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BRIEF REPORT

Affective Working Memory Capacity in Refugee Adolescents

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Objective: High numbers of adolescents today are exposed to conflict-related trauma, with trauma-exposure being associated with adverse biopsychosocial outcomes. Here we investigated the influence of trauma-exposure and high levels of posttraumatic stress disorder (PTSD) symptoms on cognitive functioning in trauma-related compared to neutral contexts. ***Method:*** Afghan adolescent refugees with high levels of PTSD symptomatology and non-trauma-exposed Afghan adolescent refugee controls (N = 47; 43% female; aged 13–19 years, M = 15.49, SD = 1.40) completed a visual working memory task including affective (trauma-related) and neutral distractors. ***Results:*** Working memory capacity in the context of trauma-related distractors (and not neutral distractors) was significantly poorer in trauma-exposed refugees with high levels of PTSD when compared to non-trauma-exposed controls. ***Conclusions:*** The findings highlight the importance of investigating posttraumatic cognitive functioning within affective contexts and suggest that affective working memory capacity may constitute a promising target for intervention.

Clinical Impact Statement
In this study we found that trauma-exposed refugee adolescents had poorer affective working memory than non-trauma-exposed refugee adolescents. Thus, it is important to consider posttraumatic cognitive functioning in affective contexts. The findings suggest that affective working memory may constitute a promising target for intervention.

Keywords: visual working memory capacity, adolescents, refugee, posttraumatic stress disorder

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War and conflict have affected millions of civilians worldwide, with around half of the survivors being estimated to be under 18 years of age (Morina, von Lersner, & Prigerson, 2011; UNHCR, 2018; Wexler, Branski, & Kerem, 2006). While war affects both children and adults, youth are especially susceptible to the negative long-term consequences of war (Wexler et al., 2006). Indeed, research has documented the enduring negative psychosocial impact of war and conflict on adolescents, which include mental health difficulties, such as posttraumatic stress disorder (PTSD) and depression, as well as social and academic difficulties and deficits in cognitive functioning (e.g., Kira, Lewandowski, Somers, Yoon, & Chiodo, 2012; Morina et al., 2011; Wexler et al., 2006).

Early deprivation, exposure to stress, and experiences of extreme interpersonal stressors can impair a broad range of cognitive abilities and their neural substrates (Hanson et al., 2012; Pollak et al., 2010). Those who go on to suffer from PTSD in the aftermath of trauma show impairments on a wide range of cognitive functions (Aupperle, Melrose, Stein, & Paulus, 2012). Executive functions appear particularly vulnerable to the effects of cumulative life stress and early adverse experiences (e.g., Cowell, Cicchetti, Rogosch, & Toth, 2015; Hanson et al., 2012, 2013; Pollak et al., 2010). Here we focus on working memory capacity (WMC; i.e.,

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the ability to maintain "access to a limited amount of information in the service of more complex cognitive operations"; Moran, 2016, p.2). While the development of executive functions (including WMC) shows a strong genetic component from adolescence to early adulthood, the developmental trajectory can be modified by exposure to environmental influences (Friedman et al., 2016; Hanson et al., 2012). Thus, investigating the impact of adverse early experiences on WMC in adolescents is imperative (Hanson et al., 2012; Pollak et al., 2010).

A limitation of this research is that the assessment of cognitive functioning has tended to use neuropsychological assessments presented in "cold" neutral contexts. Yet, recent evidence from the adult literature suggests that it is the processing of affective trauma-relevant information, which may be particularly impaired in those suffering from adverse sequelae of trauma-exposure (Khanna et al., 2017; Schweizer & Dalgleish, 2011, 2016). Moreover, it is important to specifically investigate selective deficits in response to trauma-related distractors. Such deficits have been proposed to result from the heightened attentional capture of threat-related information and are associated with greater recruitment of the fronto-parietal control network for affective compared to neutral stimuli (White, Costanzo, Blair, & Roy, 2015). This network is involved in attentional control and executive functions, including WMC (Dixon et al., 2018). Clinically these heightened perceptual and executive demands placed on cognitive resources as a function of PTSD symptom severity may contribute to the maintenance of PTSD. That is, the processing of trauma-related thoughts, memories and feelings limit cognitive resources available to inhibit attention and disengaging from trauma-related triggers (Bardeen & Daniel, 2017; Schoorl, Putman, Van Der Werff, & Van Der Does, 2014) as well as difficulties in inhibiting prepotent maladaptive emotion-regulation strategies (Bardeen & Read, 2010; Cox & Olatunji, 2017).

It is unclear, however, whether cognitive functioning is affected by trauma-exposure per se or whether cognitive deficits are only observed in those who develop PTSD following trauma exposure (Aupperle et al., 2012). While some studies have found that adult trauma survivors with PTSD show impaired WMC in the context of trauma-relevant information compared to those who did not develop PTSD (Mirabolfathi, Moradi, & Jobson, 2019; Morey et al., 2009; Schweizer & Dalgleish, 2011, 2016; Zhang et al., 2013), others have demonstrated an impact of trauma exposure but not PTSD (Steudte-Schmiedgen et al., 2014). Moreover, WMC has also been shown to be impaired in psychologically healthy survivors of early life stress compared to non-trauma-exposed controls (Philip et al., 2016). These more recent findings are in contrast with a review of the literature including studies up until 2009, which showed that PTSD symptoms rather than trauma exposure were associated with poor cognitive functioning (Qureshi et al., 2011). However, the review explicitly excluded children and adolescents and only included "cold" neuropsychological measures of cognition.

Thus, to date, little is known about how trauma-related information interacts with cognitive functions in children and adolescents. The aim of the current study was therefore to investigate the impact of trauma-exposure and PTSD on adolescents' WMC and whether it would be differentially impacted in the context of trauma-related versus affect-neutral distractors. We also aimed to investigate whether the impact of trauma-related versus neutral distractors would vary as a function of trauma exposure and/or PTSD diagnosis. While previous research has investigated childhood/adolescent trauma focusing on maltreatment, abuse, and institutionalization, it is important to also explore other traumatized adolescent groups, such as refugees, as existing findings cannot be simply applied to these groups. The World Health Organization (2018) highlights the unique factors experienced by refugee children that require specialized understanding and clinical attention. Furthermore, adolescent refugee research is imperative given the unprecedented global levels of refugees (UNHCR, 2018).

To explore this, we included Afghan refugee adolescents who had either not been exposed to trauma or had been exposed to trauma (with and without PTSD). Given adolescents with PTSD show impairments on a wide range of cognitive functions (Aupperle et al., 2012) and adult trauma survivors with PTSD show impaired WMC (Mirabolfathi et al., 2019; Morey et al., 2009; Schweizer & Dalgleish, 2011, 2016), we predicted that WMC would be particularly impaired in those with PTSD when compared to those who did not develop PTSD and those who were not trauma-exposed (Hypothesis 1). Second, given adult trauma survivors with PTSD show impaired WMC in the context of trauma-relevant information (and not neutral information; Schweizer & Dalgleish, 2011, 2016), we further predicted that this difference would be greatest for trials including trauma-related distractors (Hypothesis 2). Finally, based on the preliminary evidence indicating that trauma exposure per se may influence WMC (Steudte-Schmiedgen et al., 2014), we predicted that WMC would be impaired in the group with trauma exposure compared to the group without a history of trauma (Hypothesis 3).

Method

Participants

All participants were recruited from an adolescent vocational training center in Karaj (city near Tehran). This center provides adolescents with vocational education and skill training in an aim to assist them in obtaining a job and generating income.

The primary difference between groups in this study relates to trauma exposure and presence or absence of PTSD diagnosis. Forty-seven Afghan adolescent refugees (aged 13–19 years, $M = 15.49$, $SD = 1.40$) participated in the study. The sample currently did not have legal residential documents to remain in Iran. The Structured Clinical Interview for *DSM–5* (SCID-5; First, Williams, Karg, & Spitzer, 2015) was administered to allocate participants to the trauma-exposed PTSD group ($n = 15$), non-PTSD group ($n = 14$) or non-trauma-exposed group ($n = 18$). Group allocation was determined based on whether participants met (or did not meet) PTSD diagnostic criteria as determined by the Iranian version of (SCID-5; First et al., 2015), which has been found to have adequate reliability and validity by the Institute of Psychiatry, Medical Tehran University (contact authors for further details). Two clinical psychologists, who were independent of the research team and blind to study hypotheses, interviewed each participant independently using the SCID to determine diagnosis. There was complete agreement between the two psychologists.

The trauma-exposed groups had experienced assault and war in Afghanistan and/or severe accidents during their migration process. All traumas had been experienced within the past 5 years

(participant age between 8 and 17 years). Depression symptoms were found to be secondary to the PTSD diagnosis. Adolescents allocated to the non-trauma-exposed group ($n = 18$) had not been previously exposed to trauma and did not meet diagnostic criteria for PTSD, major depressive disorder, or any other psychiatric condition. Participants in this group specifically reported that they had not been exposed to a traumatic experience in Afghanistan (although their parents may have), in their migration to Iran, or while living in Iran. It is important to highlight that this group cannot be considered a "healthy control group," as adolescents in this group were also experiencing psychological and social distress due to their current living difficulties and immigration status.

Measures and Procedure

Ethical approval was obtained from Kharazmi University Tehran, Iran. Participants were tested individually in a quiet room. Following written informed consent (from both the adolescents and their guardians) the SCID was administered. The trauma-exposed groups completed the Impact of Event Scale–Revised (Weiss & Marmar, 1997), a measure of PTSD symptoms, in response to their index trauma. The Persian version of the IES-R was used. It has been found to have high internal consistency and good test–retest reliability (Moradi et al., 2008). All participants then completed the Children's Depression Scale (CDS; Lang & Tisher, 2004), which is a reliable assessment of depression in adolescents across diverse cultures (Lang & Tisher, 2004). In the current study the Persian version of the CDS was used (test–retest reliability $r = .73$; internal consistency $\alpha = .92$; Najarian, 1994). The Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988) was used to assess anxiety. The Farsi version of the BAI was used, which has been found to have good reliability (test–retest reliability, $r = .83$; internal consistency $\alpha = .92$) and validity (e.g., Kaviani & Mousavi, 2008). Finally, participants completed the WMC paradigm on a 15.4-in computer screen. WMC was assessed with a delayed-match-to-sample task (Mirabolfathi et al., 2019, see online supplemental materials for details). The task presented participants with between two and four (1s per face) neutral female faces. The memoranda were followed by a maintenance phase during which participants were presented with a distractor for 2 s. The distractor images were derived from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008) and were either *trauma-related*, *neutral* (images of objects), or *scrambled* (images of white noise) pictures. Each load (2–4) was presented four times across distractor type, resulting in 36 trials.

Data Analysis Plan

WMC accuracy for each distractor type was investigated by computing d'-prime scores = Z(hit rate) – Z(false alarm rate) for each distractor separately (Morey et al., 2009). As there were no differences in WMC between the scrambled and neutral trials, an average of these scores were used as an index of neutral distractor trials. To test our first hypothesis of an effect of PTSD on WMC and that this effect would be strongest for trauma-related distractors (Hypothesis 2), we ran a 2 (Distractor Type: trauma, neutral) × 3 (Group: PTSD, non-PTSD, non-trauma-exposed) mixed analysis of variance (ANOVA). We also planned to compare the trauma-exposed and non-trauma-exposed groups (Hypothesis 3); to that end we computed a 2 (Distractor Type) × 2 (Group: exposed vs. not exposed) mixed ANOVA.

Results

Participant Characteristics

As shown in Table 1, the groups did not differ significantly in age, gender distribution, or anxiety but did differ significantly in depression. The PTSD group had significantly greater depression symptoms than the non-PTSD and non-trauma-exposed groups. The non-PTSD and non-trauma-exposed groups did not differ significantly in terms of depression. A similar pattern of results, to that reported below, was found when depression was included as a covariate. Both trauma-exposed groups further showed high

Table 1
Group Descriptives

Variables	PTSD	Non-PTSD	Control	Statistics
Age [years]	15.33 (1.29)	15.14 (1.46)	15.89 (1.41)	$F(2, 44) = 1.28$
Gender [female]	8 (53%)	7 (50%)	5 (28%)	$\chi^2 = 2.64$
IES-R	52.67 (12.44)	44.43 (10.49)	–	$F(1, 27) = 3.69$
Depression	90.16 (15.67)	71.64 (15.65)	72.23 (16.21)	$F(2, 44) = 6.71^{**}$ PTSD vs. non PTSD $t(27) = 3.18^{**}$ PTSD vs. Control $t(31) = 3.21^{**}$ Non-PTSD vs. Control $t(30) = .10$
BAI	21.40 (10.07)	20.36 (11.03)	14.61 (9.41)	$F(2, 44) = 2.18$
Working memory capacity (d'-prime scores)				
Trauma-related	.18 (.26)	.21 (.31)	.41 (.27)	$F(2, 44) = 3.21^{*}$
Neutral	.43 (.31)	.42 (.30)	.42 (.36)	$F(2, 44) < 1$
Scrambled	.42 (.22)	.32 (.34)	.38 (.27)	$F(2, 44) < 1$

Note. PTSD = posttraumatic stress disorder; IES-R = Impact of Event Scale-Revised; BAI = Beck Anxiety Inventory.
$^{*}p \leq .05$. $^{**}p < .01$.

levels of PTSD symptoms, with a trend toward the PTSD group reporting greater symptomatology ($p = .065$).

Affective Working Memory Performance

Effect of distractor type. WMC scores (i.e., d'-prime scores) are presented in Table 1. There was a main effect of distractor type, $F(1, 44) = 13.89$, $p = .001$, $\eta_p^2 = .24$; WMC was significantly impaired by trauma-related distractors compared to neutral distractors.

Interacting effects of PTSD and distractor valence. In contrast with Hypothesis 1, there was no main effect of group, $F(2, 44) = .99$, $p = .38$, $\eta_p^2 = 0.04$. There was however a significant interaction between distractor type and group, $F(2, 44) = 4.80$, $p = .01$, $\eta_p^2 = 0.18$. In line with Hypothesis 2, follow-up analyses revealed that WMC differed significantly across groups only when trauma-related distractors were presented, $F(2, 44) = 3.21$, $p = .05$, $\eta_p^2 = 0.13$, but not neutral distractors, $F(2, 44) < 1$, $p = .87$, $\eta_p^2 = 0.01$. The non-trauma-exposed group differed significantly from the PTSD group, $t(31) = 2.43$, $p = .02$, $d = 0.87$. The non-PTSD group performed at the intermediate level, showing a trend level reduction in performance compared to the non-trauma-exposed group, $t(30) = 1.91$, $p = .07$, $d = 0.69$, and there was no significant difference with the PTSD group, $t(27) = .29$, $p = .77$, $d = 0.10$.

Interacting effects of trauma exposure and valence. The analysis of an effect of trauma exposure (Hypothesis 3) revealed no main effect of trauma exposure, $F(1, 45) = 2.02$, $p = .16$, $\eta_p^2 = 0.04$. There was, however, a significant distractor type by trauma exposure interaction, $F(1, 45) = 8.71$, $p < .01$, $\eta_p^2 = 0.16$. Follow-up analyses revealed that WMC differed significantly between groups only when trauma-related distractors were presented, $t(45) = 2.54$, $p = .01$, $d = 0.76$, but not neutral distractors, $t(45) < .001$, $p = .99$, $d = 0.02$. For the trauma-exposed group, WMC was significantly impaired by trauma-related distractors compared to neutral distractors, $M_\Delta = -0.20$, $SE = 0.04$, $p < .001$, 95% CI $[-0.29, -0.12]$. For the non-trauma-exposed group, performance did not differ significantly depending on distractor type, $M_\Delta = 0.01$, $SE = 0.06$, $p = .88$, 95% CI $[-0.12, 0.14]$.

Discussion

This study aimed to investigate the impact of trauma exposure and PTSD on adolescents' WMC and whether it would be differentially impacted in the context of trauma-related versus affect-neutral distractors. Our results provide preliminary evidence regarding the importance of investigating WMC in the context of trauma-related versus neutral contexts in adolescents. Specifically, WMC in the context of trauma-related distractors (and not neutral distractors) was significantly poorer in those who had been exposed to trauma and had high levels of PTSD symptoms, when compared to non-trauma-exposed controls. Further, for trauma-exposed adolescents WMC was significantly impaired by trauma-related distractors compared to neutral distractors. However, for the non-trauma-exposed adolescents, WMC did not differ significantly depending on distractor type. Our findings are in contrast with the findings on affective WMC from studies in trauma-exposed adults (Schweizer & Dalgleish, 2011, 2016); the current study provided preliminary support for trauma exposure per se having a detrimental effect on WMC in the context of trauma-related distractors.

However, these findings need to be interpreted within the context of our sample currently experiencing significant psychological distress and social concerns. Specifically, the two trauma-exposed groups had experienced assault and war in Afghanistan and severe accidents during their migration process between the ages of 8 and 17. While some of these adolescents met PTSD diagnostic criteria, the other adolescents were also experiencing elevated rates of PTSD. Due to sample size and characteristics, we cannot ascertain what factors differentiated between those with and without PTSD (e.g., age at time of trauma, location of trauma exposure, frequency of exposure). This limits the inferences that can be made regarding the effect of PTSD on WMC. Further, adolescents in the non-trauma-exposed group, while not having been exposed to a traumatic experience in Afghanistan, in their migration to Iran, or while living in Iran, were experiencing psychological distress due to their current living difficulties. However, the findings indicate that trauma exposure and trauma-related distress, as opposed to general refugee-related distress, may be associated with difficulties in WMC.

These findings suggest that adolescents may be particularly sensitive to the adverse effects of exposure to highly negative social experiences, such as war. Preliminary support for this hypothesis is provided by data from the 1958 British Birth Cohort, which shows that differences in adolescent cognitive functioning are partially accounted for by trauma exposure, even after controlling for mental health problems (Geoffroy, Pereira, Li, & Power, 2016). Further research is needed, however, to formally compare WMC in trauma-exposed adolescents and adults.

These effects may be particularly pronounced in adolescents whose WMC is still developing. Encouragingly, preliminary research has shown that training affective WMC reduces adolescents' PTSD symptoms and increases their self-reported use of adaptive emotion regulation strategies (Schweizer et al., 2017). This training includes an affective dual n-back task that trains the flexible engagement and disengagement with emotional information (words and faces) depending on their task relevance (Schweizer et al., 2017). Interventions boosting WMC in the context of trauma-related distraction constitute promising adjuncts for state-of-the science trauma interventions that are cognitively demanding, such as trauma-focused cognitive behavior therapy (Cusack et al., 2016). This is of particular relevance for refugee adolescents, as refugees are frequently encountering trauma-related stimuli (e.g., in refugee camps, during migration, in the host country), and thus, without the implementation of WMC-related interventions, refugee adolescents may have ongoing WMC difficulties.

Several caveats are worth considering when interpreting the current findings. First, the study sample included was small, which may have led to an overinflation of the effect sizes of the significant effects observed in the current study (Button et al., 2013). Second, as discussed above, the trauma-exposed non-PTSD group reported PTSD symptom levels in the clinical range (Creamer, Bell, & Failla, 2003), this limits the claims that can be made about the effect of PTSD diagnosis on WMC. Third, the non-trauma-exposed group comprised adolescent refugees that had not been exposed to trauma, but the experience of being a refugee and associated psychological effects (including intergenerational) may

impact development. Thus, future research is required using other childhood traumas and adolescent samples to investigate whether these findings hold. Fourth, while PTSD has been observed in most societies and cultures (Foa, Keane, Friedman, & Cohen, 2009), including Afghanistan, the results need to be interpreted in regards to the application of Western diagnostic criteria to an Afghan group. Fifth, there were very few females included in the non-trauma-exposed group, which potentially limits the generalizability of our findings. Finally, the cross-sectional nature of the study prohibits inferences about the predictive utility of WMC in the context of trauma-related compared to neutral distractors. Future research is needed to prospectively explore the role of WMC in the etiology and maintenance of PTSD through mechanisms such as poor emotion regulation. McLaughlin's (2016) recent Transdiagnostic Model of Childhood Adversity and Youth Psychopathology, which outlines mechanisms (especially focused on emotional processing and executive functioning) associating childhood adversity with youth psychopathology, offers a useful framework to design these future studies. Despite these limitations, the study showed that trauma-exposed adolescent refugees showed significant deficits in WMC in the context of trauma-related but not neutral distraction. Future research is needed to establish the role of these deficits in the onset and maintenance of PTSD. Yet, preliminary evidence suggests that they may provide a promising target for intervention.

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