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Greater avoidance behavior in individuals with posttraumatic stress disorder symptoms

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Abstract

While avoidance is a core symptom of PTSD, little is known about whether individuals with PTSD show a general cognitive bias to acquire and express avoidance, in situations not related to trauma or fear. Here, we used a computer-based task to examine operant acquisition and extinction of avoidance in participants with and without severe self -reported PTSD symptoms. A total of 119 participants (77 male, 42 female; 74 veteran, 45 civilian) with symptoms (PTSS; *n*=63) or with few/no symptoms (noPTSS; *n*=56) performed a task, in which they controlled a spaceship and could shoot a target to gain points or hide in "safe areas" to escape or avoid on-screen aversive events. Results show that participants with PTSS exhibited more avoidance across trials than no PTSS participants, particularly due to more avoidance behavior in PTSS females compared to noPTSS females. Avoidance behavior decreased across extinction trials but interactions with PTSS and gender fell short of significance. Overall, PTSD symptoms were associated with propensity to acquire and express avoidance behavior, in both civilians and veterans, and even in a cognitive task that does not explicitly involve trauma or fear. This effect was more pronounced in females, highlighting the role of gender differences in PTSD symptomatology. Importantly, this study also demonstrates the potential of an objective assessment of avoidance behavior, which could be used to supplement the common but limited self-report tools.

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Introduction

Posttraumatic stress disorder (PTSD) can develop following exposure to a traumatic event; symptoms include cognitive and behavioral avoidance of reminders of the trauma (American Psychiatric Association, 2013). These avoidant behaviors tend to increase over time subsequent to the incipient traumatic event (Foa, et al., 2006; Karamustafalioglu, et al., 2006), and the degree of increased avoidance can differentiate between those trauma-exposed individuals who develop PTSD and those who recover (Foa et al., 2006; North, et al., 2004; O'Donnell, et al., 2007). Lifetime prevalence of PTSD among adult Americans is estimated at about 6.8% (Kessler, et al., 2005);however, some populations may have much higher risk. For example, the prevalence of PTSD may be twice as high in females as in males (Kessler et al., 2005), while lifetime prevalence among veterans may reach 15–20% (Hoge, et al., 2004; Magruder, et al., 2016), presumably reflecting stressors such as deployment, wartime service, and exposure to combat (Dohrenwend, et al., 2006; Kessler, et al., 1995; Wolfe, et al., 1999). Given the prevalence and costs of PTSD, better understanding of how avoidance is acquired and expressed could lead to the development of better therapeutic strategies to manage or reduce PTSD symptoms(PTSS) , as well as ways to identify individuals at highest risk for PTSD following trauma exposure.

Avoidance learning is a complex phenomenon that includes both aversively motivated learning and reward learning; the balance between these two processes influences the degree and expression of avoidance (Stein, et al., 2009). Computer-based tasks, in which participants learn to avoid on-screen aversive events (such as point loss or destruction of the participant’s avatar), can provide a useful tool to examine how individuals acquire and express avoidance behavior. In one recent study, male veterans learned to categorize stimuli in order to obtain reward (point gain) and avoid punishment (point loss); participants with severe PTSD symptoms out performed those with few/no symptoms (Myers, et al., 2013). In another computer task, where participants guided an on-screen character (avatar) through several scripted scenarios, such as attending a party or participating in a volunteer activity, severity of self-assessed PTSD symptoms correlated with participants’ tendency to display avoidant behavioral patterns (Myers, et al., 2016). However, in the first task, subjects learned to select between predefined alternative responses (categorization), while in the second, subjects did not receive explicit feedback for their responses. Thus, neither task fully examined the manner in which subjects discover and acquire avoidance responses, nor the rate at which these avoidance responses extinguish when there is no longer any threat.

Recently, we developed and validated a computer-based task in which the participants control an on-screen spaceship and fire at targets to gain points (Sheynin, et al., 2014a; Sheynin, et al., 2014b). At intervals, a series of on-screen explosions occurs, which damages the participants’ ship and causes accumulating point loss. A warning signal on the screen predicts upcoming threat; participants can learn to avoid the point loss by hiding their spaceship in response to this warning signal. In prior studies with this task, young adults with inhibited temperament, an increased tendency to withdraw from or avoid aversive situations, showed more avoidance behavior than uninhibited peers; there was also an effect of gender, with females showing longer avoidance responses than males (Sheynin et al., 2014a). Note that longer avoidance duration (e.g., initiate hiding as soon as the warning signal appeared) was suboptimal ; rather, the optimal response was to continue shooting to gain points for as long as possible, and then hide at the last possible moment to avoid the upcoming threat. Ina follow -up study, females also showed slower extinction, continuing to emit avoidance responses even when the aversive event no longer followed the warning signal (Sheynin et al., 2014b). These results are intriguing, since both inhibited temperament(Biederman, et al., 1993; Hirshfeld, et al., 1992; Rosenbaum, et al., 1993)and female gender (Tolin, et al., 2006)have been noted as risk factors for the development of PTSD following trauma exposure.

Here, we adapted the spaceship task to examine acquisition and extinction of avoidance in adults with vs. without severe PTSS. Our prediction was that, since avoidance is a core feature of PTSD, participants with severe PTSS would show greater acquisition, and reduced extinction, compared to those with few/no PTSS. Given high rates of PTSD in veterans, particularly combat-exposed veterans, we included civilians, combat-exposed veterans, and non-combat exposed veterans in our sample, to determine whether history of military service and/or combat exposure affected avoidance in the task. We were also interested in whether the pattern would be similar among males and females, given data suggesting that females are at higher risk for PTSD (Tolin et al., 2006)and that the course and expression of PTSD may be different in females than in males (Olff, et al., 2007).

Methods

Participants

122 participants (including 76 veterans and 46 civilians without military experience) were recruited from the Veterans Affairs New Jersey Health Care System (VANJHCS) and surrounding community, by posted flyers and word-of-mouth referral. One participant withdrew from the testing session before completing the spaceship task, and a second participant failed to complete the task due to experimenter error. A third participant's testing session was terminated early due to a medical condition (glaucoma) which made it difficult for the participant to tolerate viewing the computer screen. Data from these three participants were excluded from analysis, leaving a final set of 119 participants. Several additional participants had physical challenges (e.g., prosthetic eye or wheelchair-bound); however, these individuals were able to position themselves comfortably to view the computer screen and register their responses, and so they were not excluded from participation. One female participant had a history of military service but did not qualify for veterans benefits; her data were included in the veteran sample.

Participants received $40 reimbursement for a single two-hour testing session. All participants signed statements of informed consent at the start of the session. Procedures were approved by the VANJHCS Institutional Review Board and conformed to guidelines for the protection of human subjects established by the Declaration of Helsinki and the U.S. Federal Government.

Participants completed a demographic questionnaire that included questions about gender, age, education, and details of military service. When asked to self-identify race, 84 self-identified as Black/African-American, 18 as White/Caucasian, and 17 as other, Mixed Race, or declined to specify. When asked to self-identify ethnicity as Hispanic or non-Hispanic, 5 self-identified as Hispanic, 111 self-identified as non-Hispanic, and 3 declined to specify ethnicity. Participants reporting prior military service (*n*=74) were also administered the Combat Exposure Scale (CES; Keane, et al., 1989); following prior studies (Myers, et al., 2012; Ginsberg, et al., 2008), those scoring below 8 on the CES were classified as non-combat-exposed (*n*=47) and the remainder as having a history of exposure to combat (*n*=27). Asked about specific conflicts in which they had served, 27 reported Vietnam, 11 Gulf War/ Operation Desert Storm, 10 Operation Enduring Freedom/Operation Iraqi Freedom, 13 Other (e.g. Beirut, Somalia, Korea, Iraq/Operation Southern Watch), and 23 reported no specific conflict or peacetime service; numbers sum to greater than 74 due to some veterans whose service spanned multiple conflicts. In summary, three subject groups were included: combat-exposed veterans, non-combat-exposed veterans, and civilians (never served in the military, *n*=45). Table 1 shows demographic characteristics for each group.

All participants also completed the PTSD Checklist-Civilian version (PCL-C), a 17-item questionnaire that asks about presence and frequency of PTSS not necessarily military in nature (Blanchard, et al., 1996). PCL scores of 50+ have been shown to predict PTSD in military samples (Blanchard et al., 1996; Weathers, et al., 1993);based on this criterion, participants were classified with current severe PTSD symptoms (PTSS), or few/no PTSS (noPTSS). PTSS rates were higher among males (47 of 77) than females (16 of 42; Yates - corrected chi-square, χ^2=4.86, df=1, p=.028, Cramer's V=.22), but did not differ between combat and non-combat groups or between civilians and either veteran group (all p >.100).

Spaceship Avoidance Task

The spaceship avoidance task was a modification of that previously described (Sheynin et al., 2014a; Sheynin et al., 2014b; Sheynin, et al., 2016);an executable version of the software is available for replication and additional study on the Open Source Framework (OSF) at www.osf.io/p78fr. The software was programmed in SuperCard version 3.7.1 (Solutions Etcetera, Pollock Pines, CA, USA) and presented on a Macintosh iMac computer. The keyboard was masked except for three keys labeled FIRE, LEFT, and RIGHT, which the subject could use to enter responses. At the start of the experiment, the following instructions appeared: "*You are about to play a game in which you will be piloting a spaceship. You may use LEFT and RIGHT keys to move your spaceship [picture below], and press the FIRE key to fire lasers. Your goal is to maximize your total score. The total score will be displayed at the bottom of the screen. (We'll start you off with a few points now.) Good luck!*"

In the task, participants controlled a spaceship, and could move it left and right across the bottom of the screen, using the LEFT and RIGHT keys. Target spaceships periodically appeared at one of six locations on the screen for approximately 2 s, and participants could use the FIRE key to shoot at and attempt to destroy these ships; participants gained one point for every target ship successfully destroyed (Figure 1A,B). Every 20 s, a large "mothership" appeared on the screen, and remained for a 5 s warning period, during which no target ships appeared(Figure 1C). The warning period was followed by a 5 s punishment period, during which the mothership would fire lasers at the participant's ship (Figure 1D). The punishment period was divided into five 1-s segments; during each segment, there was an explosion of the participant's ship and a loss of 5 points, up to a maximum of 25 points. The punishment period was followed by a 10 s intertrial interval (ITI) before the onset of the next warning period.

Throughout the experiment, two shelters representing "safe areas" were present at the left and right corners of the screen. When the participant moved left or right into one of these areas, the participant's ship entered the safe area and a door closed behind the ship ("hiding"; Figure 1E).While hiding, the participant's spaceship could not be hit by the mothership's lasers, and no point loss occurred, but neither could the participant shoot at targets and acquire points (Figure 1F). Hiding during a punishment period was defined as "escape hiding," and terminated point loss (for as long as the participant remained in hiding, up to the full length of the punishment period). Hiding during the warning period was defined as "avoidance hiding," and could cause complete omission of point loss (if the participant remained in hiding throughout the subsequent punishment period). In both cases, if the participant emerged from hiding before the end of the punishment period, point loss would resume. Importantly, participants were not given any explicit instructions about the safe areas or the hiding response.

The task was divided into acquisition and extinction phases. The acquisition phase consisted of 12 trials, each composed of a warning period, a punishment period and ITI, as described above. The transition to the extinction phase was not signaled to the participant; it consisted of 12 extinction trials which were similar to the acquisition trials except that the mothership never fired lasers and point loss never occurred. Prior to the first acquisition trial, participants received 1 min of practice time, during which target ships appeared and the participant could shoot to gain points. A running tally at the bottom of the screen showed the current points accumulated, which was initialized to 325 at the start of the experiment.

Post-Task Questionnaire

After finishing the task, participants completed a paper-and-pencil questionnaire asking about experience with computer games, whether participants noticed the different objects that appeared during the task and understood their meaning, along with an open-ended question asking participants what they thought was the purpose of the task. The purpose of these questions was to determine whether differences in computer familiarity or understanding of task demands might underlie any group differences in performance.

Data Analysis

Every 100 ms, the program recorded whether the participant's spaceship was inside one of the designated safe areas. For each trial, avoidance hiding was defined as the percent of time spent hiding during the 5 s warning period, and escape hiding was defined as the percent of time spent hiding during the subsequent 5 s punishment period. Avoidance and escape hiding were scored for the acquisition and extinction phases, even though there was no possibility of punishment during the extinction phase. ITI hiding was defined as the percent of time spent hiding during the 10 s ITI between trials, averaged separately across the acquisition and extinction phases. Several additional task variables were scored for each participant, including total score at the end of the task, number of shots fired (presses on the FIRE key), locomotion (presses on the LEFT or RIGHT keys), and total targets shot (equivalent to points gained) across the task.

Statistical analyses were conducted using IBM SPSS version 22. Primary analyses for hiding performance were mixed ANOVA with within-subjects factors of trial, or univariate ANOVA (for other task variables), with factors of group (civilian, non-combat veteran, combat veteran), gender, and PTSS status (PTSS, noPTSS). Significant results were followed up as appropriate by post-hoc tests. Chi-square test was used for comparison of distributions. For chi-square tests on a 2x2 table, Yates Continuity Correction was applied to adjust expected values. Where data failed assumptions of equality of variance/sphericity, appropriate corrections were used (Greenhouse-Geisser for ANOVA, Welch's t for t-test) to correct degrees of freedom. The threshold for significance was set at .05; effects that did not approach significance (p>.100) were generally not discussed. Where multiple tests were conducted , Bonferroni correction was used to protect against inflated risk of family-wise type-I error.

Results

Escape/Avoidance Behavior

Escape hiding increased over the 12 acquisition trials (Figure 2), as indicated by a main effect of trial (mixed ANOVA, F(4.80,513.44)=13.54, p<.001, partial η^2=.11) with no effects of group or gender and no interactions (all p>.090). A subset of 14 participants (11.8%) showed no escape hiding during the experiment. There were no differences between escapers and non- escapers in age, education, or PCL scores (t-tests, all p>.100), and no differences in distribution of escape vs. non-escape behavior across groups or genders (chi-square tests, all p >.100). The participants who never showed escape hiding never experienced the contingency that their actions could affect point loss; as such, their ability to learn an avoidance response is moot and their data were excluded from further analysis. Figure 2B re-plots average escape hiding for the 105 participants who did show escape hiding.

Avoidance hiding also increased over the 12 acquisition trials (Figure 3A), as indicated by a main effect of trial (mixed ANOVA, F(6.76,628.89)=24.60, p<.001, partial η^2=.21) with trial x PTSS (F(13.53, 628.89)=2.23, p=.032, partial η^2=.01) and trial x PTSS x gender (F(6.76, 628.89)=2.25, p=.031, partial η^2=.02) interactions. The main effect of PTSS also approached significance (F(1,93)=3.84, p=.053, partial η^2=.04). To further investigate the three -way interaction, separate analyses were run in males vs. females (Figure 3B–C). Males showed an effect of trial on avoidance hiding (F(5.95,368.59)=57.34, p<.001, partial η^2=.48) but no effect of PTSS and no interaction (all p>.400). Females also showed an effect of trial on avoidance hiding (F(5.89,229.81)=15.16, p<.001, partial η^2=.28), as well as a main effect of PTSS (F(1,39)=5.49, p=.024, partial η^2=.12) and a trial x PTSS interaction (F(5.89,229.81)=2.85, p=.011, partial η^2=.07). Post-hoc independent-samples t-tests, with alpha corrected to .0042 to protect significance levels, revealed significant differences between PTSS and noPTSS females early in training, specifically on trials 2 (Welch's

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$t(29.3)=3.14$, $p=.004$, Cohen's $d=1.01$) and 5 (Welch's $t(38.0)=2.04$, $p=.004$, Cohen's $d=0.65$).

Avoidance hiding decreased across extinction trials (Figure 4; $F(7.15,665.00)=3.77$, $p<.001$, partial $\eta^2=.04$) with no effect of group, gender, or PTSS, although both the trial x PTSS x group interaction and the trial x PTSS x group x gender interaction approached significance (both $.05<p<.100$).

Other Performance Measures

Univariate ANOVA on total score obtained during the task, revealed a significant main effect of PTSS ($F(1,93)=5.36$, $p=.023$, partial $\eta^2=.05$); specifically, PTSS participants averaged 613.8 points (SD 234.2) while noPTSS participants averaged only 531.0 points (SD 227.5). To examine whether the difference in total score might be attributable to other performance measures, multiple *t*-tests were conducted. The difference in locomotion between PTSS and noPTSS groups fell short of corrected significance (PTSS: M=1111.3, SD 532.8 ; noPTSS: M=936.4, SD 249.3; $t(103)=2.15$, $p=.034$, partial $\eta^2=.04$). There were no significant differences in total shots fired, number of target ships hit, or time spent hiding during ITI (all $p>.100$).

Post-Task Questionnaire

One participant was not administered the post-task questionnaire due to an experimenter's error. Among the remaining 118 participants, self -assessed computer gaming was modest, with only 16 participants reporting that they played games "very often" and 34 reporting "sometimes," with the remainder reporting "seldom" or "never." Distribution of these responses did not differ as a function of group, gender, or PTSS status (all $p>.100$).

Asked about the purpose of the current game, 59 participants mentioned something to do with assessing motor skills, eye-hand coordination, or reflexes; 16 mentioned something to do with testing patience or stress; 15 mentioned something to do with memory or coordination; 36 stated that the purpose was to gain points or shoot/destroy enemy ships. Only one participant specifically mentioned the concept of learning to avoid or hide from danger.

Asked whether they had noticed objects at the lower corners of the screen (i.e., the safe areas), 91 of the 104 "escapers" and 10 of the 14 "non-escapers" responded "yes;" these endorsement rates did not differ significantly between escapers and non-escapers ($p=.229$). Participants were next asked about the purpose of those objects. Of the 103 participants who specified a purpose, 81 mentioned something to do with safety, hiding, or protection; 3 additional participants mentioned "bunkers" or "hangars" without specifically mentioning the concept of hiding or safety. The remaining 19 participants said they did not know or mentioned a different concept such as "borders" or places for refueling. The concept of safety was expressed significantly more often by escapers (78 of 93) than by non-escapers (3 of 10; Yates -corrected chi-square, $\eta^2=12.56$, df=1, $p<.001$, Cramer's $V=.39$); however, there were no differences as a function of gender, group, or PTSS status (all $p>.100$).

Discussion

The central finding of the current study was that, while most participants learned an escape response, there were group differences in how well participants learned an anticipatory avoidance response. There was an interaction of trial with PTSS, indicating that PTSS participants acquired avoidance faster and to a greater degree than no PTSS participants . This result suggests that, while avoidance of reminders of the trauma is a core feature of PTSD, a propensity for avoidance can be observed even in the context of a fairly innocuous computer game. This in turn suggests that avoidance symptoms may reflect a general cognitive bias, not limited to learning about trauma or fear.

There are several possible factors that could drive a group difference in avoidance. First, it is possible that individuals with PTSS simply learn faster in general. This would be consistent with prior work that has shown faster learning by individuals with PTSS in a computer task where the goal is to earn points and avoid point loss (Myers et al., 2013), although other studies have found no such effects of PTSD or PTSS burden on computer-based tasks where the goal is to earn points (but there is no threat of point loss; Levy-Gigi, et al., 2012; Kostek, et al., 2014; Anastasides, et al., 2015). This idea is also generally consistent with a number of other studies showing better associative learning in PTSD patients on tasks that involve learning to avoid explicitly aversive stimuli, such as mild electric shocks(Blechert, et al., 2007; Orr, et al., 2000), airpuffs to the eye(Burriss, et al., 2007), trauma-specific pictures(Wessa, et al., 2007), or loud noise bursts(Peri, et al., 2000). However, in the current task, subjects typically first learn to escape from punishment (i.e., hiding once the mothership starts shooting, to terminate point loss), and then to avoid punishment altogether (via anticipatory hiding initiated during the warning period). Results showed no difference between PTSS and noPTSS participants in escape responding, nor any difference between participants who did vs. did not learn to escape (escapers vs. non-escapers) in PCL scores. This indicates that individuals with severe PTSD symptoms were not faster to learn to escape; however, they were significantly faster to learn the avoidance response. This in turn appears to argue against a general facilitation of (all types of) learning in the PTSS group, but rather a selective facilitation in learning avoidance responses.

Another factor that could drive group differences is variability in reward and punishment sensitivity. Successful performance on the spaceship task involves balancing the need to hide to avoid punishment, and the need to stay out in the open in order to shoot and gain points. Prior computational modeling of behavior in the spaceship task suggests that performance is modulated by both the absolute sensitivity to punishment, as well as the relative sensitivity to reward and punishment(Sheynin, et al., 2015).

Finally, it is possible that greater acquisition of avoidance in the PTSS group could simply reflect increased motivation to perform well, or better understanding of the goals of the game, compared to the noPTSS group. Consistent with this, the PTSS group did acquire more total points, although they did not differ from noPTSS participants in other performance measures. In addition, although the post-task questionnaire is only an indirect measure of understanding, there was no evidence that either group could verbalize that the purpose of the game was to assess avoidance learning, nor any evidence that the PTSS group had more familiarity with computer games in general.

The second key finding of the current study was the interaction with gender. In particular, the effect of PTSS discussed above appeared primarily due to greater avoidance in PTSS females compared to noPTSS females, with little difference between male groups. To our knowledge, this represents the first time that an interaction with gender has been observed in a behavioral study assessing avoidance in those with PTSS. This, together with a recent study that found gender differences in avoidance in opioid addicts (Sheynin et al., 2016), emphasize the importance of studying gender in mental disorders, and that the course and expression of avoidance may differ in men and women, which of course could have important implications for optimizing treatment by patient gender.

Finally, there was no evidence of differences in avoidance between veterans and civilians, or between combat-exposed and non-combat exposed veterans. As noted earlier, PTSD risk may be higher in veterans than in civilians, and higher in combat-exposed than non-exposed veterans, and indeed the current study also found lower PCL scores in the civilian group than in the two veteran groups, and higher PTSS rates among combat than non-combat veterans. Despite this, the current study did not find evidence of differences in how avoidance is acquired and expressed among these subgroups. This might suggest that different life experiences, leading to different rates and types of traumatic exposure, might affect vulnerability to PTSD, without necessarily affecting the course or expression of avoidance symptoms in those who do develop the disorder. Obviously, further work should explore this question further.

Several limitations of the current study raise open questions that could be addressed in future work. First, although our study included males and females, as well civilians and veterans, cell size was imbalanced. Most obviously, there was low inclusion of female combat veterans. This is unsurprising given the demographics of the population of combat veterans; nevertheless, this imbalance doubtless hindered the ability to investigate interactions between gender and history of exposure to combat. Future studies might redress this issue, particularly as the pool of female combat veterans continues to increase.

Second, while the spaceship task was validated in young adults, and later tested in opioid-addicted patients(Sheynin et al., 2014a; Sheynin et al., 2014b; Sheynin et al., 2016), the current work is the first to report performance on this task in participants with PTSS. In addition, PTSS status was assigned based on PCL scores, representing symptom self-assessment, rather than a result of clinical diagnostic status. Prior studies have suggested that PCL scores are highly predictive of clinician-rated PTSD in veterans (Lunney, Schnurr & Cook, 2014; Weathers et al., 1993). Nevertheless, self-report questionnaires are obviously subject to limitations including demand characteristics, which can lead to both underreporting and over reporting of symptoms. Additionally, clinical diagnosis includes additional factors such as duration and impact on daily life, not directly assessed by PCL. Future studies are necessary to further validate the spaceship task in PTSD, and extend it to clinically-diagnosed patients.

Additionally, participants in the current study were not assessed for, nor excluded based on, presence of comorbid disorders such as depression or anxiety, or for presence of psychoactive drugs including antidepressant medication, all of which might differ across groups and contribute to difference in learning and behavior. This is particularly salient given our prior findings of group-gender interactions among opioid-addicted and control participants(Sheynin et al., 2016). Future studies should further examine the effects of (prescription and illicit) psychoactive drugs, and possible interactions with PTSD, on avoidance learning. However, it is important to note that the prior study found a difference between opiate-addicted and never-addicted males, while the current study found a difference between PTSS and noPTSS females. Additionally, although depression is often comorbid with PTSD, depression would presumably be expected to reduce the motivation to obtain points in a computer-based task, resulting in poorer overall performance, whereas the actual direction observed in the current study was for better performance (more total points) in the PTSS group.

Perhaps the most important question raised by the current work is whether the observed effects of PTSS, and interaction with gender, on avoidance learning represent a pre-existing cognitive bias, which confers risk for PTSD, or rather emerges as a symptom in the wake of trauma exposure and/or development of PTSD. Prior studies with the spaceship task have observed greater avoidance rates in putatively healthy individuals with inhibited personality, as well as longer avoidance duration in putatively healthy females (Sheynin et al., 2014a); given that both inhibited personality and female gender may be vulnerability factors for PTSD, it is possible that increased susceptibility to acquire and express avoidance is a mechanism by which these vulnerability factors translate into pathological behavior following trauma exposure. However, only longitudinal studies can definitively answer this crucial question.

In summary, the current study demonstrated greater avoidance in participants with severe PTSD symptoms, using a computer-based task in which the aversive event to be avoided was point loss. In particular, PTSS females showed greater avoidance than noPTSS females . This is, to our knowledge, the first demonstration of such a gender difference in avoidance learning in participants with PTSD symptoms. Results suggest first, that avoidance symptoms in PTSD represent a general cognitive bias not limited to learning about trauma-related or fear-evoking stimuli, and second, that there may be important interactions with gender. A better understanding of how acquisition and expression of avoidance is altered in PTSD may provide important insight into the development and persistence of pathological behaviors, which in turn could guide the development of more effective treatments or preventative interventions, and how these might differ between male and female patients.

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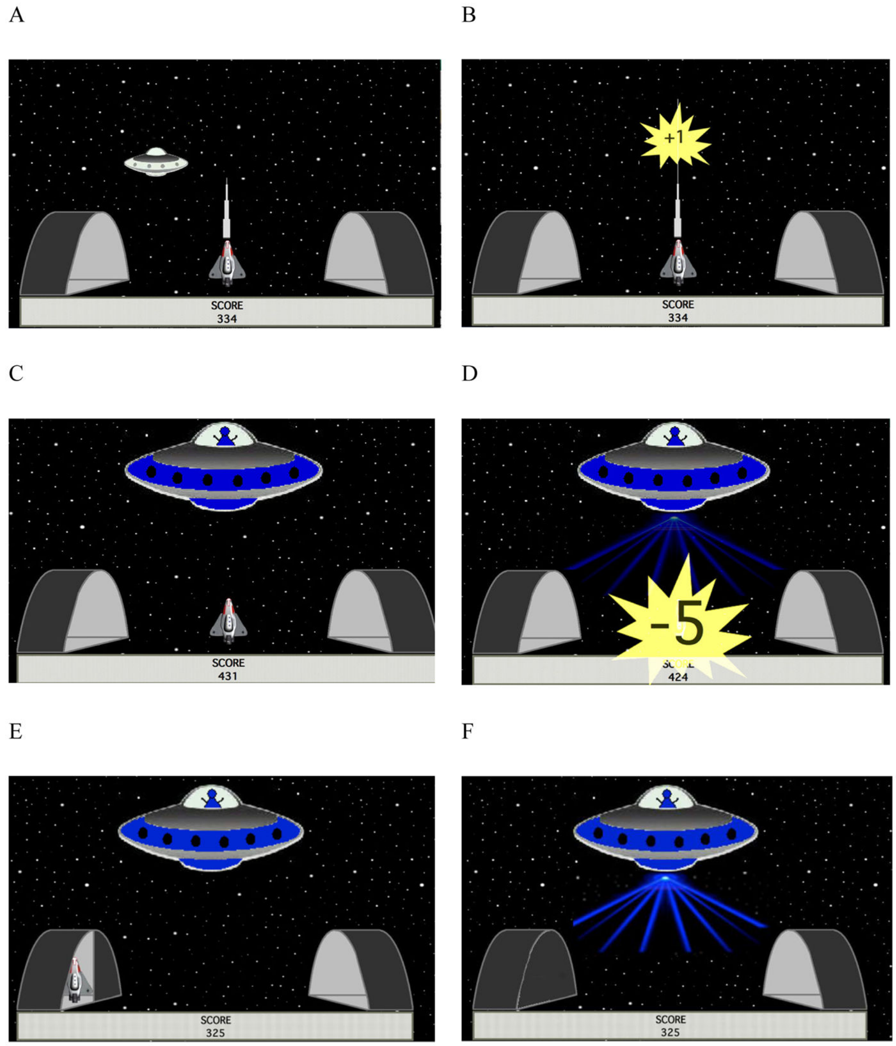

Figure 1.
Screen events during the spaceship avoidance task. (A) The participant's ship could move from left to right and fire at target ships that appeared at intervals; (B) successful "hits" were rewarded with 1 point. (C) During the warning period of each trial, a mothership appeared, and the participant's lasers were ineffective against it. (D) In the subsequent punishment period, the mothership fired lasers repeatedly, each time exploding the participant's spaceship and causing a loss of 5 points, to a maximum of 25 points lost. (E) The participant could escape or avoid point loss by hiding in either of the two designated "safe areas" at the sides of the screen; the door slid shut behind the participant, or opened when the participant emerged. (F) While the participant's ship was hidden, the mothership's lasers were ineffective (no destruction or point loss). The participant could thus hide during the punishment period to terminate point loss (escape response), or prevent point loss all together by hiding during the warning period and remaining hidden throughout the subsequent punishment period (avoidance response).

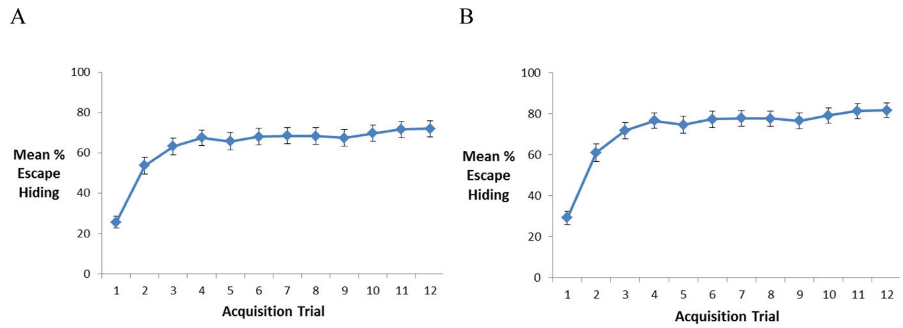

Figure 2.

Escape hiding (hiding during punishment period) across the 12 acquisition trials for (A) all *n*=119 participants, (B) *n*=105 excluding 14 non-escapers. Error bars represent standard error of the mean.

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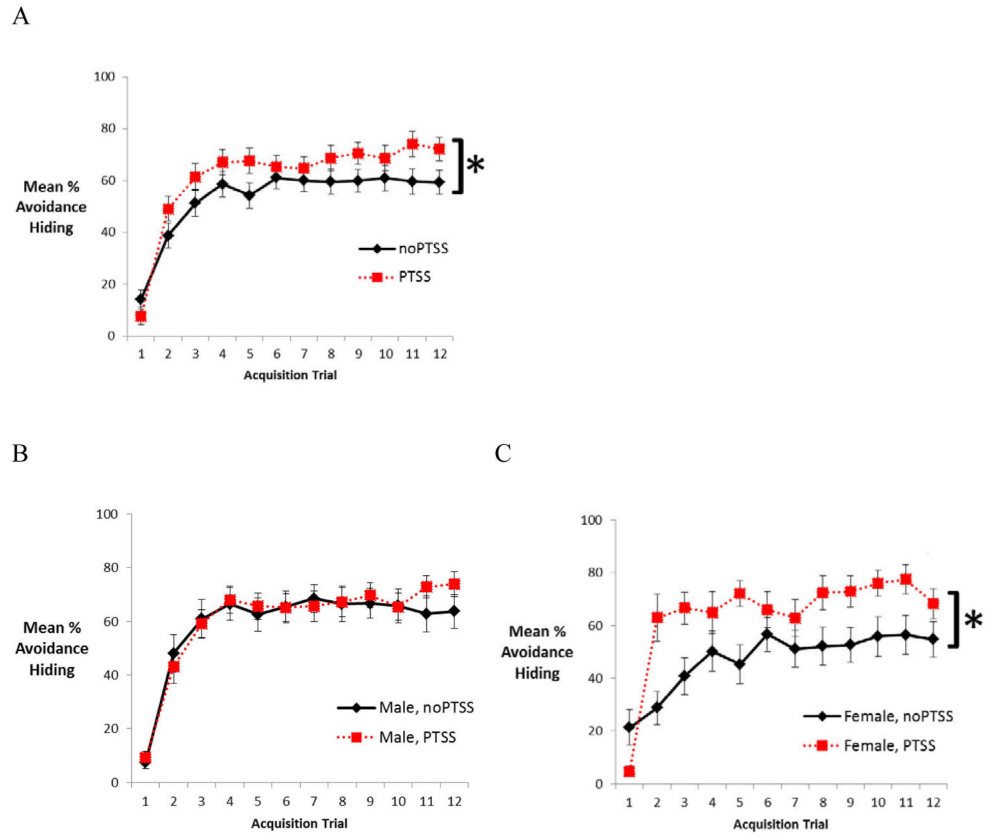

Figure 3.
Avoidance hiding (hiding during the warning period). (A) Avoidance hiding increased across trials, and was greater in the PTSS subgroup particularly toward later trials. (B) Males with vs. without PTSS showed similar levels of avoidance hiding, but (C) avoidance hiding was significantly greater in females with PTSS compared to noPTSS females. Asterisks denote significant group differences between PTSS and noPTSS groups. Error bars represent standard error of the mean.

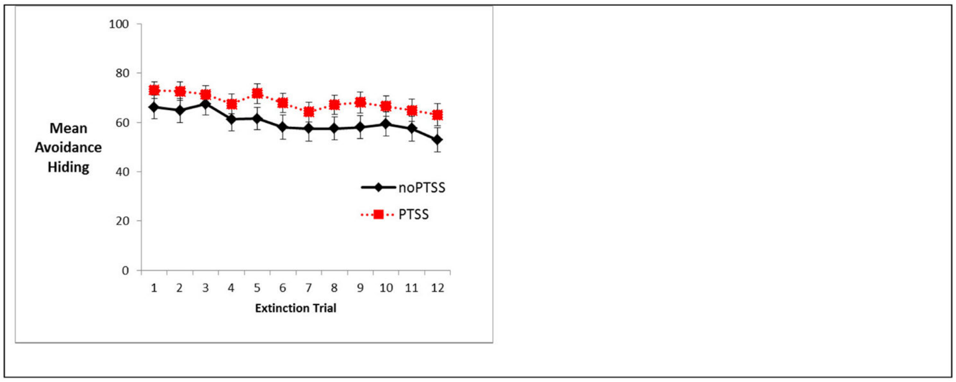

Figure 4.
Avoidance hiding during the 12 extinction trials. Error bars represent standard error of the mean.

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Table 1

Demographic characteristics and questionnaire scores for the three participant groups.

	Combat-Exposed Veterans	**Non-Combat Exposed Veterans**	**Civilians**
N	27	47	45
Gender	2 female (7.4%)	10 female (21.3%)	30 female (66.7%)
Age (years)	52.2 (SD 11.0)	55.7 (SD 10.6)	47.5 (SD 16.4)
Education (years)	15.1 (SD 3.0)	14.6 (SD 1.9)	14.9 (SD 2.4)
CES score	17.8 (SD 7.9)	1.8 (SD 2.7)	N/A
PCL score	57.3 (SD 14.5)	51.0 (SD 16.6)	39.2 (SD 15.6)
PTSS cases	21 (77.8%)	28 (59.6%)	31 (68.9%)