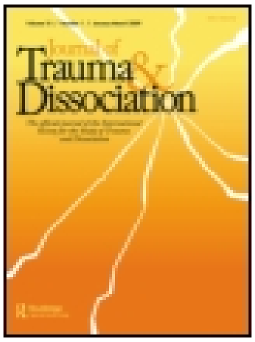

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The Relationship between Exposure to Missiles and PTSD Symptoms as a Function of Hemispheric Preference in Israelis

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Abstract

Recent research proposes that left hemispheric lateralization (HL) may protect against the effects of life events on mental distress. This study extends these findings by examining the protective role of left-HL in the relationship between war threat (missile exposure) and PTSD symptoms. A sample of 186 Israelis, exposed to missile attacks, completed brief scales of self-reported missile exposure, a subjective and a neuropsychological HL measure, and of PTSD symptoms. The sample was split into right-HL and left-HL individuals on both HL measures. Self-reported missile exposure was positively associated with PTSD symptoms in right-HL, but not in left-HL individuals on both HL measures. These results replicate and extend our previous results and suggest that left-HL may even protect against the effects of severe life threatening events. Results are discussed in relation to neuropsychological and neurophysiological differences between the hemispheres.

Keywords: hemispheric lateralization, post-traumatic stress disorder, war threat

Introduction

Post-traumatic stress disorder among citizens during wartime

A significant percentage of people, who are exposed to the threat of war or terrorism, initially develops various psychological symptoms and disorders (Priebe at al., 2012), which may be manifested in a smaller group of people by symptoms of post-traumatic stress disorder (PTSD) (Bleich, Gelkopf & Solomon, 2003; Gidron, Kaplan, Velt & Shalem, 2004). Several studies have been conducted to document the prevalence of PTSD symptoms in citizens exposed to war threat. One study conducted among Israeli citizens during the 2nd Lebanon war found a prevalence of 38% of probable PTSD (Somer, Maguen, Or-Chen, & Litz, 2009). In a study done on Lebanese people residing in villages in the south of the country, 17.6.-33.3% of the population had PTSD (Farhood & Dimassi, 2012). In a study done on 404 citizens of Kuwait, 4.5 years after the invasion by Iraq, 28.4% still had PTSD, while among students this figure rose to 45.6% (Al-Naser & Sandman, 2000). The latter finding also shows that such mental sequela may persist over time. Differences in sampling, timing from the event, using questionnaires versus structured interviews, cultural difference, and country and personal resources may account for the large differences in these prevalence rates.

Several factors make war stress unique compared to other potential traumatic events. War-related stress is deliberate and man –made, compared to natural disasters and wars are targeted at a population rather than at individuals, unlike a traffic accident. Several factors make war stress unique compared to other potential traumatic events such as traffic accidents or exposure to an earthquake. War stress includes great uncertainty concerning its duration and precise location of danger, severity of damage and injury and it is mainly targeted at a population rather than at individuals. Furthermore, war-related stress is deliberate and man-made in contrast to natural disasters. These differences could impact on people's appraisals of the event, their utilized resources and ultimate psychological reactions in the long-term.

Risk factors of war associated PTSD

Factors associated with civil post-traumatic stress symptoms have been studied in a large amount of studies. Background demographic factors include female gender, older age unemployed fathers (Kolltveit, Lange-Nielsen, Thabet, Dyregrov, Pallesen, Johnsen & Laberg, 2012; Ayazi, Lien, Eide, Ruom & Hauff, 2012) and low socioeconomic status (Ayazi, et al., 2012). Psychological background and event related factors and responses include previous stressful life events (Breslau, Chilcoat, Kessler & Davis, 1999), objective and subjective perceived threat and peri-traumatic dissociation (Gil, Weinberg, Or-Chen & Harel, 2015), In contrast, little is known about protective factors against war-related PTSD. For example, social support and higher cognitive ability predicted a reduced risk of PTSD (e.g., Tucker & Trautman, 2000; Shalev, Peri, Canetti & Schreiber, 1996; Buckley, Blanchard, & Hickling, 1996). Relevant to the present study's context, in a recent study on Israeli civilians exposed to missiles from The Gaza Strip, levels of objective threat (operationalized as shorter distance from Gaza), subjective threat (assessed by a questionnaire), female gender and peri-traumatic dissociation were positively related to PTSD symptoms (Gil et al., 2015). Thus, demographic, event-severity and psychosocial factors are risk or protective factors of PTSD development in general and in war time specifically.

Resilience factors and war associated PTSD

Several studies have examined factors which may protect people from developing PTSD following exposure to war threat. Solomon et al. (1991) found that soldiers without PTSD symptoms had higher combat-related self-efficacy than those with PTSD symptoms. While such a cross-sectional study cannot rule out the effects of current PTSD on one's perceptions of self-efficacy, it suggests that self-efficacy may have a protective role. A study in Portuguese veterans examined whether sense of coherence (SOC) is related to PTSD, and its mediating role between war-trauma exposure and PTSD. SOC reflects people's comprehensibility of their life events, manageability of their daily challenges and viewing their efforts as meaningful for perusing their goals. The investigators found that SOC was inversely related to PTSD. Furthermore, SOC mediated the relationship between both combat exposure and observing abusive violence on one hand, with developing PTSD on the other hand (Ferrajão & Oliveira, 2015). A recent study mentioned above found a negative association between various forms of forgiveness (to the situation, to self, to others) and war-related PTSD symptoms in Israelis in the recent war with Gaza (Gil et al., 2015). These studies are important in pointing at possible factors which therapy may wish to strengthen, to possibly protect people and prevent PTSD development.

Hemispheric Lateralization (HL) and affect regulation

Major advancements have been made in the neurobiology of PTSD including in the understanding of brain regions involved in trauma processing and in the brain regions involved in PTSD development (e.g., Admon, Milad, & Hendler, 2013; Shin et al., 2004). However, these studies rarely focus on neuropsychological resilience factors that may reduce the risk of PTSD. An emerging neuropsychological resilience factor is hemispheric lateralization (HL) or frontal asymmetry, the relative stable tendency to utilize or activate certain regions in one hemisphere compared to parallel regions in the other hemisphere (e.g. Davidson, 2004). It is important to note that multiple definitions and measures of HL exist, which reflect anatomical, functional and activity differences between the hemispheres. These differences contribute to the inconsistency and the confusion in this domain. Prefrontal cortical asymmetry plays a critical role in emotional and stress responses, and frontal asymmetry is commonly construed as a trait related to emotion, termed affective style (Davidson, 1992; Wheeler, Davidson & Tomarken, 1993). Specifically, high right compared to left prefrontal activity is associated with depression and anxiety (Thibodeau, Jorgensen & Kim, 2006), with dispositional negative affect (Tomarken & Davidson, 1994), and with poor regulation of negative emotions (Jackson et al., 2003). Problems in emotion regulation have been associated with PTSD (Ehring & Ehlers, 2014). Furthermore, during periods of stress, there is a relative shift from left to right hemispheric activity (Lewis, Weekes, & Wang, 2007). Some of these effects may occur via interhemispheric inhibition (Sullivan 2004). Interhemispheric inhibition (named also callosal inhibition) relates to interhemispheric communication between the right and left hemispheres as semi-independent parallel processing systems, via inhibitory pathways of the corpus callosum (Cook, 1984; Hoptman and Davidson, 1994; Van der Knaap and van der Ham, 2011). Chiarello and Maxfield (1996) propose three forms of interhemispheric inhibition:

Interhemispheric suppression, which refers to the process where the dominant hemisphere inhibits processing in the opposite hemisphere, minimizing the output conflict; *Interhemispheric isolation* which refers to reduction of signal transfer, so that the processes remain intact in each hemisphere, and there is no information transfer between the hemispheres; and the last type, *Interhemispheric inhibition*, which refers to the hindering process of one hemisphere by transferring conflicting information from the other hemisphere. Right HL being associated with mental distress and stress responses, may partially mediate the effects of severe or traumatic stress on PTSD development. In contrast, high left compared to right prefrontal activity is associated with dispositional positive affect and with behavior activation (Hoffman, 2008; Tomarken & Davidson, 1994), as well as with trait anger (Harmon-Jones & Allen, 1998) and sensation-seeking (Santesso, Segalowitz, Ashbaugh, Antony, McCabe & Schmidt, 2008; Hoffman, 2008). Giving these differences in hemispheric activity and emotional responses, do people with "trait" left and right HL respond differently to life events?

In a recent study, life events were found to be positively related to distress, especially in people with right- but not left- HL. Furthermore, experimentally induced stress led to higher perceived stress in right- but not in left- HL participants (AuthorCitation1). At the neurobiological level, the right hemisphere mediates the stress response, while the left hemisphere moderates it (Davidson, 2004; Cerqueira, Osborne, & Sousa, 2008). However, it remains unknown whether left HL protects against the possible adverse mental consequences of exposure to severe life threatening stressors such as war stress. The present study examined precisely this issue.

Hemispheric lateralization and PTSD

Previous theoretical studies emphasize the role of childhood traumatic attachment and subsequent pathological cortical development in the right hemisphere. This is then thought to result in abnormal regulation of stress responses and possibly in risk of PTSD (Schore, 2002). Studies on the relationship between attachment and trauma-related psychopathology among adults suggest that insecure attachment emerges as a potential risk factor for PTSD (Muller, Sicoli, & Lemieux, 2000), whereas secure attachment may protect against PTSD (O'Connor and Elklit, 2008). The relationship between attachment styles and PTSD might be culturally dependent, as shown in a larger subsequent study (Petersen and Elklit, 2013). Furthermore, improvements in PTSD may also have hemispheric parallels. In the context of psychotherapy for PTSD, one study examined the neural correlates of symptom reduction after cognitive behavioral treatment (CBT) for PTSD. A greater reduction in right hemisphere activity than in wait-list controls was observed after CTB, and reduction in PTSD symptoms across groups was positively correlated with reduced right anterior activity during exposure to trauma-related stimuli (Rabe, Zoellner, Beauducel, Maercker, & Karl, 2008). These results suggest that abnormal right hemisphere activity plays a role in PTSD. In contrast, Shankman et al., (2008), did not find differences in resting EEG measures of HL between PTSD cases and controls. Davidson (2004) proposed the Stress x Diathesis model, whereby the effects of HL manifest only during stressful contexts. This model may explain onset of PTSD: Only when a traumatic stressor and right HL predisposition co-occur, PTSD may develop. This hypothesis was tested in the present study.

The context of the present study

One war-laden region which has been investigated in relation to PTSD is the Arab–Israeli conflict. This conflict has included several decades of political tension and military conflicts between certain Arab countries and Israel, resulting in many lost lives on both sides. The nature of the conflict has shifted over the years from large scale regional Arab–Israeli wars to a more local Israeli–Palestinian conflict. On 8 July, 2014, Israel launched a military operation in its southern region, which it designated Operation Protective Edge (Miv'tza Tzuk Eitan in Hebrew), in response to thousands of missiles launched from the Gaza strip on Israeli civil towns for many years, particularly in its southern region. This operation resulted in the deaths of over 2,200 people, the vast majority of them Gazans. The war exposed both populations to several weeks of continuous heavy bombardments. Several studies have been conducted in relation to PTSD symptoms in Israeli citizens living near Gaza. One study found that PTSD symptoms were high mainly in citizens residing in a town near the Gaza strip compared to a socio-economically similar non-exposed city. Furthermore, lack of economic and social resources correlated with high symptomatology (Gelkopf, Berger, Bleich, & Cohen Silver, 2012).

The present study first examined the relationship between exposure to missiles and PTSD symptoms, among people living in the south of Israel. Second, it examined whether this relationship differed in people with left- versus right- HL. In line with the Stress x Diathesis model (Davidson, 2004) and recent findings (e.g., AuthorCitation2), we hypothesized that the correlation between perceived exposure to the missile threat and PTSD symptoms will be weaker in people with left- versus right- HL, reflecting a hypothesized protective role for left-HL.

Methods

Participants The present study included 186 women and men aged 18-82 who live in the south of Israel. The study was conducted face-to-face or by phone interviews, 1 to 3 months after the Israel-Gaza conflict in 2014. Participants were recruited in various workplaces in cities and towns in the South of Israel, or via phone calls to villages and Kibbutzim near the Gaza strip. This was not a randomly selected sample. Of the entire sample, 52.3% were recruited by phone. This study was approved by the Ethics committee of Tel-Hai University

College, North of Israel. The participants gave informed consent to be involved in the research.

Background data: These included age, gender, years of education and place of residence. The latter reflected the proximity to the Gaza strip, where 1 = Tel-Aviv region, 2 = Ashdod and Ashkelon, 3 = towns and villages near Gaza, similar to Gil et al. (2015).

Missile exposure: This was assessed by a validated 6-items questionnaire asking participants whether they were injured by missiles, whether anyone from their family or friends was injured, whether their property was damaged, whether they were forced to leave home, whether their family or friends had property damage, and if someone from their family or their friends was mentally affected by the missiles (Kirschenbaum, 2006). Each question was answered with a Yes/No response, and thus possible scores ranged from 0-6. In the present study, this scale's Cronbach's alpha was just below the acceptable level: $\alpha = 0.69$.

Hemispheric lateralization - HL: This was assessed by two methods. For the full sample, HL was assessed by a brief questionnaire specifically used for this study, to reduce the burden on participants during such a highly stressful period – Weeks after the war with very high chances of it restarting.

We selected four items from the original 20-item Hemispheric Preference Test (Zenhausern, 1978). Two items of left lateralization, asked about the ability to read (How quickly can you read?) and about the ability to find synonyms for words (How good is your ability to think about synonyms for words?), which reflected verbal thinking. Two other items of right lateralization asked about creativity tendencies (Are you artistically or musically creative?) and the likelihood of using symbols in solving problems (Do you like using symbols and/or images when solving problems?) which reflected visuo-spatial thinking. Scores on these items were most strongly correlated with the total mean score of their corresponding left/right HL sub-scale. The original scale was validated against an EEG-based measure of HL (Merckelbach, Muris, Pool, De Jong & Schouten, 1996). Each item was scored on a 1-10 Likert scale, where 1 = not at all, and 10 = very much. To calculate the right and left HL scores, we added up the right and left items separately, and then subtracted the right-HL from the left-HL items, yielding an overall left-HL score. Then, to create more clear HL subgroups, we only included the participants with the lowest 40% scores (reflecting right-HL) and the upper 40% scores (reflecting left-HL).

On the subsample of participants who were interviewed face to face, we additionally measured HL with the pre-bisected line bisection test. In this neuropsychological test, the participants were asked to choose which side in 18 pre-bisected horizontal lines is longer. Of the 18 lines, 15 lines were equally bisected, while 3 were unequally bisected to increase the credibility of the test. In the equally bisected lines only, when perceiving the right side of the line as longer, this reflected left HL, and vice versa. A right side choice was given 1 point and a left side choice was given 0. This selection was totaled and a higher score reflected greater left-HL. The lengths of the lines ranged from 22.9 cm. to 23.6 cm. The horizontal lines were slightly moved 0.5 cm to the right or left of the middle of the page. These lines were pre-bisected by a vertical 10 mm line. A similar non pre-bisected test was validated against EEG (Nash, McGregor & Inzlicht, 2010). In the present study, the test's Cronbach's alpha was: $\alpha = 0.59$. The correlation between the HL measures was not significant ($r = .17$, $p > .05$).

PTSD symptoms: This was assessed by a short valid measure of 4 – items (Kimerling et al., 2006). These included questions about having nightmares and intrusive thoughts, attempts to avoid thinking or going to places which remind the war, being on guard and startled, and feeling numb and detached from others. In its development, this brief 4-item scale was validated against the Clinician Administered PTSD Scale. Each item was scored with a Yes/No response and thus, the possible range of scores was from 0-4. Finally, a "probable" PTSD classification of those with PTSD scores of > 3 as cut-off was used, following Kimerling et al. (2006).

Procedure: After recruiting the participant, he or she was asked to answer a brief questionnaire about their background information, HL, exposure to missiles and their PTSD symptoms. Participants were thanked for their participation and were then provided brief information on coping with the threats of the missiles, as a way to thank them for their participation.

Statistical analysis: First, we examined the relationship between background variables, exposure to missiles and PTSD symptoms for all participants. Then, we re-examined the relationship between self-reported missile exposure and PTSD symptoms, separately for those scoring high (upper 40% percentile of HL reflecting left-HL) and low (lower 40% percentile of HL reflecting right-HL). Finally, we repeated these two analyses in a multivariate logistic regression, where significant correlates of "PTSD" classification and exposure to missiles were entered as predictors, again separately for high (left) and low HL (right) participants. Classification of "probable" PTSD was the dependent variable, and this was based on the cut-off proposed by the tool developers (Kimerling et al., 2006). For the line bisection test, because a smaller, sub-sample of participants answered it, we used the median split of that HL measure rather than the 40% upper and lower scores, to increase the sample and statistical power, in the separate analyses.

Results

Table 1 presents background characteristics of the sample. Approximately 2/3rds of the sample were women, and about half the sample lived near the Gaza strip. Of the background variables, only education and gender were significantly related to PTSD symptoms. These results are shown in Table 2. In the full sample, place of residence and type of sampling (phone versus face-to-face) were unrelated to PTSD symptoms. Missile exposure was mildly but significantly and positively correlated with PTSD symptoms: $r = 0.16$, $p < 0.05$. This remained significant, after statistically controlling for education and gender: $r = 0.18$, $p < .05$. However, when splitting the sample into participants with right- and left-HL (with the 4-item HL questionnaire), self-reported missile exposure was significantly and positively related to PTSD symptoms only in participants with right-HL ($r = 0.29$, $p < .010$) but not in those with left-HL ($r = 0.03$, $p > 0.05$). These correlations were significantly different from each other: Z for differences between rs = 1.76, $p < .05$ (1-tailed). Importantly, after statistically controlling for effects of gender and education, missile exposure was still significantly related to PTSD symptoms only in participants with right-HL ($r = 0.29$, $p = 0.01$), but not in those with left-HL ($r = 0.06$, $p > 0.05$).

We then examined these issues in relation to developing “probable” PTSD, using the cut-off proposed by the investigators. Of 182 participants for whom a full PTSD score was available, 39 or 21.4% reported “probable” PTSD. Among the tested variables, only gender, place of residence and type of sampling method were significantly related to “probable” PTSD (all ps < 0.05). In a multivariate logistic regression, exposure to missiles significantly correlated with “probable” PTSD in right-HL participants (Relative risk (R.R) = 1.8, 95% confidence-interval (CI): 1.1-2.9), but this was not the case in left-HL participants (R.R = 1.5, 95% CI: 0.8-2.7; see Table 3).

We then retested this issue in the sub-sample in whom the neuropsychological HL measure of the pre-bisected line test was used. Here, we divided the sample at the median low (right-HL) and hi7gh (left-HL) scores. Among participants with right-HL, self-reported exposure to missiles was again significantly and positively correlated with PTSD symptoms ($r = 0.30$, $p < 0.05$) but not among those with left-HL ($r = -0.22$, $p > 0.05$). This pattern remained similar also after controlling for gender and education (r = 0.25, p < .06, 1-tailed, for right-HL; r = -0.26, p < 09, for left-HL).

Discussion

The aim of the present study was to examine whether left-HL plays a possible protective role in the relationship between levels of a life threatening stressor, missile exposure, and post-traumatic stress symptoms. Left-HL was construed as an emerging protective or resilience factor based on studies reviewed above. Results of the present study revealed that left-HL indeed emerged as a protective factor in the exposure to missiles – PTSD relationship: Self-reported exposure to missiles was positively correlated with PTSD symptoms in right-HL participants, but not in left-HL participants. Importantly, this pattern was replicated using two methods for assessing HL – a brief self-report scale and a more objective neuropsychological test. The repeated pattern of results is supporting the reliability of the claim that left-HL is protective, despite the fact that both HL measures were uncorrelated. This could have resulted from each measure using a different method, and since each measure may also reflect another aspect of HL (perceived cognitive style versus neuro-visual bias). Finally, in a logistic regression, among five variables, a greater risk to develop “probable” PTSD was associated with greater exposure to missile threat, but only in right-HL participants, not in those with left-HL, using the brief self-report HL scale.

These findings support our previous study, where a brief experimentally induced stressor led to higher perceived stress in right- but not in left- HL participants (AuthorCitation2). Our results also echo the findings of a recent study (Israel-Cohen, Uzefovsky & Kashy-Rosenbaum, 2015), where negative affect (associated with right-HL) but not positive affect (associated with left-HL; Davidson, 2004) mediated the relationship between gratitude and PTSD symptoms, 2 $^{1/2}$ months after missiles attacks. However, unlike the latter study, the present study included two direct measures of HL, rather than inferring its role via assessment of positive versus negative affect. In addition, the previous study looked at affectivity as a mediator while HL was considered more as a moderator in the present study. Our findings are also in line with those of Lopez-Duran, Nusslock, George & Kovacs, (2012) who found that left HL (measured by EEG) moderated the effect of maternal history of depression on children's internalizing behavior, and with those of Farina and colleagues (Farina et al., 2012) who found that left-handers scored higher than right- and mixed-handers on the insomnia scale and 3.3 fold increase in odds to have emotional distress in mixed- handed people compared to right-handed, 22 months after an earthquake. Anyway, HL concept goes beyond the impact of handedness since HL differences occur also in right handed people alone. Finally, our findings are in line with the stress x diathesis model of Davidson (2004). The combination of a stressor and right-HL may result in greater negative consequences (e.g., PTSD symptoms), while left-HL may protect against the effects of severe stressors on well-being.

Two mechanisms are proposed to explain the results observed here and the proposed protective role of left-HL. The first mechanism is related to the differences between the two hemispheres in relation to approach and avoidance behaviors and emotions. Hofman (2008) reviewed this literature and provided a comprehensive framework which helps to integrate the findings. He concluded that the right hemisphere represents the behavioral inhibition system (BIS) and the withdrawal emotions (anxiety and depression). In contrast, the left hemisphere represents the behavior activation system (BAS) which reflects approach emotions and behaviors (positive affect, hostility and impulsiveness). Certain coping strategies are related to the BIS system, such as avoidance and disengagement (Litman, 2006). Generally, though not in all studies, emotion focused coping and avoidance coping are also positively correlated with PTSD. In contrast, more active and problem-focused coping strategies which reflect BAS, are generally inversely related to PTSD (e.g., Solomon, Mikulincer & Avitzur, 1988). Furthermore, some studies, though not all, show that the BIS is positively correlated with PTSD and its components (Contractor, Elhai, Ractliffe, & Forbes, 2013). However, coping strategies were not assessed in the present study, not enabling us to examine this proposed mechanism.

The second proposed mechanism is related to the differences between right- and left-HL in psychological and physiological responses to stress. A review of several EEG studies (Davidson, 2004) reported a slower physiological recovery period in right- versus left- HL people, suggesting a longer stress response in right-HL people following exposure to stress. Furthermore, during stressful periods, students were found to shift from a relatively left- to right- HL and this was associated with more physical illness (Lewis et al., 2007). It is possible that interhemispheric inhibition may partly be responsible for the reduced protective effects of the left hemisphere during shift to the right one. These are in line with research findings mostly from animals showing that the right hemisphere mediates the sympathetic stress response (Cerqueira et al., 2008), whereas the left hemisphere may mediate more the parasympathetic response (Wittling, Block, Genzel, & Schweiger, 1998). Furthermore, people with high vagal nerve activity, the main branch of the parasympathetic nervous system, recover more rapidly from acute stress in several physiological systems (cardiac, hormonal and immune; Weber at al., 2010). Together, these results suggest that right-HL people have insufficient stress modulation and experience a longer stress response. This could then possibly yield stronger and more enduring effects of life threats such as missile exposure on mental health, manifested by stronger correlations between missile exposure and PTSD symptoms observed in right-HL people in the present study. Yet, physiological stress responses were not measured in the present study, and this explanation requires further verification. Finally, this explanation and our findings are also in line with a study showing that, after cognitive behavioral treatment (CBT) for PTSD, there were greater reductions in right hemisphere activity than in wait-list controls, and that reduction in PTSD symptoms across groups was positively correlated with reduced right anterior activity during exposure to trauma-related stimuli (Rabe et al., 2008). Together, these results and those observed in the present study propose greater involvement of the right hemisphere in both the stress response and in the vulnerability to PTSD in people exposed to life threatening events. The role of greater sympathetic activity in right-HL people as mediating between severe stressors and PTSD must be tested.

Regardless of the mechanisms underlying our findings, this study had a few limitations. First, we used brief instruments, which could have reduced the reliability of the measures. But this was done deliberately to reduce participant burden during a war context which was expected to possibly continue during the study period. Second, we did not measure HL by more objective tests such as EEG measures (e.g., Benca et al., 1999), which was obviously not feasible for a large scale study in war conditions. Nevertheless, the brief four-item measure of hemispheric preference was highly correlated with its original full 20-item scale, which was validated against EEG measures (Merkelbach, Muris, Horselenberg, & de Jong, 1997). Furthermore, the (non-bisected) line bisection test, conceptually and methodologically similar to the one used here, was validated against EEG (Nash et al., 2010), and the prebisicted tesed used here was an objective neuropsychological measure of HL. Finally, our study didn't assess insecure attachment styles which may play a role in the development of the right hemisphere and in psychopathologies such as PTSD (Schore, 2002).

Nevertheless, to the best of our knowledge, this is the first study showing that perceived exposure to a real life threatening event is related to greater PTSD symptoms, however, mainly in people with right- but not left- HL or left hemispheric preference, using two different measures of HL. These results have theoretical significance by highlighting the emerging protective effects of left-HL even when facing serious adversity. This result echoes past studies (e.g., see review by Davidson, 2004; AuthorCitation2; Lopez-Duran et al., 2012) and extends them to the arena of life threats and PTSD. From a clinical perspective, it is possible that screening and early intervention efforts for prevention may need to focus on people with right-HL, certainly after a mass disaster where clinical help may be limited in numbers. Furthermore, future studies need to examine whether activating the left hemisphere could possibly be of therapeutic effects for preventing and even treating PTSD in trauma-survivors with right-HL. This could be achieved either electrically by repetitive transcutaneous magnetic stimulation or possibly by repeated exposure to left-hemisphere oriented cognitive exercises. A recent study exposed people to reading a text aimed at increasing the right hemisphere's activity and found it to result in lower driving anger levels (Gidron, Gaygısız & Lajunen, 2014). Such "proof of concept" study could also be tested for the context of the reduction of the acute stress response and subsequently for PTSD prevention in people with right-HL. We hope these results may pave the way for more neuroscientifically based methods of understanding, preventing and treating PTSD in people exposed to adversities.

References

Admon, R., Milad, M. R., & Hendler, T. (2013). A causal model of post-traumatic stress disorder: disentangling predisposed from acquired neural abnormalities. *Trends in cognitive sciences*, 17(7), 337-347.

Al-Naser, F., & Sandman, M. (2000). Evaluating resilience factors in the face of traumatic events in Kuwait. *Medical Sciences*, 2(2), 2111-116.

Ayazi, T., Lien, L., Eide, A.H., Ruom, M.M. & Hauff, E. (2012) What are the risk factors for the comorbidity of posttraumatic stress disorder and depression in a war-affected population? a cross-sectional community study in South Sudan. *BMC Psychiatry*, 12:175

Benca, R. M., Obermeyer, W. H., Larson, C. L., Yun, B., Dolski, I., Kleist, K. D., ... & Davidson, R. J. (1999). EEG alpha power and alpha power asymmetry in sleep and wakefulness. *Psychophysiology*, 36(04), 430-436.

Bleich, A., Gelkopf, M. & Solomon, Z. (2003). Exposure to Terrorism, Stress-Related Mental Health Symptoms, and Coping Behaviors among a Nationally Representative Sample in Israel. *The Journal of the American Medical Association*, 290(5):612-620.

Breslau, N., Chilcoat, H.D., Kessler, R.C. & Davis, G.C. (1999). Previous Exposure to Trauma and PTSD Effects of Subsequent Trauma: Results From the Detroit Area Survey of Trauma. *The American Journal of Psychiatry*,156(6): 902-907.

Buckley, T. C., Blanchard, E. B. & Hickling, E.J. (1996). A prospective examination of delayed onset PTSD secondary to motor vehicle accidents. *Journal of Abnormal Psychology*, 105(4): 617-625.

Cerqueira, J.J., Almeida, O.F.X. & Sousa, N. (2008). The stressed prefrontal cortex. Left? Right! Brain, *Behavior, and Immunity*, 22(5): 630-638.

Chiarello, C., & Maxfield, L. (1996). Varieties of interhemispheric inhibition, or how to keep a good hemisphere down. *Brain and cognition*, 30(1), 81-108.

Contractor, A. A., Elhai, J. D., Ractliffe, K. C., & Forbes, D. (2013). PTSD's underlying symptom dimensions and relations with behavioral inhibition and activation. *Journal of anxiety disorders*, 27(7), 645-651.

Cook, N. D. (1984). Callosal inhibition: the key to the brain code. *Behavioral science*, 29(2), 98-110.

Davidson, R.J. (1992). Anterior cerebral asymmetry and the nature of emotion. Review. *Brain and Cognition,* 20(1):125-51.

Davidson, R.J., Shackman, A.J. & Maxwell, J.S. (2004). Asymmetries in face and brain related to emotion. *Trends in Cognitive Sciences*, 8(9), 389-391

Davidson, R.J. (2004). What does the prefrontal cortex "do" in affect: perspectives on frontal EEG asymmetry research. *Biological Psychology*, 67(1-2): 219-234

Ehring, T. & Ehlers, A. (2014). Does rumination mediate the relationship between emotion regulation ability and posttraumatic stress disorder? European journal of psychotraumatology, 5.

Farhood, L.F. & H. Dimassi, (2012). Prevalence and predictors for post-traumatic stress disorder, depression and general health in a population from six villages in South Lebanon. *Social Psychiatry and Psychiatric Epidemiology*, 47(4): p. 639-49.

Farina, B., Mazzotti, E., Farina, F., Della Marca, G., Savoja, V., Kotzalidis, G. D., ... & Tatarelli, R. (2012). Relationship between handedness and persistent emotional distress in adults experiencing an earthquake. *Rivista di psichiatria*, *47*(4), 309-312.

Ferrajão, P. C., & Oliveira, R. A. (2015). Factores associados à adesão ao tratamento da perturbação de stresse pós-traumático: Estudo qualitativo em ex-combatentes portugueses. *Revista Portuguesa de Enfermagem de Saúde Mental*, (SPE2), 21-26.

Gelkopf, M., Berger, R., Bleich, A. & Cohen Silver, R. (2012). Protective factors and predictors of vulnerability to chronic stress: A comparative study of 4 communities after 7 years of continuous rocket fire. *Social Science & Medicine*, 74(5), 757-766

Gidron, Y., Kaplan, Y., A. Velt., A. & Shalem, R. (2004). Prevalence and Moderators of Terror-Related Post-Traumatic Stress Disorder Symptoms in Israeli Citizens. *Israel Medical Association Journal*, 6: July: 387-391

Gidron,Y., Gaygısız,E. & Lajunen, T. (2014). Corrigendum to "Hostility, driving anger, and dangerous driving: The emerging role of hemispheric preference". *Accident Analysis and Prevention*, 73, 236–241

Gil, S., Weinberg, M., Or-Chen, K. & Harel., H. (2015). Risk factors for DSM 5 PTSD symptoms in Israeli civilians during the Gaza war. *Brain and Behavior*, 5 (4) DOI: 10.1002/brb3.316

Harmon-Jones E. & Allen J. J. (1998). Anger and frontal brain activity: EEG asymmetry consistent with approach motivation despite negative affective valence. *Journal of Personality and Social Psychoogy,* 74, 1310–1316

Herzog, D., Killianova, T., Pauwels, S., Germeys, P. & Gidron, Y. (2014). Hemispheric Lateralization Moderates the Life Events–Distress Relationship. *Stress and Health*, DOI: 10.1002/smi.2577

Hofman, D. (2008). The frontal laterality of emotion: a historical overview. *Netherlands Journal of Psychology*, 64(3), 112-118

Hoptman, M. J., & Davidson, R. J. (1994). How and why do the two cerebral hemispheres interact? *Psychological bulletin*, 116(2), 195.

Israel-Cohen, Y., Uzefovsky, F., Kashy-Rosenbaum, G., & Kaplan, O. (2015). Gratitude and PTSD symptoms among Israeli youth exposed to missile attacks: examining the mediation of positive and negative affect and life satisfaction. The *Journal of Positive Psychology*, 10(2), 99-106.

Jackson, D.C. et al. (2003). Now you feel it, now you don't: frontal brain electrical asymmetry and individual differences in emotion regulation. *Psychological Science*. 2003 Nov; 14(6):612-7.

Kimerling, R., Ouimette, P., Prins, A., Nisco, P., Lawler, C., Cronkite, R., & Moos, R.H. (2006). Brief report: utility of a short screening scale for DSM□IV PTSD in primary care. *Journal of general internal medicine*, 21(1), 65-67.

Kirschenbaum, A. (2006). Terror, Adaptation and Preparedness: A Trilogy for Survival. Journal of Homeland Security and Emergency Management. Volume 3, Issue 1, *ISSN (Online) 1547-7355 DOI: 10.2202/1547-7355.1178*

Kolltveit, S. et al. (2012). Risk factors for PTSD, anxiety, and depression among adolescents in Gaza. *Journal of Traumatic Stress*, 25 (2):164–170

Lewis, R.S., Weekes, R.S. & Wang,T.H. (2007). The effect of a naturalistic stressor on frontal EEG asymmetry, stress, and health. *Biological Psychology*, 75(3): 239–247

Lopez- Duran, N. L., Nusslock, R., George, C. & Kovacs, M. (2012). Frontal EEG asymmetry moderates the effects of stressful life events on internalizing symptoms in children at familial risk for depression. *Psychophysiology*, 49(4), 510-521.

Litman, J. A. (2006). The COPE inventory: Dimensionality and relationships with approach-and avoidance-motives and positive and negative traits. *Personality and Individual Differences*, 41(2), 273-284.

Merckelbach, H., Muris, P., Pool, K., De Jong, P. J., & Schouten, E. (1996). Reliability and Validity of a Paper-and-Pencil Test Measuring Hemisphere Preference. *European Journal of Personality*, 10(3), 221-231.

Merkelbach, H., Muris, P., Horselenberg, R., & de Jong, P. (1997). EEG correlates of a pencil and paper test measuring hemisphericity. *Journal of Clinical Psychology*, 57, 739-744.

Muller, R. T., Sicoli, L. A., & Lemieux, K. E. (2000). Relationship between attachment style and posttraumatic stress symptomatology among adults who report the experience of childhood abuse. *Journal of traumatic stress*, 13(2), 321-332.

Nash, K., McGregor, I. & Inzlicht, M. (2010). Line bisection as a neural marker of approach motivation. *Psychophysiology*, 47(5), 979-983.

O'Connor, M., & Elklit, A. (2008). Attachment styles, traumatic events, and PTSD: A cross-sectional investigation of adult attachment and trauma. *Attachment & human development*, 10(1), 59-71.

Petersen, T. & Elklit, A. (2013). Attachment styles and PTSD in adolescents in three Nordic countries.

Priebe, S., Jankovic Gavrilovic, J., Bremner, S., Ajdukovic, D., Franciskovic, T., Galeazzi, G. M., ... & Schützwohl, M. (2012). Psychological symptoms as long-term consequences of war experiences. *Psychopathology*, 46(1), 45-54.

Rabe, S., Zoellner, T., Beauducel, A., Maercker, A. & Karl, A.(2008). Changes in Brain Electrical Activity After Cognitive Behavioral Therapy for Posttraumatic Stress Disorder in Patients Injured in Motor Vehicle Accidents. *Psychosomatic Medicine*, 70, 13–19

Santesso, D.L., Segalowitz, S.J., Ashbaugh, A.R., Antony, M.M., McCabe, R.E.& Schmidt L.A.(2008). Frontal EEG asymmetry and sensation seeking in young adults. *Biological Psychology*, 78(2):164-72

Schore, A. N. (2002). Dysregulation of the right brain: a fundamental mechanism of traumatic attachment and the psychopathogenesis of posttraumatic stress disorder. *Australian and New Zealand Journal of Psychiatry*, 36(1), 9-30.

Shalev, A.Y., Peri, T., Canetti, L. & Schreiber, S. (1996). Predictors of PTSD in Injured Trauma Survivors: A Prospective Study. *The American Journal of Psychiatry*, 153(2): 219-225

Shankman, S. A., Silverstein, S. M., Williams, L. M., Hopkinson, P. J., Kemp, A. H., Felmingham, K. L., ... & Clark, C. R. (2008). Resting electroencephalogram asymmetry and posttraumatic stress disorder. *Journal of traumatic stress*, 21(2), 190-198.

Shin, L. M., Orr, S. P., Carson, M. A., Rauch, S. L., Macklin, M. L., Lasko, N. B., ... & Alpert, N. M. (2004). Regional cerebral blood flow in the amygdala and medial prefrontalcortex during traumatic imagery in male and female vietnam veterans with ptsd. *Archives of general psychiatry*, 61(2), 168-176.

Solomon, Z., Mikulincer,M. & Avitzur, E. (1988). Coping, Locus of Control, Social Support, and Combat-Related Posttraumatic Stress Disorder: A Prospective Study. *Journal of Personality and Social Psychology*, Vol. 55, No. 2,279-285

Solomon, Z., Bleich, A., Koslowsky, M., Kron, S., Lerer, B., & Waysman, M. (1991). Post-traumatic stress disorder: issues of co-morbidity. *Journal of psychiatric research*, 25(3), 89-94.

Somer, E., Maguen, S., Or-Chen, K., & Litz, B. T. (2009). Managing terror: differences between Jews and Arabs in Israel. *International Journal of Psychology*, 44(2), 138-146.

Sullivan, R. M. (2004). Hemispheric asymmetry in stress processing in rat prefrontal cortex and the role of mesocortical dopamine. *Stress*, 7(2), 131-143.

Thibodeau R., Jorgensen R. S. & Kim S. (2006). Depression, anxiety, and resting frontal EEG asymmetry: a meta-analytic review. *Journal of Abnormal. Psychology*, 115, 715–729.

Tomarken, A.J. & Davidson, R.J. (1994). Frontal brain activation in repressors and nonrepressors. *Journal of Abnormal Psychology*. 103(2):339-49.

Tucker, P., & Trautman, R. (2000). Understanding and treating PTSD: past, present, and future. *Bulletin of the Menninger Clinic*, 64(3), A37.

van der Knaap, L. J., & van der Ham, I. J. (2011). How does the corpus callosum mediate interhemispheric transfer? A review. *Behavioural brain research*, 223(1), 211-221.

Weber, C. S., Thayer, J. F., Rudat, M., Wirtz, P. H., Zimmermann-Viehoff, F., Thomas, A., ... & Deter, H. C. (2010). Low vagal tone is associated with impaired post stress recovery of cardiovascular, endocrine, and immune markers. *European journal of applied physiology*, 109(2), 201-211.

Wheeler, R. E., Davidson, R.J. & Tomarken, A.J. (1993). Frontal brain asymmetry and emotional reactivity: a biological substrate of affective style. *Psychophysiology*. 30(1):82-9.

Wittling, W., Block, A., Genzel, S. & Schweiger, E. (1998). Hemisphere asymmetry in parasympathetic control of the heart. *Neuropsychologia*, 36(5): 461-468

Zenhausern, R. (1978). Imagery, cerebral dominance, and style of thinking: An unfiled field model. *Bulletin of Psychosomatic Society*, 12, 381–384.

Table 1. Characteristics of the study sample

a. Continuous variables

Variable	Mean	SD
Age	43.75	14.98
Education (years)	14.68	2.66
Exposure to missiles (0-6)	1.83	1.57
PTSD symptoms (0-4)	1.46	1.44
Left-HL scale	3.18	5.66

b. Categorical variables

Variable	%
Female gender	69.60
Residence near Gaza	47.30

Table 2. Pearson correlations between study variables and PTSD symptoms in the full sample and in each laterality group

Variable	r with PTSD symptoms
In full sample	
Place	-.23
Exposure	-.01
Sampling type	-.24
In right HL people	
Place	.00
Exposure	.23*
Sampling type	.02
In left HL people	
Place	-.01
Exposure	-.01
Sampling type	-.05

*. Correlation is significant at the 0.05 level (2-tailed). Sampling type refers to whether assessment was done face-to-face or over the phone.

Table 3. Multivariate logistic regression

Variable	*B*	*SEB*	Sig	RR	CI (95%)
In full sample					
Missile exposure	-.32	.15	.03	1.37	1.03-1.84
Gender	.83	.53	.12	2.29	.81- 6.47
Age	-.01	.01	.64	.99	.97-1.02
Education	-.21	.09	.02	.81	.68- .96
Residence place	.71	.68	.30	2.04	.53-7.80
Sample type	-1.13	.50	.02	.32	.12- .86
In right HL people					
Missile exposure	.69	.27	.01**	1.99	1.17-3.39
Gender	.47	.73	.52	1.61	.38-6.75
Age	-.01	.02	.56	.99	.95-1.03
Education	-.20	.17	.25	.82	.59-1.14
Residence place	1.97	1.61	.22	7.18	.31-67.5
Sample type	-1.24	.88	.16	.29	.05-1.64
In left HL people					
Missile exposure	.33	.30	.28	1.39	.77-2.51
Gender	1.18	1.20	.32	3.27	.31-34.1
Age	-.01	.03	.60	.99	.93-1.04
Education	-.24	.13	.06	.79	.61-1.01
Residence place	-.17	1.00	.86	1.19	.17-8.44
Sample type	-1.75	.93	.06	.17	.03-1.08

a. Variables entered on step 1: Exposure, gender, age, education and place.