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Brief report

# Impact of emotion on cognition in trauma survivors: What is the role of posttraumatic stress disorder?

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ABSTRACT

*Background:* Cognitive theories of anxiety disorders postulate an increased attentional bias to environmental cues associated with threat that underlies the exaggerated fear response. The role of trauma, which may represent strong competitive advantage for attention, remains unclear. We investigated the influence of trauma exposure and the presence of anxiety/stress disorders on the impact of emotional distractors on cognitive performance.
*Methods:* Fourteen trauma-exposed subjects with PTSD, 12 trauma-exposed subjects with anxiety disorders other than PTSD, 12 trauma-exposed healthy subjects and 19 non-trauma-exposed healthy controls participated in this study. The impact of emotion on cognition was determined by the Affective Stroop task that measures the effect of irrelevant emotional distractors on the speed of operant responding.
*Results:* The speed of cognitive performance was significantly reduced in the presence of negative distractors versus neutral or positive distractors in subjects with PTSD, while there was no significant influence of the distractor type on performance in the other diagnostic groups (diagnosis-by-distractor type interaction, $p<0.001$). While negative distractors induced the same levels of anxiety and depersonalization in subjects with PTSD and subjects with other anxiety disorders, distractor-induced depersonalization was associated with slowing of cognitive performance in PTSD ($p=0.02$) but not in other groups.
*Limitations:* Different types of anxiety disorders in the non-PTSD group might reduce the selectivity of the results; some subjects received medication possibly impacting on their cognitive functioning.
*Conclusions:* The cognitive impairments in the presence of negative distractors specifically found in PTSD call for research into novel psychotherapeutic approaches, e.g. attentional training, for PTSD.



## 1. Introduction

An increased attentional bias to environmental cues associated with threat is a major neuropsychological feature of anxiety and stress disorders (Bar-Haim et al., 2007; Rauch et al., 2003). Cognitive models have proposed that this bias reinforces the perception of fearful stimuli, which may induce increased

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arousal, somatic and psychic anxiety symptoms and excessive worry in subjects with anxiety disorders (Eysenck et al., 2007).

The biased competition model of attention suggests that attending to one stimulus or class of stimuli decreases the availability of cognitive resources for others (Desimone and Duncan, 1995). Stimuli that are relevant to ongoing behavior can be selected for processing through executive attention mechanisms, and thereby minimizing the influence of distractors. In addition, experience and memory are thought to play important roles in stimulus selection (Desimone and Duncan, 1995). In subjects who survived traumatic events, negative emotional stimuli may conceivably represent strong competitive advantage for attention. This advantage may explain the hyper-responsiveness to perceived threat in subjects with posttraumatic stress disorder (PTSD) (Vythilingam et al., 2007).

In this study we were first interested in investigating the pathogenetic factor that relates to the hyper-responsiveness to perceived threat in clinical anxiety after trauma. Is an increased impact of threat cues on cognitive processing in trauma survivors associated with exposure to trauma, the presence of an anxiety or stress disorder, or specifically PTSD? A second aim was to examine the processes involved in the excessive impact of emotional stimuli on cognitive performance in vulnerable subjects.

## 2. Methods

### 2.1. Participants

Participants ($N=57$) included 14 trauma-exposed subjects fulfilling the DSM-IV criteria for posttraumatic stress disorder (PTSD), 12 trauma-exposed subjects with various anxiety disorders (Table 1), but not fulfilling the DSM-IV criteria for PTSD (Trauma-AD), 12 trauma-exposed healthy subjects (Trauma-Controls), and 19 non-trauma-exposed healthy subjects (non-Trauma-Controls). PTSD and other diagnoses were established for all groups by the Mini International Neuropsychiatric Interview (MINI) (Lecrubier et al., 1997) according to DSM-IV criteria. The experience of a traumatic event was assessed according to DSM-IV Criterion A1 (stressor criterion) and A2 (response criterion). Psychometric questionnaires included the trait measure of the State-Trait Anxiety Inventory (STAI) (Laux et al., 1981), Beck Depression Inventory (BDI) (Hautzinger et al., 1994), and Dissociation Experience Scale (DES) (Spitzer et al., 1998). Traumatic load was estimated by assessing the number of different traumatic event types experienced or witnessed (Neuner et al., 2004) as reported in the Posttraumatic Stress Diagnostic Scale (PDS) (Ehlers et al., 1996). The study protocol was approved by the local ethics committee. All participants provided written informed consent.

### 2.2. Procedure

Subjects were recruited at the Psychiatric Department of the University Hospital Zurich and at two other psychiatric services in the German-speaking part of Switzerland, including in- and outpatient departments. Healthy controls were recruited among staff members of the involved departments and their surroundings. Exclusion criteria were: cognitive impairment or mental retardation; psychosis, substance abuse, or presence of suicidal ideation assessed by the MINI.

### 2.3. Affective Stroop Task

We used the Affective Stroop (Blair et al., 2007) to measure the impact of positive and negative emotional distractors on goal-directed cognitive processing. The Affective Stroop task is described in more detail in the legend of Fig. 1. The task was implemented with E-Prime version 1.2 (Psychology Software Tools, Pittsburgh, PA).

### 2.4. Data analysis

Chi-square (or Fisher) test was used to assess differences in distributions of nominal variables. To compare continuous variables between groups, analysis of variance (ANOVA) was used.

We used a linear mixed effects model design (model I) to compare the affective valence ratings of IAPS pictures across picture categories and diagnostic groups. Diagnostic group, picture category and group-by-picture category interaction were treated as fixed effects and subject as random effect.

We examined the effect of the emotional distractors on accuracy and response time (RT) for the different diagnostic groups using another mixed model (IIa) with subject included as random effect, and diagnostic group, distractor type (negative, neutral, positive), and interactions among these categorical variables included as fixed effects. In further steps, affective valence ratings of IAPS pictures (model IIb) and potentially confounding clinical variables (model IIc) were included as covariates in the model. A first-order autoregressive covariance structure was accommodated in both model I and II to take into account within-subjects residual correlations of repeated observations for the same subject. A mixed model (III) examined distractor-induced anxiety and depersonalization for the different groups. To estimate the effect of distractor-induced anxiety and depersonalization, respectively, on RT, a mixed model (IV) was applied including diagnostic group (PTSD, Trauma-AD), distractor type, self-reported anxiety and their interactions as fixed effects and subject as random effect. Bonferroni correction was used for post-hoc $t$-tests if a global test was significant by multiplying $p$-values with the number of pairwise comparisons between factor levels (4 in ANOVA, 33 each in model I and II, and 4 in model III).

The level of significance was set at 0.05 (two-sided). Statistical analyses were performed using PASW Statistics 17.0 (SPSS, Inc., Chicago, Ill, USA).

## 3. Results

### 3.1. Sociodemographics and clinical variables

Descriptive statistics of the participants and tests on group comparisons are displayed in Table 1.

### 3.2. Evaluation of the pictorial stimuli

As expected, there was a significant effect of picture category on affective valence ratings in the mixed model I ($F=663.90$,

**Table 1**
Demographic and clinical characteristics of trauma-exposed subjects with posttraumatic stress disorder, trauma-exposed subjects with other anxiety disorder, trauma-exposed healthy controls, and healthy controls without any self-reported traumatic experiences.

| Group | Posttraumatic stress disorder ($N=14$) | | Other anxiety disorder with trauma history ($N=12$) | | Healthy controls with trauma history ($N=12$) | | Healthy controls without trauma history ($N=19$) | | Analysis [a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | *N* | % | *N* | % | $X^2$ | *df* | *p* |
| Female | 14 | 100 | 9 | 75.0 | 8 | 66.7 | 15 | 78.9 | 12.49 | 12 | 0.41 |
| Achieved level of education | | | | | | | | | 25.81 | 23 | 0.011 |
| Obligatory school (9 years) | 2 | 14.3 | 6 | 50.0 | – | – | 1 | 5.3 | | | 0.003 [b] |
| Apprenticeship, college | 9 | 64.3 | 5 | 41.7 | 7 | 58.3 | 7 | 36.8 | 3.11 | 3 | 0.38 |
| Technical or commercial college/university | 3 | 21.4 | 1 | 8.3 | 5 | 41.7 | 11 | 57.9 | | | 0.024 [b] |
| (Comorbid) diagnoses [c] | | | | | | | | | | | |
| Current major depression | 6 | 42.9 | 6 | 50.0 | | | | | | | |
| Past major depression | 3 | 21.4 | 2 | 16.7 | | | | | | | |
| Panic disorder with/without agoraphobia | 3 | 21.4 | 1 | 8.3 | | | | | | | |
| Agoraphobia without panic disorder | 6 | 42.9 | 6 | 50 | | | | | | | |
| Social anxiety disorder | 3 | 21.4 | 2 | 16.7 | | | | | | | |
| Obsessive–compulsive disorder | 1 | 7.1 | 1 | 8.3 | | | | | | | |
| Generalized anxiety disorder | 1 | 7.1 | 8 | 66.7 | | | | | | | |
| Medication | | | | | | | | | | | |
| Antidepressants | 10 | 71.4 | 5 | 41.7 | 1 | 8.3 | – | – | | | |
| Antipsychotics | – | – | 3 | 25.0 | – | – | – | – | | | |
| Tranquilizer | 1 | 7.1 | 1 | 8.3 | – | – | – | – | | | |
| Hypnotics | 2 | 14.3 | 0 | 0 | – | – | – | – | | | |
| Antiepileptics | 1 | 7.1 | 0 | 0 | – | – | – | – | | | |
| Lithium | 2 | 14.3 | 0 | 0 | – | – | – | – | | | |
| Stimulants | 1 | 7.1 | 1 | 8.3 | – | – | – | – | | | |
| Somatic medication | 2 | 14.3 | 2 | 16.7 | 1 | 8.3 | 3 | 15.8 | | | |
| Beta blockers | 1 | 17.1 | 2 | 16.7 | – | – | 1 | 5.3 | | | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | *F* | *df* | *p* |
| Age (years) | 33.4 | 11.3 | 36.4 | 14.5 | 41.4 | 8.8 | 34.7 | 8.0 | 1.418 | 3, 53 | 0.25 |
| PDS: number of self-reported trauma | 3.6 | 1.7 | 2.8 | 2.4 | 1.6 | 1.3 | – | – | 4.028 | 2, 35 | 0.027 [d] |
| STAI: trait anxiety | 50.2 | 3.9 | 47.6 | 4.7 | 41.1 | 3.1 | 42.3 | 4.5 | 15.092 | 3, 53 | 0.000 [e] |
| BDI: depression | 26.3 | 13.4 | 18.8 | 12.2 | 3.0 | 2.5 | 3.4 | 3.8 | 23.564 | 3, 53 | 0.000 [f] |
| DES: total score | 17.7 | 9.6 | 18.4 | 13.8 | 8.2 | 7.7 | 2.3 | 1.9 | 12.348 | 3, 53 | 0.000 [g] |
| DES: depersonalization | 14.9 | 11.9 | 19.2 | 21.4 | 4.4 | 8.1 | 0.7 | 1.7 | 7.584 | 3, 53 | 0.000 [h] |

PDS: Posttraumatic Stress Diagnostic Scale; STAI: State-Trait Anxiety Inventory; BDI: Beck Depression Inventory; DES: Dissociative Experience Scale.

[a] Chi-square or Fisher's tests were used to compare categorical data, univariate ANOVA to compare continuous data between groups. Post hoc comparisons are Bonferroni corrected.

[b] Fisher's exact test.

[c] Diagnoses are not mutually exclusive.

[d] Post hoc testing: Posttraumatic stress disorder>healthy controls with trauma history: $p=0.02$.

[e] Post hoc testing: Posttraumatic stress disorder>healthy controls with trauma history: $p<0.001$, corrected. Posttraumatic stress disorder>healthy controls without trauma history: $p<0.001$, corrected. Other anxiety disorder with trauma history>healthy controls with trauma history: $p=0.002$, corrected. Other anxiety disorder with trauma history>healthy controls without trauma history: $p=0.007$, corrected.

[f] Post hoc testing: Posttraumatic stress disorder>healthy controls with trauma history: $p<0.001$, corrected. Posttraumatic stress disorder>healthy controls without trauma history: $p<0.001$, corrected. Other anxiety disorder with trauma history>healthy controls with trauma history: $p<0.001$, corrected. Other anxiety disorder with trauma history>healthy controls without trauma history: $p<0.001$, corrected.

[g] Post hoc testing: Posttraumatic stress disorder>healthy controls with trauma history: $p=0.05$, corrected. Posttraumatic stress disorder>healthy controls without trauma history: $p<0.001$, corrected. Other anxiety disorder with trauma history>healthy controls with trauma history: $p=0.04$, corrected. Other anxiety disorder with trauma history>healthy controls without trauma history: $p<0.001$, corrected.

[h] Post hoc testing: Posttraumatic stress disorder>healthy controls without trauma history: $p=0.009$, corrected. Other anxiety disorder with trauma history>healthy controls with trauma history: $p=0.02$, corrected. Other anxiety disorder with trauma history>healthy controls without trauma history: $p=0.001$, corrected.

$df=2$, 1960, $p<0.001$) with negative pictures rated more negatively than neutral pictures ($p<0.001$, corrected), and neutral pictures more negatively than positive pictures ($p<0.001$, corrected). There was a significant diagnostic group-by-picture category interaction effect regarding affective valence ratings ($F=4.70$, $df=6$, 1960, $p<0.001$): subjects with PTSD reported significantly lower valence ratings for negative distractors than non-PTSD subjects ($p<0.001$, corrected).

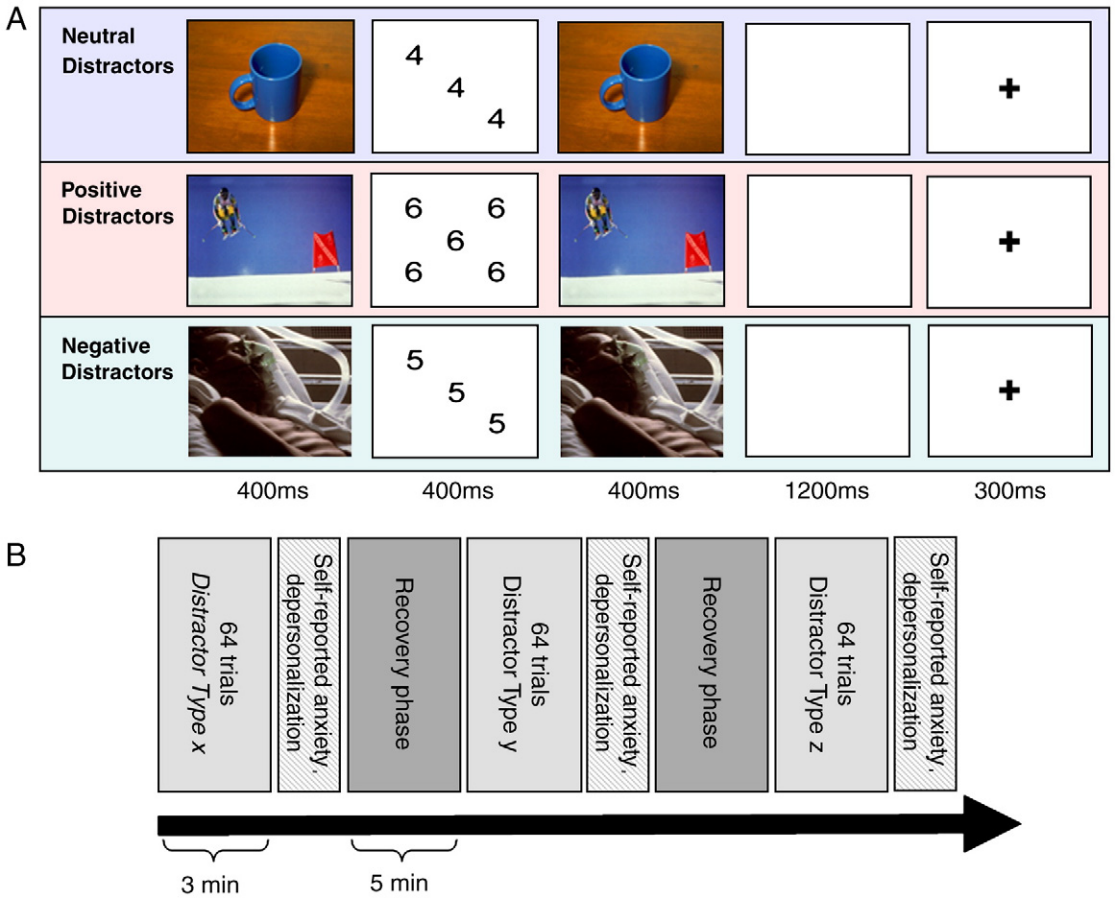


**Fig. 1.** Trial sequence (A) and experimental design (B) of the Affective Stroop Task. A. Example trial sequences for neutral, positive and negative distractor type conditions. Participants are presented sequentially with a numerical display consisting of three, four or five number 3, 4, 5 or 6 randomly presented within the grid of a six-sided dice. They must determine the count of the numerical display. A neutral or emotional picture from the International Affective Picture System (IAPS) (Lang et al., 2005) is flashed as a distractor before and after the numbers are displayed. Each trial ends with a blank screen and a fixation point. Participants were instructed to respond as quickly as possible. Responses were collected on an ordinary computer keyboard. No feedback was given on the performance. B. Experimental design. The distractor conditions are administered in a randomized order to the participants after they started with a practice block of equal length whose distractor stimuli were replaced by a blank image. The 64 trials per block comprised 16 different pictorial distractor stimuli, thus each distractor stimulus is repeated four times. After each block a recovery phase of five minutes was applied in which the participants were instructed to actively put themselves in a state of relaxation as best they can. The aim of the intermittent recovery phase was to avoid carry-over effects between the three blocks (wash-out). Self-reported distractor-induced anxiety and depersonalization was measured using the four self-report items "afraid", "scared", "nervous", "jittery" for anxiety, and "numbed", "unreal" for depersonalization on an electronically administered visual analogue scale (1–100) for each item; the mean scores of the four and two ratings were used as the anxiety and depersonalization level estimates, respectively. After the task completion, each visual IAPS picture was rated by the participants for its affective valence (ranging from pleasant to unpleasant) using a computerized 9-point scale equivalent to the Self-Assessment Manikin that have been devised for the estimation of IAPS pictures (Lang et al., 2005).

### 3.3. Effects of emotional distractors on cognition

Given the overall low error rate (Table 2), conclusions about cognitive dysfunction regarding quality of a task performance are not appropriate. Thus, analyses on accuracy are not presented, and trials with incorrect responses (4.0%) were excluded from the analyses on RT.

There was no significant main effect of diagnostic group ($p=0.2$) but a significant main effect of distractor type on RT ($F=21.46$, $df=2, 2671$, $p<0.001$, model IIa). There was a significant diagnostic group-by-distractor type interaction ($F=9.09$, $df=6, 2668$, $p<0.001$). Subjects with PTSD were significantly slower to respond in trials involving negative distractors relative to neutral distractors (Fig. 2, $p<0.001$, corrected, group difference = 101.5, 95% CI = 74.4, 128.6), while there was no significant differential impact of negative and neutral distractors in the other diagnostic groups ($p$'s>0.05, corrected). Subjects with PTSD were significantly slower to respond in trials involving negative distractors than subjects without PTSD (Fig. 2, $p=0.008$, corrected, group difference = 150.8, 95% CI = 41.6, 260.1), while there was no diagnostic group effect in trials involving neutral and positive distractors ($p$'s>0.279, corrected). The diagnostic group-by-distractor type interaction remained significant after including picture affective valence ratings as fixed effect in the model ($F=9.09$, $df=6, 3300$, $p<0.001$). When adjusting for picture affective valence ratings scores (model IIb), a change of −3.4% in the estimated effect of PTSD relative to non-PTSD on processing speed in the negative condition was obtained.

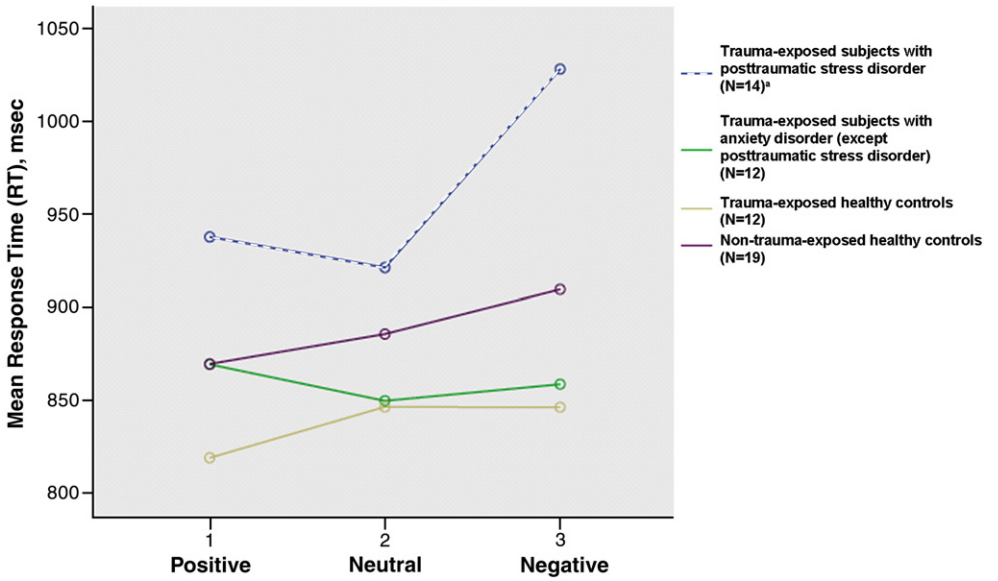


**Fig. 2.** Mean response time in the Affective Stroop Task as a function of distractor type and diagnostic group. [a]Significant difference between neutral and negative condition in trauma-exposed subjects with posttraumatic stress disorder ($t=-4.96$, $df=2660$, $p<0.001$, corrected for multiple comparisons).

### *3.4. Anxiety and depersonalization levels during the experiment*

According to model III we found a significant main effect of diagnostic group regarding distractor-induced self-reported anxiety and depersonalization levels (anxiety: $F=3.78$, $df=3$, 53, $p=0.02$; depersonalization: $F=3.80$, $df=3$, 53, $p=0.02$): subjects with PTSD and Trauma-AD reported more anxiety and depersonalization than healthy trauma survivors and controls ($p=0.008$ and 0.002, respectively, corrected) across distractor types. There was a significant main effect of distractor type on anxiety scores ($F=5.42$, $df=2$, 277, $p=0.005$) but not on depersonalization ($p=0.3$). According to model IV, higher levels of anxiety during the task was significantly associated with lower responding speed in both patients with PTSD and Trauma-AD ($F=24.29$, $df=1$, 1210, $p<0.001$). Higher levels of depersonalization was significantly associated with lower responding speed in PTSD ($F=5.09$, $df=1$, 2122, $p=0.02$), but not in Trauma-AD ($F=1.77$, $df=1$, 986, $p=0.18$). The estimated effects of anxiety and depersonalization on RT in PTSD were similar and significant, when including these scores as concomitant covariates in model IV ($p$'s$<0.01$). A table in the supplemental material lists means and standard deviations of outcome variables classified by diagnostic group and experimental conditions.

## 4. Discussion

Our finding of a relatively strong impact of negative pictorial distractors on cognitive performance in PTSD compared to healthy trauma victims is in line with others (Phan et al., 2006; Vythilingam et al., 2002) and expands the results of previous work in which an adverse influence of *trauma-associated* visual distractors on goal-directed performance in individuals with PTSD was shown (Chemtob et al., 1999; Morey et al., 2009). We could not find an inhibition of task performance by negative distractors in trauma victims with anxiety disorders other than PTSD which is in concordance with Bryant and Harvey (1995). The negative impact of self-reported anxiety on cognitive performance we obtained in our data is supported by previous studies showing adverse effects of anxiety on cognitive processing efficiency (Eysenck et al., 2007). In addition, we found an adverse impact of depersonalization on attentional control in PTSD that was not found in previous studies (Guralnik et al., 2007).

Reduced task performance was only found in the presence of negative, but not neutral, or positive distractors, indicating a temporal but not permanent deficiency of the executive system in PTSD. Our findings also indicate that in PTSD but not in trauma-related anxiety disorders other than PTSD, abnormal emotional and behavioural responses to trauma-related cues might be transferred ("generalized") to general negative material.

According to the biased competition model of attention (Desimone and Duncan, 1995), negative pictures were appraised more negatively in PTSD than in other diagnostic groups, which is consistent with a fear conditioning model of PTSD (Rauch et al., 2003) that hypothesizes hyperresponsivity within amygdala to threat-related stimuli (bottom-up dysfunction). However, differences in valence ratings explained only part of the reduced task performance in the presence of negative distractors in PTSD. Moreover, patients with PTSD reported anxiety levels similar to patients with other anxiety disorders, and the disruptive effect of anxiety was found to be similar in the two groups. These results suggest that pathological factors relating to top-down mechanisms are part of the attentional dysfunction in PTSD. We found a significant anxiety-independent disruptive effect of distractor-induced depersonalization in PTSD, but not in trauma survivors with other anxiety disorders suggesting that dissociative symptoms play important and selective roles in cognitive deficits in PTSD. For instance, it could be that state depersonalization as a stress-response in PTSD (Frewen and

Lanius, 2006) might have a different impact on cognition than trait depersonalization as a feature of depersonalization disorder.

Several methodological limitations merit comment. Thirty-seven percent of the study participants received medication, mostly antidepressants, with possible influence on cognitive functioning. Though statistical significance in cognitive speed difference across distractor conditions in medicated versus unmedicated subjects might not be met because of a lack of power ($p = 0.06$), we found no significant interaction between medication status and diagnostic group ($p = 0.2$). Dose equivalents of antidepressants were not correlated with cognitive speed ($p = 0.9$). Statistical models that adjusted for group-differences in age, gender, educational level and number of traumatic events yielded very similar results. Since we did not collect information about the chronological sequence of traumatic events and onset of an anxiety disorder, we cannot provide evidence for or against causality between anxiety disorder and trauma in the Trauma-AD group.

In summary, our findings suggest that specifically PTSD, but not other anxiety disorders, seems to be characterized by a reduced ability to perform a cognitive task in the presence of threatening stimuli in trauma survivors. The relationship between negative emotional distractors and impaired cognitive functioning appeared to be mediated by distractor-induced anxiety. An important additional factor might be depersonalization: the disruptive effect of stress-induced depersonalization seems to be more pronounced in trauma survivors with PTSD than in trauma survivors with other anxiety disorders. This study underlines the importance of intermittent cognitive deficits in PTSD with possible relevance in psychosocial functioning and disability, and the development of new psychotherapeutic approaches (e.g., attentional training) for PTSD.

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**Conflict of interest**

The authors report no competing interests.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jad.2010.03.006.

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