Actas do 14º Congresso Nacional de Psicologia da Saúde
Organizado por José Alberto Ribeiro-Gonçalves, Soraia Garcês, & Isabel Leal
8, 9 e 10 de setembro de 2022, Funchal: Faculdade de Artes e Humanidades

ATTENTIONAL BIAS TOWARD FOREST FIRES-RELATED STIMULI AMONG FIREFIGHTERS AND GENERAL POPULATION

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Firefighters are first responders in emergencies, being repeatedly exposed to traumatic events and extreme conditions, much more so than the general population (Berger et al., 2012; Meda et al., 2012). There seems to be a relationship between emotions, cognitions and trauma, with critical incidents inducing more traumatic symptoms (Hayes et al., 2012; Pinto et al., 2015). Emotional reactions are organized by motivational systems – namely appetitive and defensive – that engage processes facilitating attention allocation to specific cues (Bradley et al., 2001; Lang & Bradley, 2013).

Attentional bias is the phenomenon of hyper-attention to stimuli with enhanced saliency or relevance (Fadardi et al., 2016). Specifically, a systematic tendency to direct attention toward stimuli that are perceived as dangerous in the environment (increased vigilance toward threatening stimuli), most notably trauma reminders, resulted in biased processing of trauma-related stimuli, at the expense of trauma-unrelated cues (Buodo et al., 2018). Attentional bias has commonly been examined using a dot-probe experimental paradigm (MacLeod et al., 1986). This has been widely applied among clinical samples involving emotional stimuli (Buodo et al., 2018; Greinacher et al., 2019). The methodological assumption of the task is that participants will respond more quickly to probes that appear in the

position of the stimulus with greater emotional salience, that is, faster responses to a probe that replaces a threatening rather than a neutral stimulus are interpreted as indicating preferential attention toward threatening information (Buodo et al., 2018). Attention biases for threat cues can manifest as either selective attention toward threat, which indicates attentional hypervigilance (MacLeod et al., 1986), or a bias away from threatening material, indicating avoidance (Koster et al., 2004).

Attention biases have been found to occur with various mental illnesses including depression, anxiety, and trauma- and stressor-related disorders (Khoury- Malhame et al., 2011; Lebeaut et al., 2020). A growing number of studies have examined PTSD and its relation to attention bias (Bryant & Harvey, 1997; Herzog et al., 2019; Iacoviello et al., 2014; Khoury-Malhame et al., 2011; Naim et al., 2017; Thomas et al., 2013).

Firefighters play an important role in emergencies and are exposed to potentially traumatic situations, increasing the risk of developing traumatic symptoms (Berger et al., 2012; Meda et al., 2012; Skeffington et al., 2017). The forest fires in Portugal in 2017 and 2018 were particularly devastating and challenging. Firefighters who fought these fires interpreted them as emotionally traumatic events. However, each individual had their own personal perception of the same event and evaluation of trauma, even if not necessarily formally diagnosed with PTSD (Carvalho & Maia, 2009a, 2009b; Maia & Fernandes, 2003).

So far, nothing is known about how cognitive processing of firefighters' practice-related information occurs, depending on levels of trauma. More specifically, there is no evidence of how the perception of trauma related to forests fires in Portugal in 2017 and 2018 (i.e., fire-related or fire unrelated stimuli) affects attentional processes, and how these relate with specific psychological variables. Thus, the present study aimed to explore the possible association between basic attentional processes in perception of trauma in firefighters and the general population, and its relation with psychopathological symptomatology and empathy. Considering the influence of approach and avoidance behaviors on cognitive performance, specifically, on visual selective attention (Memmert & Cañal-Bruland, 2009), this study explored whether there was a bias in the allocation of attention toward forest fires-related visual stimuli among firefighters with

low perceived trauma, firefighters with high perceived trauma and controls from the general population.

We expected that a natural approach to forest fire-related content would produce a prioritization of these specific stimuli at the cost of other information. Therefore, we hypothesized that all people, whether they are firefighters or not, would have a bias toward the fire-related cues. Nonetheless, we expected firefighters with high perceived trauma to have a greater bias toward fire-related cues than firefighters with low trauma, and to the control group without trauma.

METHOD

Participants

This study included firefighters and people from the general population. Eligibility criteria were: being of Portuguese nationality, over 18 years old, and not having any cognitive or physical inability that would prevent participants from independently replying to the self-report measures.

Taking into account the sum of the scores obtained in the IES-R specifically in the firefighter group, the participants were divided into two groups, low trauma and high trauma. Participants whose scores on the trauma scale corresponded to the lowest tercile (33.3 percentile), with a cutoff point lower than or equal to 8 points, belonged to the group of firefighters with low trauma (N=65) and those with scores in the highest tercile (66.7 percentile), with a cutoff point equal to or greater than 25 points, became part of the group of firefighters with high trauma (N=66). Thus, the final sample of 194 participants consisted of three groups: firefighters with low trauma (FLT, N=65), firefighters with high trauma (FHT, N=66) and control group (N=63).

Materials

Visual Dot-Probe Task: Attentional bias was examined using a dot-probe experimental paradigm to investigate the attentional processes (van Rooijen et al., 2017). This task, involving emotional stimuli, has been widely applied among traumatized samples (Naim et al., 2017; Schäfer et al., 2018). Each

trial in the dot-probe task consisted of the simultaneous presentation of two pictures, on the left and right side of the screen, with a resolution of 500x400 pixels. In baseline trials, the images consisted of two control stimuli. In the experimental condition, the picture pair contained a fire-related stimulus and a matched picture without fire-related content. A fixation cross was initially presented in the center of the screen for 500ms followed by presentation of the paired images for 300ms (van Rooijen et al., 2017). Afterwards, a small asterisk appeared for 100ms in the position previously occupied by one of the images. Participants were instructed to press the Z or M response key as quickly and accurately as possible, corresponding to left or right location, respectively, to indicate the position of the asterisk (probe detection). A trial was considered to be congruent when the dot emerged on the location of the fire-related image and incongruent when the dot emerged on the location of the neutral image. Response times (RT) were recorded for all trials. The baseline trials allowed comparison with congruent and incongruent RTs. Participants completed 8 practice trials and a total of 216 experimental trials (72 trials for each type: congruent, incongruent and baseline) without a break, presented in randomized order. The right or left position of the fire-related images in the experimental trials was counterbalanced across trials. Subjects did not receive feedback on their responses. The dot-probe task was run on a 15.4 inch monitor using EPrime 2.0 Professional (Psychology Software Tools, Inc.).

Sociodemographic Questionnaire: This questionnaire was divided into three blocks: (i) Sociodemographic Characterization; (ii) Firefighter Experience, only to be answered by firefighters, there were also several questions regarding the firefighter work, such as the regional location of the fire brigade, firefighter career (volunteer or professional), category or position in the fire brigade, and years of working as a firefighter; (iii) Trauma Experience, there were questions about fighting or knowledge forest fires in 2017 and/or 2018 and the traumatic exposure to them.

Impact of Event Scale-Revised (IES-R): IES-R assesses the subjective suffering for a specific life event. It contains 22 items distributed over three subscales: intrusion (8 items), avoidance (8 items), and hyperarousal (6 items) (Matos et al., 2011). The Cronbach alpha of our sample (0.98) reveals excellent internal consistency, as well as for each subscale with 0.96, 0.95 and 0.94 respectively in intrusion, avoidance and hyperarousal (Matos et al., 2011).

When completing the questionnaire, participants had to take into account the emotionally traumatic event previously described, related to the 2017 or 2018 fires, or other non-related event, regarding their firefighting action in the group of firefighters, or regarding their direct exposure to the event in the control group.

Brief Symptom Inventory (BSI): BSI is a self-report measure that assesses psychopathological symptoms across nine symptom dimensions and 53 items (somatization, obsession-compulsion, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism) and three global indices (global severity index, positive symptom distress index, and positive symptom total) (Derogatis, 1982). The Cronbach's alpha of the sample for the nine symptom dimensions ranges from 0.79 (psychoticism) to 0.90 (depression) (Canavarro, 2007).

Interpersonal Reactivity Index (IRI): IRI is a measure of empathy consisting of 24 statements about feelings or thoughts that a person may or may not have experienced (Davis, 1980, 1983). It has four subscales (perspective taking, fantasy, empathic concern, and personal distress), each with six items. The Cronbach alphas for the four subscales range from 0.60 (empathic concern) to 0.70 (personal discomfort) (Limpo et al., 2013).

Toronto Alexithymia Scale (TAS-20): TAS-20 is a self-report instrument with 20 items distributed over three factors: difficulty in identifying feelings and distinguishing them from the bodily sensations of emotions, difficulty in describing feelings to others, and externally oriented cognitive style of thinking (Bagby, Parker, et al., 1994; Bagby, Taylor, et al., 1994). The Cronbach alpha of our sample (0.85) shows appropriate internal consistency (Praceres et al., 2000).

Procedures

This study was approved by the Ethics and Deontology Council of the University of Aveiro. The commanders of 193 Portuguese Fire Departments across the country were initially contacted to obtain authorization to administer the questionnaires to the firefighters at the beginning or end of an instruction/meeting or another time, or asked to disseminate the study. Cultural and recreational associations were contacted to recruit the sample for the control group. The aims of the study were explained to the commanders

and firefighters, and the control group, emphasizing that their cooperation was voluntary, and confidentiality was ensured. Of the total of commanders contacted, 40 agreed to their corporation collaborating in the study. Paper-and-pencil questionnaires were the main data-collection method adopted in this study. Informed consent was obtained from all participants.

Statistical analyses were performed using SPSS Version 26.0 (IBM Corp. Released 2019). Descriptive statistics (means, standard deviation, frequencies) were used to summarize the sociodemographic information of the participants included in the three groups.

Comparisons of sociodemographic characteristics between groups were performed with one-way analysis of variance (ANOVA), independent t-tests and chi-square tests (χ^2) of independence. Specifically, ANOVA for age as continuous variable; independent *t*-tests for continuous variables in comparison of firefighters such as average time working, weekly hours of work; and chi-square tests (χ^2) of independence, considering categorical variables, such as gender, marital status, level of education, firefighter category and participants' region.

Univariate ANOVA was used to compare the attentional bias index of the three experimental groups (firefighters with low trauma *vs.* firefighters with high trauma *vs.* general population controls). When necessary, significant results were further explored with multiple comparisons with Bonferroni correction. Additionally, the following formula was used to determine the attentional bias index: Attentional bias index=[(trpl-tlpl)+(tlpr-trpr)]/2 (MacLeod et al., 1986; Mogg et al., 1992), where t=fire-related stimulus; p=probe location, r=right, l=left. Attentional bias is interpreted as a lower RT in the congruent condition than in the incongruent condition and greater accuracy in the congruent condition compared to the incongruent condition.

As recommended in the review study by van Rooijen et al. (2017), mean RTs and ACCs for valid trials were computed separately for congruent, incongruent and baseline trials for better understanding of the underlying attentional mechanisms. RTs and ACCs were analyzed using a mixed-design 3x3 analysis of variance with group (firefighters with low trauma *vs.* firefighters with high trauma *vs.* general population controls) as the between-subjects factor, and trial type (congruent *vs.* incongruent *vs.* baseline) as the within-subjects factor.

Pearson's correlations were used to evaluate the bivariate relations between the task performance of each group in each condition with BSI and IRI variables. The correlations were classified as weak (0-0.3), moderate (0.3-0.7) and strong (>0.7-1.0) (Ratner, 2009).

RESULTS

Sociodemographic characteristics

Overall, 194 participants completed the protocol. The sample included 131 firefighters (63 FLT and 66 FHT) and 63 controls from the general population. Table 1 presents socio-demographic characteristics for the FLT, FHT and control groups. Differences were found between the three groups when analyzing age, sex, marital status and level of education.

Table 1

Sample characteristics according to age, sex, marital status and level of education of samples

			Low trauma (*n*=65)	High trauma (*n*=66)	Control (*n*=63)
Age (years)		Mean (*SD*)	35.92 (11.02)	38.98 (11.54)	31.98 (13.17)
Gender	Woman	*n* (%)	7 (10.8)	14 (21.2)	32 (50.8)
	Man	*n* (%)	58 (89.2)	52 (78.8)	31 (49.2)
Marital status	Not married	*n* (%)	30 (46.2)	25 (37.9)	35 (55.6)
	Married/partnership	*n* (%)	29 (44.6)	33 (50.0)	28 (44.4)
	Widowed/separated/divorced	*n* (%)	6 (9.2)	8 (12.1)	0 (0.0)
Level of education	Basic education	*n* (%)	20 (30.8)	16 (24.2)	9 (14.3)
	High school	*n* (%)	36 (55.4)	40 (60.6)	33 (52.4)
	University education	*n* (%)	9 (13.8)	10 (15.2)	21 (33.3)

There were significant group differences for age [$Z(2,193)=5.570$, $p=.004$], gender [$\chi^2(2,194)=27.69$, $p<.001$], marital status [$\chi^2(4,194)=9.57$, $p=.048$] and level of education [$\chi^2(2,194)=11.54$, $p=.021$]. As for the category in the firefighter corporation, most of the firefighters recruited were 3rd class (40.5%) and 2nd class (20.6%) firefighters. In decreasing order, the firefighter sample is distributed in chief/sub-chief (16.0%), command team (10.0%), 1st class firefighters (9.2%), official (3.1%), with missing (.8%). There were no significant group differences for category of firefighter

[$\chi^2(6,122)=2.65$, $p=.85$]. Despite finding non-significant differences between the groups, the average time working as a firefighter, in years, was greater in FHT ($M=17.15$, $SD=10.76$) than in FLT ($M=14.78$, $SD=10.26$), [$t(129)=.093$; $p=.200$], and FHT reported a greater number of weekly hours of work as a firefighter ($M=37.31$, $SD=25.70$), compared to FLT ($M=31.24$, $SD=17.00$), [$t(118)=2.670$; $p=.128$].

As for participants' region, groups differed statistically [$\chi^2(2,194)=22.75$, $p<.001$], with 52.3% of FLTs, 45.5% of FHTs and 84.1% of participants in the control group belonging to the north, and 47.7% of FLTs, 54.5% of FHTs and 15.9% of the control group to the south.

Attentional bias toward fire-related stimuli

The bias, RT and ACCs for the FLT, FHT and controls are shown in Table 2.

Table 2

Bias, RT and ACC for each group

	FLT *M (SD)*	FHT *M (SD)*	Control *M (SD)*
Bias	3.75 (21.99)	5.30 (17.01)	-.71 (16.05)
RT	262.37 (62.09)	263.20 (62.80)	265.88 (63.33)
ACC	.969 (.005)	.960 (.005)	.973 (.005)

Regarding the attentional bias index, no significant group differences were observed, $F(2,193)=1.811$, $p=.166$. Positive values indicated biased cognitive processing toward fire-related images for all firefighters, with firefighters with low trauma showing, in absolute terms, a smaller degree of bias towards fire-related stimuli than firefighters with high trauma. Negative values indicated withdrawal from fire-related images, shown by the control group. However, the difference did not reach statistical significance.

Regarding RTs, the 2-way ANOVA revealed a significant main effect of trial type [$F(2,382)=3.84$, $p<.022$, $\eta^2p=.20$] indicating that all participants responded faster in the baseline ($M=262.36$, $SD=62.09$) than incongruent trials ($M=265.88$, $SD=63.33$) [$p=.023$ for incongruent *vs.* baseline; $p=.149$ for congruent *vs.* baseline]. There was no significant main effect of group [$F(2,191)=.087$, $p=.917$, $\eta^2p=.001$, that is, firefighters with low and high

trauma presented overall similar RTs to the control group. Nor was the interaction effect between trial type and group statistically significant [$F(4,382)=1.71$, $p=.147$, $\eta^2p=.018$].

Concerning accuracy, the ANOVA revealed a significant main effect of trial type [$F(1.86, 356)=13.15$, $p<.001$, $\eta^2=.064$] indicating that all participants had higher accuracy in the baseline trials ($M=.972$, $SD=.038$) and congruent trials ($M=.970$, $SD=.038$) than in the incongruent trials ($M=.960$, $SD=.051$) [$p=.001$ for congruent *vs.* incongruent; and $p<.001$ for baseline *vs.* incongruent]. There was no significant main effect of group [$F(2,191)=1.98$, $p=.141$, $\eta^2p=.020$] on accuracy. Nor was the interaction effect between trial type and group statistically significant [$F(3.728, 356)=.920$, $p=.447$, $\eta^2p=.010$]. The mean RTs and accuracy for the FLT, FHT and controls are shown in Figures 1 and 2, respectively.

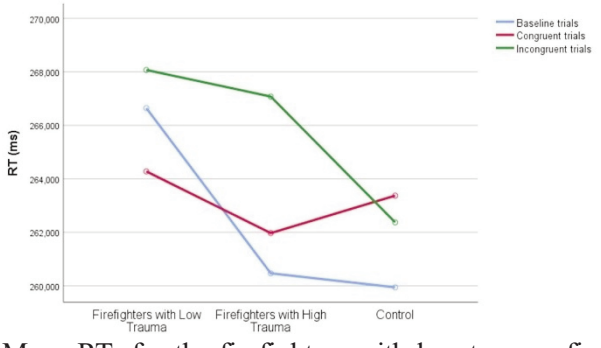

Figure 1. Mean RTs for the firefighters with low trauma, firefighters with high trauma and control

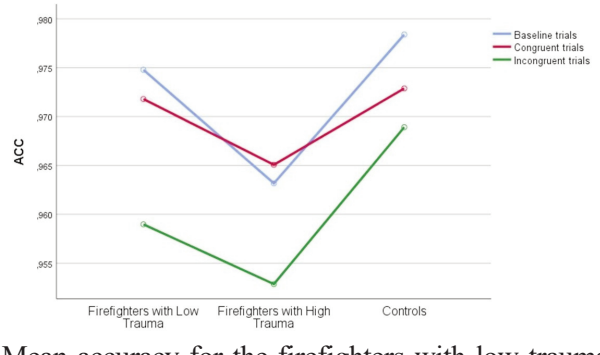

Figure 2. Mean accuracy for the firefighters with low trauma, firefighters with high trauma and control

Correlations between bias and self-report questionnaires for each group

In the group of firefighters with low trauma, there was a moderate positive correlation between bias and the BSI subscales, specifically with the anxiety subscale (r=.355, p=.004) and paranoid ideation subscale (r=.290, p=.020) (see Table 4). Bias was also positively associated with two subscales of Alexithymia, in particular, difficulty finding feelings (r=.357, p=.004) and externally oriented thinking style (r=.261, p=.037). In turn, moderate positive correlations were found between bias and Personal Discomfort subscale of IRI, in the group of firefighters with high trauma (r=.321, p=.012).

DISCUSSION

To the best of our knowledge, this is the first study to examine attentional biases toward fire-related stimuli among firefighters. To summarize, the current study used a dot-probe task to address the question of fire-related attentional bias in firefighters with low and high trauma, and controls without trauma, and the relation with psychosocial variables, such as symptomatology and empathy.

Overall, the results suggest biased attention toward fire-related specific stimuli using the dot-probe paradigm. Consistent with our predictions, higher vigilance regarding fire-related visual cues was observed, namely in firefighters. When analyzed individually for each of the trial types, it was found that firefighters showed a positive bias to fire-related stimuli, that is, they have a longer reaction time in the incongruent condition, when the asterisk appears on the other side of the emotional image related to forest fires. The control group, on the other hand, presented a negative bias score, indicating a departure from the incongruent condition, which means there is no attention bias. Furthermore, we found an increase in the attentional bias index of firefighters with high trauma compared to firefighters with low trauma and to the controls. However, all group differences failed to reach statistical significance. The faster RTs on baseline trials can likely be explained by the lower arousal level of these images. The general direction of the results is consistent with the literature, since attention is allocated

more rapidly to a location containing emotional stimuli than to a location containing neutral stimuli (van Rooijen et al., 2017), and attentional bias is the phenomenon of hyper-attention to stimuli with enhanced saliency or relevance (Fadardi et al., 2016). In addition, attention biases for threat cues can manifest as either selective attention toward threat, indicating attentional hypervigilance (MacLeod et al., 1986), which was verified in firefighters, or on the other hand, a bias away from threatening material, indicating avoidance (Koster et al., 2004) found in the control group (although no differences reached statistical significance).

In general, statistically significant differences for accuracy were found, with a higher percentage of correct answers (i.e., fewer errors), and therefore better performance, in the congruent and baseline conditions compared to the incongruent condition. Higher accuracy in congruent trials, i.e., trials where the probe replaced the fire-related image, than in incongruent trials. This is not surprising since biologically significant stimuli modulate attention. Pictures involving forest fires and survival scenes elicit activation of the motivational system (Bradley et al., 2001) that prepares the organism for responses to those events, increasing attention allocation. The results seem to indicate that the paradigm worked, as we found this bias towards emotionally relevant stimuli, but the effect, in this study, will not be specific to firefighters.

Despite the non-significant results between the groups regarding the attentional bias, the hypervigilance can be related to the state of alert and immediate preparation for the action that firefighters must undertake in emergency situations, including forest fires, when they have to react quickly and with the minimum performance failures (Berger et al., 2012).

The attentional bias, with the threat-related stimuli more salient and an estimate of danger biased, results in a subsequent rise of anxiety and emotional disturbances (Bryant & Harvey, 1997; Herzog et al., 2019; Iacoviello et al., 2014; Khoury-Malhame et al., 2011; MacLeod et al., 1986; Mogg & Bradley, 2004; Mogg et al., 2000; Naim et al., 2017; Sipos et al., 2014; Thomas et al., 2013). In our study, exploring correlations between bias and self-report questionnaires, we found that, among firefighters with low trauma, a greater bias is associated with greater anxiety, and among firefighters with high trauma, a greater attentional bias is related to more

personal distress. At the time of presenting fire-stimuli, anxiety symptoms can be naturally triggered, and individuals with lower trauma perception may be especially sensitive to anxiety symptoms and feel them with more intensity. However, these anxiety symptoms are not sufficient for the diagnosis of PTSD, but only to perceive to low trauma. On the other hand, firefighters who perceive themselves as having more traumatization, experience these triggers with greater personal distress (Lebeaut et al., 2020), which is related with "self-oriented" feelings of personal anxiety and unease in tense interpersonal settings (Limpo et al., 2013). As for the group of firefighters with low trauma and the correlations found between the bias and the paranoid ideation subscale of the BSI and between the bias and the two alexithymia scales, there are no explanations for the results found.

Nevertheless, a number of methodological limitations of the current study need to be addressed. First, due to the small sample size, the power to detect small to moderate differences between groups was limited. Furthermore, a larger sample would have allowed examination of additional predictors and/or moderators of symptoms and empathy. Second, this study used a cross-sectional design, and could not establish how attentional bias may contribute to the development and maintenance of fire-related trauma and symptoms among firefighters. Longitudinal studies should be conducted to evaluate attentional bias at various moments, namely immediately after the traumatic event, and in the short and long term. Lastly, future research should use other methodologies, e.g. eye-tracking methodology, to assess other more objective indicators of attention allocation and bias toward the various types of stimuli.

The findings of the present study contribute to better understanding of the cognitive processing of fire-related information and its relationship with trauma symptomatology reported by firefighters who experienced traumatic events and the general population. Overall, the results support the idea of hypervigilance to fire-related visual cues, which negatively influences anxiety and personal distress in individuals with perception of trauma. While more research is needed to validate the current results, interventions promoting goal-oriented attention self-regulation and emotional management strategies may improve the ability to cope with trauma situations among those involved in emergencies.

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