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ORIGINAL RESEARCH REPORT

The hidden price and possible benefit of repeated traumatic exposure

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Abstract

There is a growing evidence showing that first-responders who are frequently exposed to traumatic events as part of their occupational routine may pay a hidden price. Although they display low to moderate levels of post-traumatic stress disorder (PTSD) symptoms, similar to individuals with full-blown PTSD, they show impaired ability to process and react according to contextual demands. We aimed to test whether this impairment affects performance on simple unrelated tasks and its association with cumulative traumatic exposure and level of PTSD symptoms. Thirty-nine trauma-exposed criminal scene investigator police and 35 unexposed civilians matched for age, gender, and education performed a simple discrimination task in the presence of aversive pictures with low or high intensity. We predicted and found that trauma-exposed individuals failed to modify their behavior in accordance with levels of negative intensity. Hence they were equally distracted in both low and high negative intensity conditions, compared to unexposed controls who showed improved performance in low intensity conditions. Importantly, performance of trauma-exposed individuals on conditions of low intensity negatively correlated with their levels of PTSD symptoms. These results highlight the maladaptive tendency of individuals with repeated traumatic exposure to maintain the same behavior in low-intensity contextual conditions when it is no longer adequate. Interestingly however, in high-intensity conditions trauma-exposed individuals outperformed unexposed controls. Specifically, when completing simple tasks in high intensity conditions. The results suggest that repeated traumatic exposure has both positive and negative consequences on the way individuals interpret and react to their environment.

Keywords

Context, repeated traumatic exposure, hippocampus, negative intensity, functioning, first-responders

History

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Introduction

While there is an abundant of research on the short- and long-term effects of stress (Betts et al., 2014; Nakai et al., 2014; for review, see Crestani et al., 2013; Paykel, 2003), little is known about the possible consequences of repeated traumatic exposure. Interestingly, many studies on active-duty first-responders who are frequently exposed to traumatic events as part of their daily routine report low to moderate levels of post-traumatic stress disorder (PTSD) symptoms (e.g. Fushimi, 2012; Inslicht et al., 2010; Meyer et al., 2012; Orr et al., 2012). On the other hand, neuroimaging studies show that independent of PTSD diagnosis trauma-exposed individuals display deficits in hippocampal function and structure compared to trauma-unexposed controls (see Karl et al., 2006; Woon et al., 2010 for meta-analysis).

Animal and human models suggest that these hippocampal deficits impair the ability to process and integrate contextual information (Desmedt et al., 2015; Dickerson & Eichenbaum, 2010; Rudy, 2009). Possible support for such claim comes from a growing number of studies showing that after repeated traumatic exposure, both individuals with and without PTSD fail to behave in accordance with contextual demands (Hennig-Fast et al., 2009; Levy-Gigi & Richter-Levin, 2014; Levy-Gigi et al., 2014,2015a). For example, once trauma-exposed individuals learn that a specific context is negative they struggle to learn that the same context becomes positive, and hence fail to modify their behavior accordingly.

The aim of the present study is to test the effect of repeated traumatic exposure on the ability to function in contextual conditions with different aversive intensities and its association with levels of cumulative traumatic exposure and levels of PTSD symptoms. To that end we tested the ability of non-PTSD active-duty criminal scene investigator (CSI) police and unexposed civilians matched for age, gender, and education to perform simple target discrimination tasks in aversive contextual conditions with low and high intensity.

Previous studies report that, in general, task performance is impaired when conducted in aversive compared to neutral contextual conditions (Gronau et al., 2003; Hartikainen et al., 2000). More specifically, studies of healthy individuals, which used a similar paradigm, revealed decreased target

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discrimination in aversive compared to neutral contextual conditions (Okon-Singer et al., 2007,2014). In line with these findings we expect that unexposed controls will show better performance in aversive conditions with low compared to high intensity. On the other hand, we predict that individuals with repeated traumatic exposure will fail to flexibly modify their behavior and hence show a relatively poor performance not only in contextual conditions with high intensity but also in contextual conditions with low intensity.

Methods and materials

Participants

Thirty-nine active-duty CSI police who are repeatedly exposed to trauma as part of their daily routine and 35 unexposed civilians matched for age, gender, and years of education volunteered to participate in the study (see Table 1 for a detailed description of the sample). All participants were interviewed using the Clinical Interview for Diagnostic and Statistical Manual for Mental Disorders-Forth Edition (DSM-IV) Axis I Disorders (SCID-CV) (First et al., 1996). Exclusion criteria included any current DSM-IV psychopathology including PTSD, and any history of psychiatric or neurological disorders, alcohol abuse or dependence. CSI police were randomly recruited from six different police stations in central Israel, which are all located in a similar setting within a radius of 20 miles. All CSI police reported multiple exposures to DSM-5 Criterion A events (see more details in the following section on traumatic exposure). Since the present study aims to test the effect of repeated traumatic exposure independent of PTSD, three CSI police with a clear diagnosis of PTSD were excluded from the sample. The remaining 36 non-PTSD CSI police were interviewed to assess levels of subclinical PTSD symptoms. We used the Clinician Administrated PTSD Scale (CAPS) for DSM-IV-TR (Blake et al., 1995) since the new version of the interview (CAPS-5) was not yet available at the beginning of the study. All interviews were conducted by a trained and regularly supervised clinical psychologist. Participants in the unexposed control group were civilians who work in a production line in an industrial factory and trained to pay close attention to detail. They were recruited by a clinical psychologist that interviewed them to ensure no recall of significant past exposure to DSM-5 criterion A events. Five participants from this group were excluded from the study due to past exposure to a potential traumatic event. Individuals in both groups had high rates of consent; approximately 95% of the people we sampled agreed to participate in the study. The investigation was approved by The University of Haifa human subject review panel and carried out in accordance with the Declaration of Helsinki. All participants provided a written informed consent at the beginning of the experiment after the nature of the procedures had been fully explained.

Table 1. Demographic characteristics of the trauma-exposed CSI police and the trauma-unexposed matched-controls.

	Trauma-exposed CSI ($N = 36$)	Unexposed-controls ($N = 30$)
Age (years)	39.19 (9.36)	35.13 (10.03)
Male/female	29/7	25/5
Years of education	14.25 (1.48)	13.9 (1.88)
Medications[a] (N)	2/36	1/30
Years in police service	10.03	N/A
Individuals exposed to personally threatening incidents	36/36	0/30
Average critical incidents per person per year	60.5 (22.42)	N/A

[a]Two trauma-exposed participants and 1 unexposed control participant received benzodiazepine.

PTSD symptoms as measured by the Clinician Administrated PTSD Scale (CAPS) for DSM-IV-TR (Blake et al., 1995). Average critical incidents per person per year as measured by the modified version of the CIHQ (Weiss et al., 2010).

Measures

The aversive context paradigm

We developed a paradigm based on an affective perceptual paradigm (Lavie, 1995; Okon-Singer et al., 2007). In this paradigm participants need to discriminate a target letter among several distractor letters, while ignoring negative pictures with low or high intensity that were presented simultaneously (Figure 1). We used color real-life pictures from the International Affective Picture System (IAPS; Lang et al., 2008). Similar to other studies (Sheppes et al., 2011,2014) we applied the IAPS normative ratings for arousal (1 = low; 9 = high) and valence (1 = very unpleasant; 9 = highly pleasant) to determine pictures' intensity. According to the rating in these two scales we selected 80 IAPS pictures; 40 with low and 40 with high negative intensity. In order to further validate the intensity of these pictures we asked a sample of 50 police and 50 trauma-unexposed controls that were not part of the main study, to rate the negative intensity of these pictures on a 1–9 Likert scale. We compared the rating and excluded three pictures that were rated differently by the two groups (more than ±1SD difference in mean negative rating). From the remaining 77 pictures, we chose 20 low-intensity pictures (mean IAPS arousal = 4.89; mean IAPS valence = 3.72) and 20 high-intensity pictures (mean IAPS arousal = 6.29; mean IAPS valence = 1.75). Further analyses confirmed significant differences between both the arousal and the balance of the low and high intensity pictures, $Fs(1,38) > 21.03$, $ps < 0.001$. The content of the low- and high-intensity pictures was related to a wide range of aversive situations including sadness, disgust, threat, fear, and mutilations. Importantly, as illustrated in Figure 1, the pictures' general content, was roughly matched across the low- and

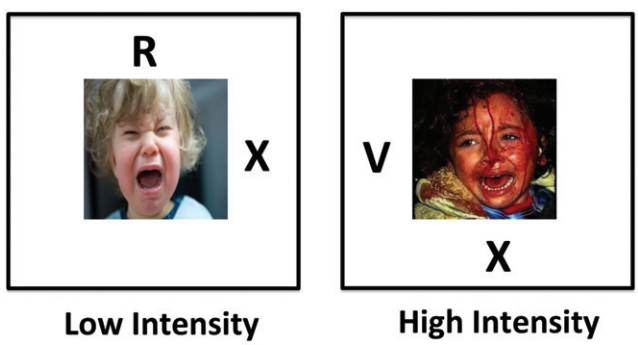

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Figure 1. Illustration of pictures with low and high intensities surrounded by target and distractor letters as appear in the aversive context paradigm.

high-intensity categories. *T*-test showed no difference in luminance, contrast, or dominant spatial frequency between the high- and low-intensity pictures (all t-values < 1, all p values > 0.6). An experimental trial started with a fixation cross, presented for 1 s, followed by a low- or high-intensity picture in the center of the screen for 2 s and surrounded by two letters. The letters always included a target letter (i.e. ''X'' or ''N'') and a distracting letter (Figure 1). Participants were asked to ignore the picture and discriminate the target letter by pressing the appropriate button (''X'' or ''N'') on the keyboard. They were requested to respond as fast and accurately as possible. At the beginning of the experiment participants performed a short practice session to familiarize them with the task. The experiment was presented in short blocks separated by ''null trials'' to control for habituation and expectancy effects. The trials were presented in a pseudorandomized order, with the criterion that no more than three consecutive short blocks of the same intensity (i.e. low or high) were presented. A subsequent part of the task, comprising other experimental conditions, is not included in the current report.

Cumulative traumatic exposure

Traumatic exposure was measured by the Critical Incident History Questionnaire (CIHQ), which is a 39-item self-report scale designed to produce a measure of cumulative exposure to critical incidents (Weiss et al., 2010). Similar to previous studies that used 14 items out of this list (e.g. Inslicht et al., 2010), we selected 14 items that were considered as personally life threatening to CSI police and confirmed as the most relevant items by the unit commander. CSI police were asked to rate the frequency they have personally experienced each of these items on an average year. Cumulative traumatic exposure was estimated by multiplying the number of years in service by the number of traumatic events on an average year.

Self-report questionnaires and cognitive assessment

All participants completed self-report questionnaires in order to control for possible effects of depression and anxiety symptoms. Depressive symptoms over the past 2 weeks were assessed using the revised version of the Beck Depression Inventory (BDI-II; Beck et al., 1996). Anxiety was measured using the STAI (State-Trait Anxiety Inventory; Spielberger et al., 1983) questionnaire. In addition, we used the Childhood Trauma Questionnaire (Bernstein & Fink, 1998), a 28-item questionnaire in which participants need to rank any experience of emotional, physical, and sexual abuse and emotional and physical neglect during childhood on a 5-point Likert scale. While none of our participants reported any significant traumatic experience during childhood, we used this careful screening to ensure no significant differences between the groups even in mild aversive experiences during childhood. Finally, we used the scaled scores of the Wechsler Adult Intelligence Scale III (WAIS-III) blocks design subtest to estimate and control for possible effects of IQ levels (Wechsler, 1997).

Data analysis

All data were checked for normality of distribution using Kolmogorov–Smirnov tests. Data from trials in which the reaction time was faster than 100 ms or slower than 3000 ms (less than 0.1% of the trials) were excluded from the analysis.

Results

The aversive context paradigm

We conducted a Group (trauma-exposed CSI police vs. unexposed controls) by Negative Intensity (low vs. high) mixed-model ANOVA on both reaction time and percentage of correct responses. In this model, Group was the between-participants factor while Negative Intensity was the within-participant factors. There were no effects on reaction time (all $ps > 0.28$) but robust effects on the percentage of correct response. Specifically, we found a significant main effect of Negative Intensity, $F(1,64) = 24.38$, $p < 0.001$, $\eta_p^2 = 0.28$, indicating that the percentage of correct responses in low intensity was significantly higher compared to high-intensity conditions. In addition, we found a significant Group by Negative Intensity interaction, $F(1,62) = 26.54$, $p < 0.001$, $\eta_p^2 = 0.29$ (Figure 2). Follow-up paired-samples t-tests revealed that as expected unexposed controls performed significantly better in the low compared to the high intensity condition, $t(29) = 5.95$, $p < 0.001$, while CSI police performed similarly in both conditions, $t(35) = -0.19$, $p = 0.86$. Moreover, when we compared the performance of the two groups in each of the intensity conditions we found that while in the low-intensity conditions unexposed participants outperformed CSI police, $t(64) = -2.38$, $p < 0.05$, in the high-intensity conditions CSI police outperformed the unexposed participants, $t(64) = 3.30$, $p < 0.005$. These results suggest that, as expected, unexposed individuals are affected by the intensity of the contextual conditions. Hence they perform better in conditions of low compared to high intensity. On the other hand, in high-intensity conditions, individuals with repeated traumatic exposure showed an advantage and performed better than unexposed individuals, while in low-intensity conditions they show poor performance compared to unexposed individuals.

Self-report questionnaires and cognitive assessment

Table 2 depicts the comparison of trauma-exposed individuals and unexposed controls on the BDI-II (Beck et al., 1996), the

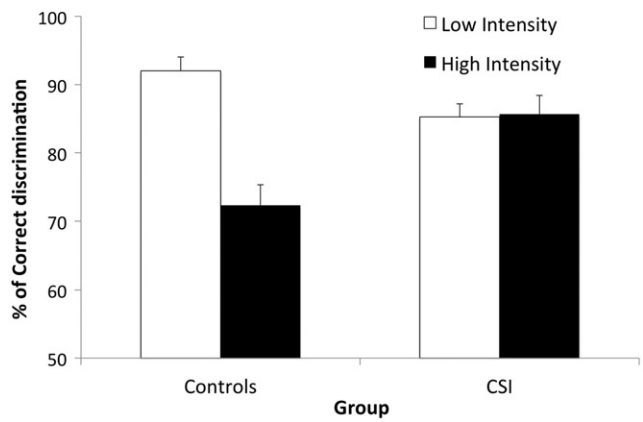

Figure 2. Percentage of correct discrimination in the aversive context paradigm as a function of Group (trauma exposed CSI police vs. trauma unexposed controls) and Negative Intensity (low vs. high).

STAI (Spielberger et al., 1983), the Childhood Trauma Questionnaire, and the IQ assessment (WAIS-III, Wechsler, 1997). There were no significant differences in childhood trauma, anxiety, and IQ scores between trauma-exposed individuals and the unexposed controls. Similar to previous reports trauma-exposed individuals exhibited lower levels of depressive symptoms compared to unexposed controls (e.g. Berg et al., 2006; Levy-Gigi & Richter-Levin, 2014; Levy-Gigi et al., 2014; van der Velden et al., 2013).

Correlation between performance, PTSD symptoms, and traumatic exposure

Tables 3 and 4 report Pearson's correlations between performance on conditions of low- and high negative intensity and levels of PTSD symptoms and cumulative traumatic exposure (when applicable), as well as depression and anxiety symptoms for the trauma-exposed participants and unexposed matched controls respectively. The results show a significant negative correlation between the performance of trauma-exposed individuals in low-intensity conditions and their level of PTSD symptoms, and a significant positive correlation between performance of trauma-exposed individuals in high-intensity conditions and levels of traumatic exposure. Hence, for trauma-exposed individuals, higher PTSD symptoms meant lower ability to perform tasks in aversive conditions with low intensity, while greater traumatic exposure meant better ability to perform tasks in aversive conditions with high intensity.

Table 2. Questionnaires and cognitive assessment (means and standard deviation) of trauma exposed firefighters and trauma unexposed matched controls.

	Trauma-exposed CSI ($N = 34$)	Unexposed controls ($N = 30$)
Depression	3.33 (3.94)*	6.07 (4.53)*
Anxiety	58.06 (13.16)	56.60 (12.08)
Childhood trauma	35.83 (6.12)	34.76 (4.51)
PTSD symptoms	10.58 (10.01)	N/A
IQ scaled scores	11.94 (1.35)	12.13 (1.70)

*$p < 0.05$.

Depression as measured by the BDI-II – The Beck Depression Inventory (Beck et al., 1996); anxiety as measured by the STAI – State-Trait Anxiety Inventory (Spielberger et al., 1983); childhood trauma as measured by the Childhood Trauma Questionnaire (Bernstein & Fink, 1998); IQ scores as estimated by the WAIS-III block-design subtest (Wechsler, 1997).

Table 3. Correlations between performance on the low- and high-intensity conditions, PTSD symptoms, cumulative traumatic exposure, depression, and anxiety symptoms in the trauma-exposed group.

	Low intensity	High intensity	PTSD	Cumulative exposure	Depression	Anxiety
Low intensity	1					
High intensity	0.46**	1				
PTSD	−0.61***	−0.18	1			
Cumulative exposure	0.31	0.42*	−0.13	1		
Depression	−0.14	0.06	0.35*	0.19	1	
Anxiety	−0.19	0.03	0.53**	0.22	0.48**	1

*$p < 0.05$
**$p < 0.005$
***$p < 0.001$.

Table 4. Correlations between performance on the low- and high-intensity conditions, depression, and anxiety symptoms in the unexposed control group.

	Low intensity	High intensity	Depression	Anxiety
Low intensity	1			
High intensity	0.39*	1		
Depression	0.14	0.22	1	
Anxiety	−0.07	0.26	0.24	1

*$p < 0.05$
**$p < 0.001$.

Discussion

The goal of the present study was to test the ability of individuals with repeated traumatic exposure to function in different aversive contextual conditions and its association with levels of cumulative traumatic exposure and PTSD symptoms. A unique population of active-duty, non-PTSD CSI police, and a matched group of civilians with no history of traumatic exposure underwent clinical interviews and completed a discrimination task in aversive contextual conditions with low and high intensity.

As predicted we found that trauma-unexposed controls performed better in low relative to high aversive conditions. These findings are in line with previous studies in healthy individuals, which compared performance in neutral and aversive conditions (Okon-Singer et al., 2007,2014), suggesting that conditions of both neutral and low intensity result in better performance compared to conditions of high intensity. Importantly, our findings demonstrated that unexposed individuals are affected by the intensity of the contextual condition and their functioning level is changed accordingly.

By the same token, individuals with repeated traumatic exposure reached similar level of performance in both contextual conditions. These results add to a growing amount of evidence demonstrating a noteworthy price of repeated traumatic exposure (Hennig-Fast et al., 2009; Levy-Gigi & Richter-Levin, 2014; Levy-Gigi et al., 2014,2015a; Steudte-Schmiedgen et al., 2014). Specifically, despite the relatively low levels of PTSD symptoms and diagnosis in first-responders (e.g. Admon et al., 2013; Chang et al., 2008; Del Ben et al., 2006; Fushimi, 2012; Guthrie & Bryant, 2006; Meyer et al., 2012; Orr et al., 2012; Soo et al., 2011), these individuals appear to have impaired processing of contextual information. Interestingly, similar patterns were found in individuals with PTSD (Levy-Gigi & Kéri, 2012; Levy-Gigi et al., 2012,2015b), indicating that despite categorically different symptom levels, the two groups share similar deficits.

These results are also in line with neuroimaging studies that demonstrate deficit in hippocampal structure and function in both trauma-exposed individuals with and without PTSD (for meta-analyses, see Karl et al., 2006; Woon et al., 2010) and provide further support for animal and human models of PTSD suggesting that such hippocampal deficits may result in inappropriate processing of contextual information, and may affect the way trauma-exposed individuals interpret and react to their environment (e.g. Acheson et al., 2012; Desmedt et al., 2015; Maren et al., 2013).

Importantly, when we compared the performance of individuals with repeated traumatic exposure to the performance of unexposed matched controls in conditions of low intensity, as expected, we found poorer performance of the trauma exposed group. Moreover, there was a significant negative correlation between their performance in these conditions and levels of PTSD symptoms. Hence, poorer performance in aversive conditions with low intensity was associated with higher levels of PTSD symptoms. This finding emphasizes the price of repeated traumatic exposure, suggesting that such behavior is not merely a by-product of traumatic exposure. Rather it may reflect a tendency to be highly alerted and use extra caution in mild aversive conditions when there is no substantial life threat (Acheson et al., 2015; McKibben et al., 2010).

When we compared the performance of the two groups in conditions of high intensity we found that, in opposed to our expectation, individuals with repeated traumatic exposure performed better than unexposed individuals. Our results are in line with previous studies, which showed strong connection between the ability to suppress emotions in high-intensity aversive conditions and general adjustment (Bonanno et al., 2004; Bonanno & Burton, 2013). It may suggest that such ability allows first-responders to keep doing their job and face traumatic events over and over again. This finding may reflect a possible benefit of frequent exposure and training to cope and function in intense aversive conditions. Specifically, it is possible that the professional training together with the frequent encounter with high aversive conditions improve the ability of CSI police to successfully function in such conditions. Additional support for such view can be found in the positive correlation between level of cumulative traumatic exposure and functioning in aversive conditions with high intensity, suggesting that increased traumatic exposure is associated with better performance.

The current study has several limitations. First, it was designed to detect possible effects of repeated traumatic exposure among active-duty, highly functioning first-responders. Therefore we excluded individuals who were diagnosed with PTSD. Previous studies suggest that individuals with PTSD show similar impairments in contextual processing (Acheson et al., 2012; Levy-Gigi et al., 2012; Levy-Gigi & Kéri, 2012). However, this is the first study, which tested the ability to function in different contextual conditions with low and high intensity. Future studies may aim to directly compare first-responders with and without PTSD to test whether they show similar functioning pattern.

In addition, due to the size of our sample and the relatively low level of PTSD symptoms we could not evaluate the possible associations between performance in conditions of low and high intensity and specific clusters of PTSD symptoms (see, for example, Levy-Gigi & Kéri, 2012; Kostek et al., 2014). The nature of the results suggests that such impairment would be associated with symptoms of alterations in arousal and reactivity (DSM-V, Criterion E). Future studies with larger enrollment may aim to further investigate this connection.

Another possible limitation is that for trauma-exposed individuals highly intense stimuli have little meaning. However, this seems unlikely given that prior to the study they rated the high-intensity pictures as significantly more negative than the low-intensity pictures. Therefore, it is not reasonable to assume that their similar performance in conditions of low and high intensity is due to impaired ability to distinguish between them or to a tendency to under estimate the negativity of high-intensity pictures.

Finally, since we compared CSI police and unexposed civilians it is possible that variables related to job selection and professional training affected our results. In order to minimize possible effects of job selection the unexposed participants in the current study were product line workers who were recruited from an industrial factory. Hence they share similar basic professional characteristics with CSI police such as attention to detail, accuracy, and through exploration. Controlling for possible effects of training is highly challenging within a population of active-duty servicemen due to the difficulty to distinguish between training and traumatic exposure. Specifically, each time CSI police are out in the field they gain more experience and become more trained. Moreover, testing these individuals at the end of their training course is not a potential solution since the training process itself includes working in real scenes with real evidence, and hence might be experienced as traumatic. Therefore, we believe that in order to test possible effects of training, future studies may wish to compare first-responders and civilians with repeated traumatic exposure (e.g. refugees or civilians who live in a continuous war zone). This comparison will allow teasing apart effects of job related factors and repeated traumatic exposure.

Conclusions

In conclusion, the present study supports a proposal of a hidden price in non-PTSD individuals with repeated traumatic exposure. Specifically, it shows that active-duty CSI police who are repeatedly exposed to traumatic events as part of their occupational routine fail to modify their behavior in accordance with changing contextual demands. Specifically, they react in a similar way in aversive conditions with both high and low intensity. In low-intensity conditions their performance is worse than unexposed individuals and negatively correlates with their levels of PTSD symptoms. This impaired performance may account for their tendency to be highly alerted and use extra caution not only in emergency situations but also in safe environments when such a response is no longer adequate. However, the study shows that repeated traumatic exposure may also have a value. Specifically, in high intensity conditions CSI police perform better than unexposed controls. Moreover, their performance significantly improves with levels of cumulative traumatic exposure. Hence, the study illuminates the multifaceted effects of repeated traumatic exposure, suggesting that such exposure may have diverged impact on the way trauma-exposed individuals interpret and react to their environment.

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Declaration of interest

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