfunction was not supported. It is possible that, within our nonpsychiatric sample of young adults, childhood trauma, rather than a vulnerability for psychosis, may be driving WM impairments, as has been found in prior studies in individuals with PLEs (Begemann, Heringa, & Sommer, 2016) and FEP (Campbell et al., 2013). Alternatively, it has been suggested that impairments in executive functions such as WM may constitute a causal mechanism through which childhood trauma leads to the later development of psychotic symptoms (Begemann, Daalman, et al., 2016). While the effect sizes are small, given that this is a nonpsychiatric sample of undergraduate students, even a small impact on WM could be meaningful, as we would expect these effects to

Table 2

Hierarchical Linear Regression Models of Positive PLEs and Childhood Trauma Predicting WM, Controlling for Age (Total N = 466, Female n = 355, Male n = 131)

	Outcome (DV)	Total sample				Females only				Males only			
Step	WM	B_1	95% CI (B_1)	β_1	f^2	B_2	95% CI (B_2)	β_2	f^2	B	95% CI (B)	β	f^2
Step 1	Positive PLEs	−.02	[−.11 to .07]	−.03	<.01	.01	[−.10 to .11]	.01	<.01	−.10	[−.27 to .07]	−.11	.01
	CTQ	−.08	[−.17 to −.01]	−.10	.01	**−.11***	**[−.21 to −.01]**	**−.13**	**.02**	.03	[−.18 to .25]	.03	<.01
	Gender	**.24***	**[.05 to .43]**	**.12**	**.04**	—	—	—	—	—	—	—	—
Step 2	Positive PLEs × CTQ	−.06	[−.14 to .01]	−.08	.03	−.04	[−.12 to .04]	−.06	<.01	−.17	[−.35 to .02]	−.18	.03
	Positive PLEs × Gender	−.13	[−.33 to .07]	−.07	.02	—	—	—	—	—	—	—	—
	CTQ × Gender	.17	[−.06 to .39]	.08	.02	—	—	—	—	—	—	—	—
Step 3	Positive PLEs × CTQ × Gender	−.13	[−.32 to .07]	−.08	.02	—	—	—	—	—	—	—	—

Note. Bolded values indicate significant result. Effect size values of f^2 and significance for Step 2 reflect the change in variance explained for Step 2 over and above Step 1. Effect size values of f^2 and significance for Step 3 reflect the change in variance explained for Step 3 over and above Steps 1 and 2. B = unstandardized coefficient; β = standardized coefficient; PLEs = psychotic-like experiences; WM = working memory; DV = dependent variable; CI = confidence interval; CTQ = childhood trauma questionnaire.
* $p < .05$.

be subtle in a community sample. It is important to recognize that only 12% of the total sample ($n = 56$) endorsed eight or more positive symptoms items as distressing on the PQ, which is validated against the SIPS in predicting psychosis risk syndromes (Loewy et al., 2005, 2007). Furthermore, even socioeconomic status (SES) only has a small to moderate impact on spatial WM in children (Mooney et al., 2021). As such, even small effects on WM are likely meaningful given the robust relationship between SES and cognition (Hackman et al., 2014), with SES reflecting environmental disadvantages associated with poor outcomes and is often confounded with race due to structural racism (Anglin et al., 2021).

Our findings suggest that childhood trauma is related to poorer WM performance in females, even in a community sample of undergraduates experiencing a range of PLEs, though it is important to note that the stratified analysis was exploratory in nature and there was no significant three-way interaction of gender. Although the underlying mechanisms of this distinction remain unclear, it has been suggested that this association may be due to an increase in stress sensitivity, which occurs when early exposure to life stress (i.e., childhood trauma) makes individuals more sensitive or reactive to stressful events later in life (Collip et al., 2007). This impaired stress tolerance then leads to higher levels of psychotic experiences in reaction to daily life stress, which constitutes a vulnerability for developing frank psychosis (Myin-Germeys et al., 1999, 2001). In fact, our previous work has shown that traumatic life events were associated with higher levels of PLEs, and that this relationship is mediated by stress sensitivity (Gibson et al., 2014). Importantly, this relationship was only true for females, thus indicating that females with childhood trauma may represent a particularly vulnerable group. Post hoc analyses examining childhood trauma subtype revealed that physical neglect was a significant predictor of poorer WM performance in the entire sample, and trended toward significance in females; however, childhood sexual abuse trended toward predicting WM performance in males. These findings again confirm the need to examine processes by which childhood trauma impacts cognition separately by gender, as a combined sample may mask sex-specific effects through which specific traumas differentially impact individuals.

In addition, childhood trauma has been associated with structural and functional brain changes in regions involved in WM processes, such as the prefrontal cortex and orbitofrontal cortex (Hanson et al., 2010, 2012). Furthermore, trauma is associated with greater activation of prefrontal regions during WM (Philip et al., 2016), as well as enhanced deactivation of the default mode network (Philip et al., 2013), suggesting the possibility that additional cognitive resources are required during WM among those with a history of trauma.

Table 3

Linear Regression Examining Childhood Trauma Subtypes Predicting WM Performance, Controlling for Age, in the Total Sample and in Females and Males (Total N = 466, Female n = 355, Male n = 131)

Outcome (DV)	Total sample				Females only				Males only			
WM	B_1	95% CI (B_1)	β_1	f^2	B_2	95% CI (B_2)	β_2	f^2	B	95% CI (B)	β	f^2
Emotional abuse	.01	[−.01 to .04]	.06	.02	.01	[−.03 to .04]	.02	.02	.05	[−.01 to .11]	.18	.03
Physical abuse	−.02	[−.06 to .02]	−.06	.03	−.03	[−.07 to .01]	−.09	.03	−.04	[−.12 to .04]	−.10	.02
Sexual abuse	−.01	[−.04 to .01]	−.05	.02	−.02	[−.05 to .01]	−.08	.03	**.09**†	**[−.001 to .18]**	**.18**	**.06**
Emotional neglect	−.002	[−.03 to .02]	−.01	.02	.01	[−.02 to .04]	.05	.02	−.01	[−.06 to .04]	−.06	.03
Physical neglect	**−.04***	**[−.08 to −.001]**	**−.11**	**.03**	**−.05**†	**[−.1 to .00]**	**−.13**	**.04**	−.05	[−.12 to .03]	−.14	.04

Note. Bolded values indicate significant result. B = unstandardized coefficient; β = standardized coefficient; WM = working memory; DV = dependent variable; CI = confidence interval.
* $p < .05$. † $p < .06$.

Differential gender outcomes have also been previously related to differences in neurological functioning, such as greater activation of the hypothalamic–pituitary–adrenal axis in response to stress in females (DeSantis et al., 2011) and lower prefrontal–amygdala connectivity among females versus males with a history of childhood trauma (Herringa et al., 2013). While there is some evidence that sex is a moderator for heterogeneity of hippocampal volumes (Kribakaran et al., 2020), a region that has been previously implicated in WM processes (Hyman et al., 2010; Spellman et al., 2015), sex differences in the relationship between childhood trauma and neural correlates of WM have yet to be directly examined. However, there is some evidence for sex-specific activation patterns during WM in healthy, nontrauma-exposed adults, such that females show greater activation in prefrontal and limbic regions while males activate more parietal regions (Hill et al., 2014). Taken together, these findings suggest a potential mechanism through which females may be particularly affected by childhood trauma.

This study had several strengths and limitations. Although the college sample may limit generalizability, participants were recruited from a large, diverse university, reflecting the demographics of the surrounding area. The use of a nonhelp-seeking, nonpsychotic sample avoids illness-related factors such as potential impact from antipsychotic medications. Furthermore, our measure of childhood trauma was retrospective, which yields much lower endorsement rates than prospective measures (Baldwin et al., 2019), suggesting that prevalence of childhood trauma may be underreported in samples utilizing retrospective measures of childhood trauma. Similarly, the cross-sectional nature of this study does not allow us to determine causality and we cannot be sure if childhood trauma predated PLEs and/or WM dysfunction. Future studies should examine the relationship between childhood trauma, PLEs, and WM prospectively to better disentangle the mechanisms at play. Furthermore, while we did find sex differences in our analysis stratifying our sample by gender, this analysis was exploratory and should be interpreted as such, particularly in the context of the nonsignificant interaction. Additionally, our supplemental analyses utilizing the negative and disorganized scales of the PQ should be interpreted with caution, as these scales have poor validity or have not been validated, respectively. Future studies should replicate these analyses using well-validated measures of attenuated negative and disorganized symptoms. Lastly, these findings are limited to a binarized conceptualization of gender, and future studies should utilize more inclusive gender identities (e.g., intersex, nonbinary, gender-fluid, and gender nonconfirming).

Overall, our findings suggest that females who have experienced maltreatment in childhood are at risk for developing poorer WM performance, which has important implications for treatment efforts. Cognitive remediation programs, which have been utilized in individuals with frank psychotic disorders (Ventura et al., 2019; Vidarsdottir et al., 2019) and in individuals at CHR (Glenthøj et al., 2017), may be considered as a potential adjunctive treatment to test for improving WM performance in females with a history of childhood trauma, as well as determining whether trauma-focused cognitive behavioral therapy can improve cognition in nonpsychiatric samples.

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(*Appendix follows*)

Appendix

Table A1
Description of Multiple Uses of Data Collected From the Same Sample

Manuscript number	Variables examined	Difference from the current manuscript
1[a]	Psychotic-like experiences, anhedonia, attenuated disorganized symptoms, working memory performance, social and role functioning	Does not examine the impact of childhood trauma and their interaction with psychotic-like experiences on working memory performance. Does not include gender differences

[a] Chun et al. (2020).

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