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Psychiatry Research 135 (2005) 179–183

PSYCHIATRY RESEARCH

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Probing reward function in post-traumatic stress disorder with beautiful facial images

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Received 1 September 2004; received in revised form 26 April 2005; accepted 27 April 2005

Abstract

Reward dysfunction may be implicated in post-traumatic stress disorder (PTSD). This study applied a behavioral probe, known to activate brain reward regions, to subjects with PTSD. Male heterosexual Vietnam veterans with ($n=12$) or without ($n=11$) current PTSD were administered two tasks: (a) key pressing to change the viewing time of average or beautiful female or male facial images, and (b) rating the attractiveness of these images. There were no significant group differences in the attractiveness ratings. However, PTSD patients expended less effort to extend the viewing time of the beautiful female faces. These findings suggest a reward deficit in PTSD.

Keywords: Stress disorders; Post-traumatic; Face; Beauty; Reward

1. Introduction

Post-traumatic stress disorder (PTSD) is a complex condition with features beyond anxiety. Among these are symptoms of "emotional numbing", which include diminished interest in significant activities, feelings of detachment or estrangement from others, restricted range of affect, and sense of a foreshortened future (American Psychiatric Association, 1994).

The pathophysiological significance of emotional numbing remains unclear. One interpretation posits that processing of emotional stimuli in PTSD is essentially normal, but expression of positive feelings is constrained by painful affects triggered by trauma-

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0165-1781/$ - see front matter © 2005 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.psychres.2005.04.002

related memories (Litz and Gray, 2002). Another interpretation is that PTSD is associated with deficits in reward mechanisms subserving enjoyment of everyday events, similar to diminished hedonic capacity in substance use disorders (SUDs; Volkow et al., 2003).

Numerous epidemiological surveys have found SUDs to be a prevalent comorbidity in PTSD patients. The most comprehensive of these studies, the National Comorbidity Survey, reported that 34.5% of men and 26.9% of women with PTSD (versus 15.1% of men and 7.6% of women without PTSD) were diagnosed with drug abuse or dependence (Kessler et al., 1995). Preclinical studies demonstrate similar neural processes in stress and addiction, including acute stress-induced activation of dopaminergic transmission in brain reward regions (Puglisi-Allegra et al., 1991), and their subsequent reduced functioning following chronic stress exposure (Volkow et al., 2003). Furthermore, "addiction to trauma" (Van der Kolk et al., 1985) and "combat addiction" (Solursh, 1988; Nadelson, 1992) have been anecdotally depicted as PTSD features.

Despite suggestive clinical experience and supportive animal data (Puglisi-Allegra et al., 1991), we are unaware of prior studies that assessed reward function in PTSD. Reward research in humans is limited by a paucity of laboratory-based paradigms that consistently activate brain-reward systems and can control the "amount" of reward. A recent study (Aharon et al., 2001) using naturally rewarding stimuli found that healthy males rated beautiful male and female faces as equally attractive, but they expended more effort (in units of computer key presses) to increase the viewing time of the attractive female faces, which was accompanied by activation of major brain-reward regions. Given that pictures of faces can be evaluated as having worth using an objective marker, i.e., operant key-press behavior, these social stimuli can be considered rewarding, and potentially useful as behavioral probes of reward function.

In the present study, we probed reward function in PTSD using the same facial stimuli. We hypothesized that male PTSD subjects, in comparison to non-PTSD controls, would find the beautiful female faces less rewarding, as achieved by fewer key presses to extend viewing time.

2. Methods

Subjects included 23 male heterosexual (self-report) Vietnam combat veterans, 12 with and 11 without current, combat-related PTSD, diagnosed via the Clinical Interview for DSM-IV (SCID; First et al., 1997) and the Clinician-Administered PTSD Scale (CAPS; Weathers et al., 2001). All subjects gave written informed consent for participation after the procedures had been fully explained.

Mean (SD) ages in the two subgroups were as follows: PTSD 54.9 (4.7), non-PTSD 60.5 (5.4), $t(21) = -2.7$, $P = 0.01$ (all P values two-tailed). Current mean (SD) CAPS scores were as follows: PTSD 63.6 (22.0), non-PTSD 2.8 (8.1), $t(21) = 8.6$, $P < 0.0001$. According to the SCID, no subject met criteria for current substance dependence; three PTSD subjects met criteria for current major depressive disorder (MDD). Seven PTSD subjects were using psychotropic medication at the time of testing. All subjects gave written informed consent for participation after the procedures had been fully explained.

The experimental paradigm is detailed elsewhere (Aharon et al., 2001). Subjects were presented with 80 pictures of nonfamous human faces in the following four categories of 20 each: average female, beautiful female, average male, and beautiful male. There were two tasks administered in separate runs: a key-press task, followed by an image attractiveness rating task. For each run, faces were presented in blocks by gender. The order of gender was counterbalanced across subjects. Within each gender block, the average and beautiful faces were presented intermingled, in random order.

For the key-press task, it was explained to the subjects that they could keep the viewing time at 8 s for a face by not pressing any key, or either increase or decrease this time by up to 4 s (depending upon the frequency of the key presses) by alternately pressing a keyboard's "n" and "m," or "z" and "x" keys, respectively. The former key presses were scored as positive and the latter as negative. The average of these values for the 20 pictures in each of the four facial categories yielded a subject's "net" key presses for each category. In addition, each subject's total key presses, i.e., absolute number of key presses, regardless of whether scored positive or negative, during the entire experiment was calculated for use as a covariate.

During the subsequent rating task, the subject rated the attractiveness of the same faces on Likert-type scales ranging from 1 ("very unattractive") to 12 "very attractive." The averages for the 20 pictures in each of the four facial categories yielded a subject's attractiveness rating for each facial category.

The attractiveness rating and net key-press data were analyzed separately by means of Student's *t*-tests between the PTSD and non-PTSD groups, separately for each of the four facial categories. In light of the stated hypothesis, a priori emphasis was given to the *t*-test comparing net key presses for the beautiful female faces. To control for the possibility that a group difference in net key presses for a facial category merely reflected a group difference in general key-press activity, analysis of covariance (ANCOVA) was performed with total key presses as the covariate. ANCOVAs were also performed with age as the covariate.

3. Results

The groups did not differ in their attractiveness ratings for any of the four facial categories. Group means (SD) were as follows: average female faces: PTSD 4.6 (1.7), non-PTSD 4.5 (1.1), $t(21)=0.5$, $P=0.89$; beautiful female faces: PTSD 8.8 (1.8), non-PTSD 8.5 (1.5), $t(21)=0.5$, $P=0.65$; average male faces: PTSD 4.5 (1.8), non-PTSD 4.8 (1.1), $t(21)=-0.5$, $P=0.64$; beautiful male faces: PTSD 6.6 (2.7), non-PTSD 6.9 (1.5), $t(21)=-0.3$, $P=0.79$.

Group mean (SD) total key presses were as follows: PTSD 1320 (816), non-PTSD 1936 (1008), $t(21)=-1.6$, $P=0.12$. Fig. 1 presents individual subjects' net key presses. Group means (SD) for female and male faces were as follows: average female faces, PTSD −3.6 (10.4), non-PTSD −7.9 (5.1), $t(21)=1.2$, $P=0.23$; beautiful female faces, PTSD 5.6 (10.9), non-PTSD 23.0 (15.0), $t(21)=-3.4$, $P=0.003$; average male faces, PTSD −7.4 (7.6), non-PTSD −10.0 (5.7), $t(21)=0.9$, $P=0.37$; beautiful male faces, PTSD −4.0 (9.8), non-PTSD −2.2 (8.5), $t(21)=-0.5$, $P=0.64$.

For beautiful female faces (the only facial category with a significant group difference in net key presses), the group effect adjusted for absolute total key presses was $F(1,20)=7.4$, $P=0.01$; adjusted for age, it was $F(1,20)=7.0$, $P=0.02$. The mean number of key presses for the beautiful female faces was (nonsignificantly) lower in the PTSD subgroup without MDD ($n=9$, mean=5.3, SD=7.7) than in the subgroup with MDD ($n=3$; mean=6.6, SD=10.0); the former mean was significantly different from the non-PTSD group's mean: $t(18)=3.0$, $P=0.007$. The mean of the unmedicated PTSD subgroup ($n=5$) of 2.5 (8.1)

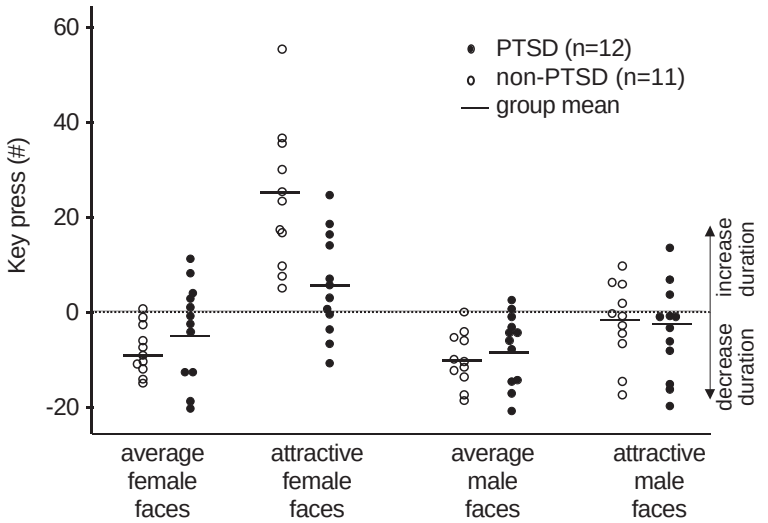

Fig. 1. Male Vietnam combat veterans' efforts to increase or decrease viewing times of four categories of faces (values represent a subject's net key presses, as defined in the text).

was (nonsignificantly) lower than the mean of the medicated PTSD subgroup ($n=7$) of 7.9 (12.6); the former mean also was significantly different from that of the non-PTSD subgroup: $t(14)=3.0$, $P=0.01$. Collapsed across subjects, the Pearson correlation between total CAPS score and net key presses for the beautiful female faces was $r(21)=-0.43$, $P=0.04$.

4. Discussion

A growing body of animal research suggests that brain-reward function is not a homogeneous entity. Rather, it can be dissected, using neurochemical, neuroanatomical and functional criteria, into two core processes, namely "liking" and "wanting" (Berridge and Robinson, 2003). According to this theory, liking or pleasure and positive affective states are mediated via μ-opioid neurotransmission within the scattered network of subcortical and brainstem nuclei, whereas mesolimbic dopaminergic pathways are responsible for the wanting or the incentive motivational aspects of reward function.

A report of normal subjects performing the same behavioral tasks as employed here noted dissociation between assessments of attractiveness and quantified measures of reward valuation, which the authors referred to as "liking" and "wanting," respectively. Heterosexual males rated pictures of beautiful males and females as comparably attractive, but they exerted effort only to view the pictures of the latter (Aharon et al., 2001).

The present results extend this dissociation to a psychopathological condition. Specifically, male veterans with combat-related PTSD rated beautiful female faces as highly attractive as did male combat veterans without PTSD, but they expended less effort to increase the viewing times of these same faces. This group difference was not explained by age, psychotropic medication use, comorbid depression, or overall level of key-press activity. Our findings are therefore consistent with the conclusions that (1) the PTSD subjects assessed the attractiveness of beautiful faces similarly but did not derive similar reward (assessed operantly) from viewing them; and (2) the neural systems identified for wanting in preclinical studies (Berridge and Robinson, 2003) may be the same systems that are affected by PTSD.

To our knowledge, this is the first demonstration of reward deficit in PTSD using an objective behavioral measure. The possibility that the PTSD subjects' failure to work harder to extend the viewing time of the beautiful female faces represents a general performance decrement, rather than a specific reward deficit, is disputed by two considerations. First, this effect remained significant after adjusting for total key presses to all faces, which serves as a control for general psychomotor performance. Second, in behavioral studies involving threatening, rather than appetitive, stimuli, PTSD subjects' performance is actually superior (Vrana et al., 1995; Amir et al., 1996; Bryant and Harvey, 1997).

At least two possible origins exist for a hyporesponsive reward system in PTSD. The first possibility is that it is a pre-existing, possibly genetic, risk factor for PTSD (Gilbertson et al., 2002). The second possibility is that it is acquired as a result of the traumatic exposure along with the PTSD. Given that in both combat and non-combat patients PTSD often heralds the appearance of SUDs, the course of which parallels the severity of the PTSD symptoms (Bremner et al., 1996; Chilcoat and Breslau, 1998; Jacobsen et al., 2001), it is tempting to favor the second origin. However, resolving the origin of reward deficit in PTSD will require prospective studies or twin studies. In addition, further studies are needed to examine whether the current finding generalizes to females, and to non-combat-related PTSD.

In conclusion, these direct experimental behavioral findings add to a body of preclinical research and clinical anecdotes implicating reward deficit in PTSD. Neuroimaging research is needed to determine neural correlates of this reward deficit, and whether other psychopathological states resembling emotional numbing in PTSD, such as anhedonia in SUDs and MDD and negative symptoms in schizophrenia, have related reward pathophysiologies.

Acknowledgments

The authors thank Hans C. Breiter and Brett T. Litz for helpful consultation. This research was supported by grants DA#17959 (IE) and DA#00343 (SEL) from the National Institute on Drug Abuse, and by the

Department of Veterans Affairs Medical Research Service.

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