



No distance is too far between friends: associations of comfortable interpersonal distance with PTSD and anxiety symptoms in Israeli firefighters

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ABSTRACT

Background: Previous research indicates that PTSD patients may show alterations in interpersonal distance regulation (IDR). However, it is not clear whether altered IDR is correlated with psychopathology after trauma and whether attentional processes might be involved in these alterations.

Objective: The current study investigated IDR and attentional processing in a sample of Israeli firefighters.

Method: Twenty-four participants completed an experimental IDR task as well as measures of PTSD and anxiety. During the task, event-related potentials were recorded to assess attentional processing as reflected in the P1 and N1 components.

Results: Participants who did not choose a closer distance towards friends than strangers experienced greater anxiety. Moreover, participants who showed attentional avoidance towards strangers reported more PTSD symptoms. By contrast, participants who showed hypervigilant attention towards strangers reported greater anxiety.

Conclusions: Our results demonstrate an association between IDR, PTSD, and anxiety after trauma. Future studies should re-investigate these associations in larger samples and explore potential implications for prevention and treatment.

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Exposición a trauma; distancia interpersonal; PTSD; ansiedad; ERP

关键词

创伤暴露; 人际距离; PTSD; 焦虑; ERP

HIGHLIGHTS

- Individuals who did not let friends approach them closer than strangers experienced greater anxiety.
- Individuals who showed attentional avoidance towards strangers reported more PTSD symptoms.
- Individuals who showed hypervigilant attention towards strangers reported greater anxiety.

Ninguna distancia es demasiado grande entre amigos: asociaciones de distancia interpersonal cómoda con el trastorno de estrés postraumático y síntomas de ansiedad en los bomberos israelíes

Antecedentes: Investigaciones anteriores indican que los pacientes con TEPT pueden mostrar alteraciones en la regulación de la distancia interpersonal (IDR en su sigla en inglés). Sin embargo, no está claro si la IDR alterada se correlaciona con la psicopatología después del trauma y si los procesos atencionales podrían estar involucrados en estas alteraciones.

Objetivo: El estudio actual investigó la IDR y el procesamiento atencional en una muestra de bomberos israelíes.

Método: Veinticuatro participantes completaron una tarea de IDR experimental, así como medidas de TEPT y ansiedad. Durante la tarea, se registraron los potenciales relacionados con evento para evaluar el procesamiento de la atención como se refleja en los componentes P1 y N1.

Resultados: Los participantes que no eligieron una distancia más cercana con los amigos que con los extraños experimentaron una mayor ansiedad. Además, los participantes que mostraron evitación atencional hacia extraños reportaron más síntomas de TEPT. Por el contrario, los participantes que mostraron una atención hipervigilante hacia los extraños reportaron una mayor ansiedad.

Conclusiones: Nuestros resultados demuestran una asociación entre IDR, TEPT y ansiedad después de un trauma. Los estudios futuros deberían volver a investigar estas asociaciones en muestras más grandes y explorar las posibles implicaciones para la prevención y el tratamiento.

朋友之间的距离不算太远：以色列消防员的舒适人际距离与PTSD和焦虑症状之间的关联

目的:本研究考查了以色列消防员样本中的IDR和注意加工。

方法:24名参与者完成了一项实验性IDR任务以及PTSD和焦虑的测量。在任务过程中，记录了与事件相关的电位，以评估P1和N1成分中反映出的注意加工。

结果:没有选择与朋友比与陌生人更近距离的参与者经历了更多焦虑。此外，表现出对陌生人注意回避的参与者报告了更多PTSD症状。相比之下，表现出对陌生人高度警惕的参与者报告了更多焦虑。

结论:我们的结果表明创伤后的IDR, PTSD和焦虑之间存在关联。未来的研究应该在更大的样本中重新考查这些关联,并探讨其对预防和治疗的影响。
背景:前人研究表明, PTSD患者可能出现人际距离调节 (IDR) 改变。但是,尚不清楚IDR改变是否与创伤后精神病相关,以及这些改变是否涉及注意加工。

1. Introduction

Due to the nature of their work, first responders experience high rates of potentially traumatic events (Nazari et al., 2020), resulting in a cumulative burden that increases their risk of developing trauma-related disorders such as posttraumatic stress disorder (PTSD; Geronazzo-Alman et al., 2017). In firefighters, reported rates of PTSD vary considerably across studies, ranging from 11% to 37% (Petrie et al., 2018). This variability could be related to several factors including – but not limited to – age, sex, training, mentorship system, previous traumatization, and the number of duty-related traumatic incidents (Armour, Fried, Deserno, Tsai, & Pietrzak, 2017; Schnell, Suhr, & Weierstall-Pust, 2020). Another emerging – yet scarcely studied – factor is the impact of trauma on social interactions (Pfaltz et al., 2019) and specifically on interpersonal distance regulation (IDR), which may facilitate the development of PTSD symptoms.

IDR refers to our individual tendency to approach others and to allow others to approach us (Perry, Rubinsten, Peled, & Shamay-Tsoory, 2013). IDR is context-sensitive and may be affected by traumatic incidents, which often elicit fear, anxiety, and mistrust (Maier et al., 2020). Bogovic, Mihanovic, Jokic-Begic, and Svagelj (2014) investigated IDR of veterans with and without PTSD and found that veterans with PTSD preferred a greater interpersonal distance than controls. In line with these findings, a subsequent study found that participants with high childhood trauma preferred a larger interpersonal distance compared to participants with low-to-moderate childhood trauma (Maier et al., 2020).

Although these studies provide important insights into the effects of trauma on IDR, several gaps remain to be addressed. Firstly, the correlation between IDR and PTSD symptoms has not been investigated to date. Secondly, it is unclear how this correlation differs for interaction partners with different levels of intimacy (i.e. friends vs. strangers). That is, differential effects may be evident for interaction partners, who pose a greater level of potential threat (i.e. strangers). Finally, the underlying mechanisms of an association between PTSD symptoms and IDR – for instance the involvement of abnormal attentional processing – remain elusive (for details on the relation between IDR and attentional processing see, e.g. Perry et al., 2013).

These gaps can be addressed ideally using the Comfortable Interpersonal Distance (CID) task (Perry et al., 2013), which combines the assessment of interpersonal distance preference for different interaction partners with the assessment of attentional processes by means of electroencephalography (EEG). During each trial, participants are exposed to a virtual representation of an approaching friend or stranger and are asked to indicate their minimal CID. EEG is recorded while participants anticipate being approached. Using this task, Perry et al. (2013) found that subjects with greater anxiety chose a greater CID towards both strangers and friends. EEG analyses focused on two event-related potentials (ERPs) that are known to be involved in early attentional processing (P1 and N1). These analyses revealed an attenuated P1 and N1 in anxious participants, suggesting attentional avoidance during IDR. No study to date has investigated these ERPs in PTSD patients during IDR. However, PTSD patients have shown a similar pattern of attentional avoidance (attenuated P1) while processing threatening as opposed to non-threatening stimuli (Shah et al., 2018). By contrast, two studies (Fang et al., 2019; Zhang, Kong, Han, Ul Hasan, & Chen, 2014) found an opposing pattern, indicating hypervigilant attention (greater P1 and N1) for threatening as opposed to non-threatening stimuli in traumatized individuals (for a more detailed account on attentional processing in PTSD see e.g. Shah et al., 2018).

The aim of the current study was twofold: first, to investigate associations between IDR towards friend vs stranger and PTSD symptoms using the CID task; second, to examine potential links between attentional processing during IDR and PTSD symptoms. These objectives were investigated in a sample of Israeli firefighters. Based on the findings from Perry et al. (2013) indicating a strong relationship between anxiety and IDR, we assessed both PTSD and anxiety as outcomes of traumatization. Moreover, in line with previous research (Levy-Gigi et al., 2016), we assessed general and duty-related trauma exposure as well as depression to control for unrelated sources of variance.

We hypothesized that firefighters who choose a greater CID and a smaller difference in CID towards strangers vs. friends would experience more PTSD symptoms and greater anxiety. With respect to attentional processing prior to IDR, the lack of relevant literature precludes testing any hypothesis. However, we explored two potential result patterns: Based on Shah et al. (2018), a pattern of attentional

avoidance could be evident when individuals with PTSD symptoms are confronted with potential threat as evident when approached by a stranger. Such attentional avoidance would be reflected in a greater N1 and P1 for the friend than for the stranger condition. By contrast, other findings indicate that individuals with PTSD symptoms could exhibit hypervigilant attention when confronted with potential threat as when approached by a stranger (Fang et al., 2019; Zhang et al., 2014). Such hypervigilance would be reflected in a greater N1 and P1 in the stranger as opposed to the friend condition.

2. Methods

2.1. Participants

Twenty-four active-duty Israeli firefighters were recruited to participate in the study on a voluntary basis (Table 1). Participants were all male with normal or corrected-to-normal vision. We used the *Structured Clinical Interview for DSM-IV* to exclude participants with mental disorders except for PTSD, MDD, and/or anxiety (see Supplementary Material 1). The study design was approved by the Institutional Review Board of the University of Haifa. Informed consent was obtained.

2.2. Measurements

2.2.1. The CID task

We used the CID task (Perry et al., 2013) to assess IDR (see Supplementary Material 2). In each trial, participants either saw the word ‘friend’ or ‘stranger,’ indicating that a member of this category would begin to approach them shortly. Following a fixation cross,

Table 1. Descriptive statistics and clinical measures.

	Mean	SD
Age (years)	30.58	3.62
Education (years)	12.61	1.20
PTSD symptoms	24.13	25.49
Depression	6.21	5.66
State anxiety	31.17	9.85
Non-duty-related general traumatic life events	1.33	1.55
Duty-related traumatic exposure	41.39	5.77
Mean CID – stranger*	43.17	24.49
Mean CID – friend*	11.02	9.93
Minimum CID – stranger**	9.13	14.24
Minimum CID – friend**	2.46	4.49

Note: PTSD symptoms were measured using the Clinician-Administered PTSD Scale for DSM-IV (CAPS-4); Depression was assessed using Beck Depression Inventory-II (BDI-II); State anxiety scores were evaluated using the State scale of the State-Trait Anxiety Inventory (STAI-S); Non-duty-related general traumatic life events were measured using the Traumatic Life Events Questionnaire (TEQ); Duty-related traumatic exposure was assessed using the Repeated Traumatic Exposure Questionnaire; Interpersonal distance preference for the stranger and friend conditions was measured using the Comfortable Interpersonal Distance (CID) paradigm.

*Mean distance differed significantly between the friend and stranger condition, $t(23) = 6.55, p < .001$.

** Minimum distance differed significantly between the friend and stranger condition, $t(23) = 2.35, p = .028$.

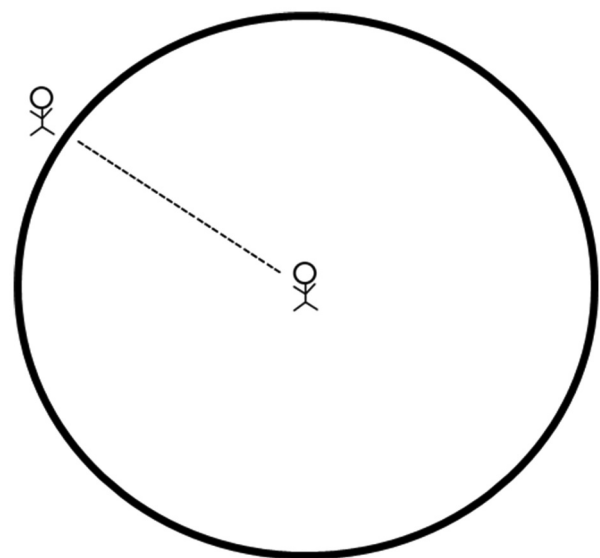


Figure 1. Depiction of the CID scenario: Participants imagine themselves in the centre of the room and are asked to respond to an imaginary friend or stranger approaching them by indicating where they would want the person to stop.

participants saw a circular room on a computer screen with a line-figure located in the centre (representing the participant) and another located at the entrance (Figure 1). Thereafter, the line-figure representing the friend or stranger began to approach the participant in the centre of the room. Participants were asked to press the space bar when they would ask the approaching figure to stop. ERPs were time-locked to the presentation of the circular room (Figure 2).

2.2.2. Clinical assessment

Duty-related traumatic exposure was measured using a 14-item questionnaire that asks participants to rank their exposure to common fire and rescue related events. PTSD symptoms were assessed using the

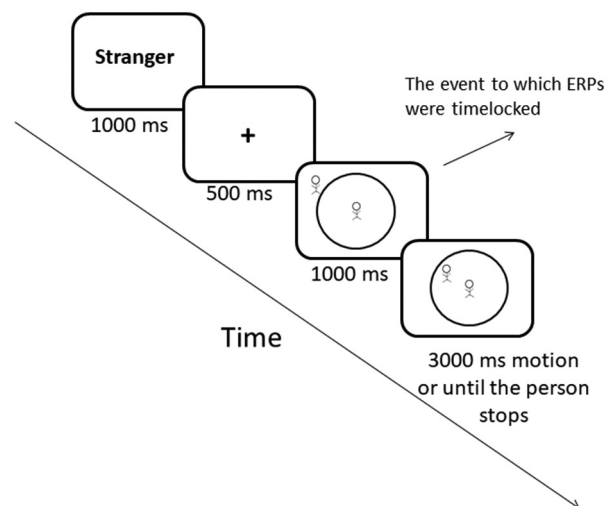


Figure 2. Example of a trial during the CID task.

Clinician-Administered PTSD Scale for DSM-IV. The State version of the *State-Trait Anxiety Inventory* was used to assess anxiety levels. We used the *Traumatic Events Questionnaire* to assess non-duty related trauma exposure and the *Beck Depression Inventory* to assess depression (see Supplementary Material 3).

2.3. EEG recording

EEG signals were recorded continuously (from DC with a low-pass filter set at 100 Hz, sampling rate: 512 Hz) using 32 Ag–AgCl active electrodes, according to the extended 10–20 system (Supplementary Material 4). Data were analysed using Brain Vision Analyser software and Matlab. ERPs were determined by averaging the 1-s segmented trials separately for the stranger and friend condition. In line with Perry et al. (2013), our analysis focused on PO7 and PO8. The P1 peak was determined for each participant individually as the most positive peak between 50 and 150 ms, and the N1 peak as the most negative peak between 150 and 250 ms.

2.4. Data analyses

We used SPSS 25 for data analysis. Associations between behavioural and neurophysiological markers of IDR and symptoms were examined using linear regression models. In addition to IDR markers, we included depression, general trauma exposure, and duty-related trauma exposure as predictors to account for any variance driven for by these variables. Overall model tests and the amount of explained variance (R^2) are reported in Tables 2–Table 5. Significant regression coefficients (β) of IDR markers are reported in the main text with corresponding t -values. To test our hypotheses, we first examined whether model tests were significant. We then inspected regression weights to ascertain whether the respective marker of IDR significantly predicted PTSD and/or anxiety.

Table 2. Regression models with mean CID as a predictor.

	R^2	Model test
<i>Outcome: PTSD symptoms</i>		
Depression, general trauma exposure, duty-related trauma exposure, mean CID	.45	$F(4,16) = 3.28$, $p = .038$
Depression, general trauma exposure, duty-related trauma exposure, mean CID difference	.45	$F(4,16) = 3.23$, $p = .040$
<i>Outcome: anxiety</i>		
Depression, general trauma exposure, duty-related trauma exposure, mean CID	.53	$F(4,17) = 4.80$, $p = .009$
Depression, general trauma exposure, duty-related trauma exposure, mean CID difference	.52	$F(4,17) = 4.68$, $p = .010$

Note: CID: Comfortable Interpersonal Distance; General trauma exposure: non-duty-related general traumatic life events.

3. Results

3.1. Behavioural CID

First, we examined CID averaged across all trials (mean CID) and contrasted between the stranger and friend condition (mean CID difference) as predictors of PTSD and anxiety (Table 2). None of these analyses yielded significant effects of mean CID ($p > .05$).

Next, we examined minimum CID chosen across trials (min CID) and contrasted between the stranger and friend condition (min CID difference) as predictors of PTSD and anxiety (Table 3). The model including min CID difference as predictor and anxiety as outcome reached significance and revealed that beyond the effects of our covariates, a smaller difference in minimum distance chosen for friends as compared to strangers was linked with greater anxiety; $\beta = -.42$, $t(18) = 2.46$, $p = .025$. None of the other analyses yielded significant effects of min CID ($p > .05$).

3.2. P1 and N1

We first examined the difference in P1 between the friend and stranger condition (Figure 3) as a predictor of symptoms (Table 4). The model including the P1 at P08 as a predictor and PTSD symptoms as outcome reached significance and revealed that beyond the effects of our covariates, a greater P1 in the friend than in the stranger condition was associated with more PTSD symptoms; $\beta = .45$, $t(15) = 2.39$, $p = .030$. For anxiety, the model including the P1 at P07 as predictor reached significance, revealing that a greater P1 in the stranger than the friend condition significantly predicted anxiety irrespective of our covariates; $\beta = -.48$, $t(16) = 3.87$, $p = .001$. None of the other analyses yielded significant effects of the P1 ($p > .05$).

Next, we examined the difference in N1 between the stranger and friend condition (Figure 3) as a predictor of symptoms (Table 5). The model including the N1 difference at P07 as predictor and anxiety as outcome reached significance and revealed

Table 3. Regression models with min CID as a predictor

	R^2	Model test
<i>Outcome: PTSD symptoms</i>		
Depression, general trauma exposure, duty-related trauma exposure, min CID	.38	$F(4,16) = 2.41$, $p = .093$
Depression, general trauma exposure, duty-related trauma exposure, min CID difference	.36	$F(4,16) = 2.27$, $p = .107$
<i>Outcome: anxiety</i>		
Depression, general trauma exposure, duty-related trauma exposure, min CID	.58	$F(4,17) = 5.94$, $p = .004$
Depression, general trauma exposure, duty-related trauma exposure, min CID difference	.65	$F(4,17) = 7.84$, $p = .001$

Note: CID: Comfortable Interpersonal Distance; General trauma exposure: non-duty-related general traumatic life events.

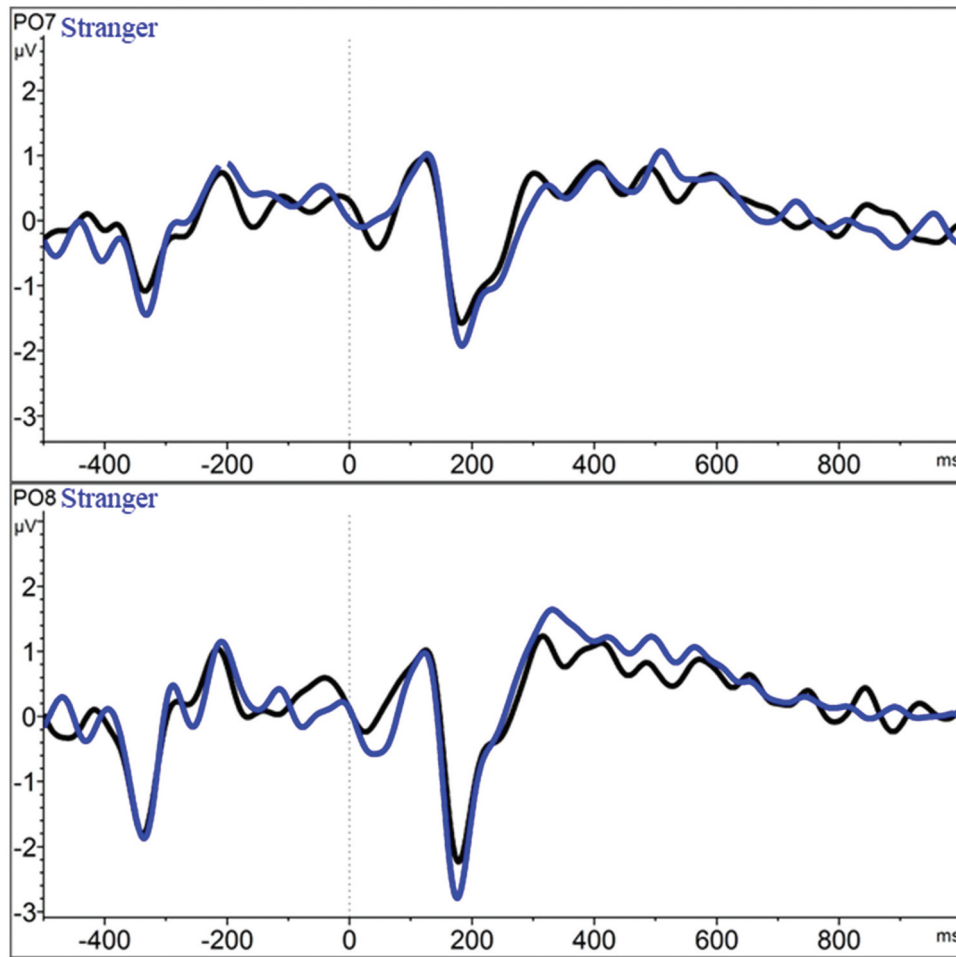


Figure 3. ERP differences between the friend (black) and stranger (blue) condition for the P1 and N1 component at PO7 and PO8. The P1 amplitude was larger in the friend condition than in the stranger condition, whereas the N1 amplitude was larger in the stranger condition than in the friend condition. ERP differences analysed below were calculated accordingly.

Table 4. Regression models with P1 as a predictor.

	R^2	Model test
<i>Outcome: PTSD symptoms</i>		
Depression, general trauma exposure, duty-related trauma exposure, $P1_{\text{Friend-Stranger}}$ at PO7	.39	$F(4,15) = 2.40, p = .096$
Depression, general trauma exposure, duty-related trauma exposure, $P1_{\text{Friend-Stranger}}$ at PO8	.53	$F(4,15) = 4.27, p = .017$
<i>Outcome: anxiety</i>		
Depression, general trauma exposure, duty-related trauma exposure, $P1_{\text{Friend-Stranger}}$ at PO7	.77	$F(4,16) = 13.35, p < .001$
Depression, general trauma exposure, duty-related trauma exposure, $P1_{\text{Friend-Stranger}}$ at PO8	.63	$F(4,16) = 6.87, p = .002$

Note: General trauma exposure: non-duty-related general traumatic life events.

Table 5. Regression models with N1 as a predictor.

	R^2	Model test
<i>Outcome: PTSD symptoms</i>		
Depression, general trauma exposure, duty-related trauma exposure, $N1_{\text{Stranger-Friend}}$ at PO7	.39	$F(4,15) = 2.38, p = .098$
Depression, general trauma exposure, duty-related trauma exposure, $N1_{\text{Stranger-Friend}}$ at PO8	.35	$F(4,15) = 2.05, p = .138$
<i>Outcome: anxiety</i>		
Depression, general trauma exposure, duty-related trauma exposure, $N1_{\text{Stranger-Friend}}$ at PO7	.74	$F(4,16) = 11.54, p < .001$
Depression, general trauma exposure, duty-related trauma exposure, $N1_{\text{Stranger-Friend}}$ at PO8	.67	$F(4,16) = 7.96, p = .001$

Note: General trauma exposure: non-duty-related general traumatic life events.

that a greater N1 in the stranger than in the friend condition predicted greater anxiety irrespective of our covariates; $\beta = .45, t(16) = 3.43, p = .003$. The same pattern emerged for the N1 difference at PO8; $\beta = .34, t(16) = 2.31, p = .034$. None of the other analyses yielded significant effects of the N1 ($p > .05$).

4. Discussion

The present study examined behavioural and neuro-physiological markers of IDR as predictors of PTSD and anxiety in trauma-exposed firefighters. Extending previous work, we found that a smaller difference in

minimum CID towards friends vs. strangers predicted greater anxiety, but not PTSD symptoms. With respect to attentional processing during IDR, we found that a greater P1 in the friend than in the stranger condition was predictive of PTSD symptoms. By contrast, a greater P1 and N1 in the stranger than in the friend condition was associated with anxiety.

On a behavioural level, IDR was only associated with anxiety, not with PTSD symptoms. This could be explained by the small sample size or by the fact that the CID task assesses IDR in a trauma-neutral context. Thus, greater preferred distances may be more indicative of anxiety than PTSD, since PTSD symptomatology is strongly linked to the occurrence of trauma-related reminders. Contrasting this assumption, previous research has shown alterations in IDR in traumatized samples using the stop-distance technique (Bogovic et al., 2014; Maier et al., 2020). Hence, further research using larger samples needs to investigate whether our findings are related to methodological limitations of the CID task.

Although we found an association between the difference in minimum CID and anxiety, we did not replicate the association between mean CID and anxiety found by Perry et al. (2013). This discrepancy may be explained by differences between study samples since Perry et al. examined individuals with a social anxiety disorder. As such, a lack of differentiation between approaching interaction partners – rather than mean CID – might be predictive of anxiety after trauma. Although speculative, this finding could be integrated with research on maladaptive appraisals: After trauma, views about intimacy and the trustworthiness of others are fundamentally challenged, resulting in appraisal biases (Sachschaal, Woodward, & Ehlers, 2019) such that traumatized individuals may refuse to let friends approach them any further than strangers, which in turn may be predictive of anxiety. This hypothesis should be investigated further in individuals with exclusively interpersonal traumatization.

On a neurophysiological level, we found diverging result patterns for PTSD and anxiety: A greater P1 in the friend than in the stranger condition predicted greater PTSD symptoms, whereas a greater P1 and N1 in the stranger than in the friend condition was correlated with greater anxiety. Although diverging, both of these patterns have been found in traumatized samples: Shah et al. (2018) found a reduced P1 for non-threatening as opposed to threatening stimuli in PTSD patients, whereas others (Fang et al., 2019; Zhang et al., 2014) have found a greater P1 and N1 for threatening as opposed to non-threatening stimuli in traumatized individuals. Based on these findings, one could speculate that attentional avoidance in the

presence of an approaching stranger – representing potential threat – might predispose traumatized individuals towards PTSD development, whereas hypervigilant attention towards an approaching strangers – representing potential threat – could be a precursor to the development of anxiety after trauma. As such, we found indications for two different attentional styles that may be differentially linked to PTSD and anxiety. However, this interpretation strongly relies on the assumption that traumatized individuals associate an approaching stranger with potential threat, requiring further investigation in future studies. Hence, more confirmatory studies are needed before any strong conclusions can be drawn.

4.1. Limitations

A major limitation of our study is the lack of a control group. Comparing our sample to a non-traumatized sample would have strengthened the interpretation of our findings. Moreover, our restricted sample size limits statistical test power. Hence, our findings can only be regarded as pilot data that require replication in future studies with sufficient statistical power. Another limitation concerns our cross-sectional study design, which does not allow us to draw causal inferences. Also, it must be considered that the CID task has limited ecological validity, which could be improved by combining it with the stop-distance technique. Moreover, using a more comprehensive anxiety measure would allow drawing more specific conclusions regarding the association of IDR and anxiety. Finally, future studies should take specificities of emotional processing and coping strategies of firefighters into account when examining such samples.

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Disclosure statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Data availability statement

The data that support the findings of this study are openly available in Mendeley Data at doi: [10.17632/vk2mpn4myx.1](https://doi.org/10.17632/vk2mpn4myx.1).

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