Fear-Potentiated Startle and Fear Extinction in a Sample of Undergraduate Women Exposed to a Campus Mass Shooting

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THANK YOU!

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Fear-Potentiated Startle (FPS)

- FPS builds upon classical conditioning principles
- FPS is defined by the relative increase in the amplitude of the acoustic startle reflex when a subject sees a conditioned stimulus (CS+) that predicts an aversive unconditioned stimulus (US; Jovanovic et al., 2011)
  - This is compared to startle amplitude elicited in the absence of that cue

Fear-Potentiated Startle (FPS)

- Myers and Davis (2004) developed a discrimination procedure in rats that allowed for an independent evaluation of fear acquisition and inhibition of fear
- Aversive US is paired with a third stimulus, X, depending on the presence of either CS+ or CS–.
  - CS+ -> fear response
  - CS– -> fear inhibition (learn safety signals)
FPS, Fear Inhibition, and PTSD

- A dysregulated fear response is one of the hallmark clinical presentations of PTSD
  - Over-generalization of fear/ability to inhibit fear responses in the presence of safety
- “Exaggerated startle response”
  - Unlike other symptoms of PTSD, this can be measured experimentally

Jovanovic et al. (2009) assessed fear potentiation and fear inhibition in male Vietnam veterans with and without PTSD

- Findings:
  - Subjects with a history of PTSD, but with low current symptoms, responded similarly to healthy controls, showing both fear potentiation to the danger cue and the ability to discriminate between the danger and safety cues
  - PTSD patients with high current symptoms showed strong fear potentiation to danger, but no significant difference in discrimination between the danger and safety cues
  - This impairment appeared to be related mostly to high re-experiencing symptoms rather than the hyperarousal symptoms
  - May be surprising at first because the exaggerated startle response is part of the hyperarousal cluster

Pole et al. (2009) assessed FPS longitudinally in police officers

- 138 police academy cadets exposed to sound bursts under increasing (low, medium, high) threat of mild electric shock
- Following 1 year of exposure to police-related trauma, participants assessed for PTSD symptom severity
- Found that more severe PTSD symptoms were prospectively predicted by greater subjective fear under low threat
  - Under low and medium threat of electric shock, officers with greater PTSD symptoms reacted as if they were under high threat
- Pole and colleagues concluded that hyperarousal to contextual threat (evidenced by greater fear under low threat) is a unique preexisting vulnerability factor for greater PTSD symptom severity following a potentially traumatic event

Jovanovic et al. (2009) investigated whether history of childhood abuse was associated with increased startle reactivity in adulthood

- 60 participants total (ages ranged from 18-63; 47% female; majority were African American)
- History of CPA and CSA was associated with increased baseline startle
  - CEA had no impact on baseline startle
- Childhood abuse did not affect the degree of FPS or fear inhibition
  - Subjects reporting high levels of child abuse had intact inhibition
  - Suggests that the effects of perceived abuse may not parallel the effects of PTSD, but rather have unique effect on physiology
FPS, Fear Inhibition, and PTSD

• Norrholm et al. (2010) investigated FPS in trauma exposed individuals with and without PTSD living in inner-city Atlanta, Georgia
  • 127 total participants (78 PTSD−; 49 PTSD+)
  • Found that the PTSD group showed increased FPS to both the CS+ (with the airblast) and the CS− (without the airblast) compared to the non-PTSD group

Summary of Research

• Many individuals with PTSD have elevated FPS and greater inability to inhibit fear responses in the presence of safety signals
  • Lack of safety signal learning may be a specific marker of vulnerability for developing PTSD
  • May not be the case for individuals with a history of childhood abuse → much more research is needed

The Current Study

• The current study is investigating FPS and fear inhibition in a sample of undergraduate women exposed to the February 14, 2008 campus mass shooting at NIU
  • Hypothesis 1
    • Women with probable PTSD immediately following the campus mass shooting will demonstrate greater FPS to a safety signal than women without probable PTSD
  • Hypothesis 2
    • Women with probable PTSD immediately following the campus mass shooting will demonstrate altered fear extinction compared to women without probable PTSD
Methods

- Participants were women who participated in a longitudinal study following the mass shooting at NIU on 2/14/08
- Current pregnancy, vision impairment, and hearing impairment were exclusion criteria
- Seven women were excluded from participating in the study due to current pregnancy
- $N = 75; \text{M}age = 19.40, SD = 2.53$ prior to shooting

Methods

- All participants had provided questionnaire data related to trauma and PTSD prior to the shooting, and at multiple time points afterwards.
- Participants also completed a self-report pre-survey online prior to the FPS session (e.g., mental health, trauma exposure, etc.)
- PTSD
  - Assessed with Distressing Events Questionnaire for DSM IV (Kubany et al). A cut off of 18 and above used to indicate probable PTSD.

Methods - Procedure

- Informed consent
- Auditory screening
- Questions about vision
- Stimulants
- Estrogen
- Blood draw and saliva sample
Methods

• Heart rate
  • Left forearm and right clavicle

Methods

• Skin conductance
  • First and third fingers

• Respiration

Methods

• EMG response of right orbicularis oculi
• Headphones for sound burst (108 dB for 40 ms)
• Camelbak for airblast (140 psi for 250 ms)

Methods

• Instructions given for computer stimuli

CS+  CS−
Methods

• Dark-enhanced session (5 minutes)
  • Habitation phase: noise alone (NA), one minute (light)
  • Two light and two dark phases, each lasting one minute
  • 3 startle probes in each phase
  • Counterbalanced order

• Acquisition session (20 minutes)
  • Habitation phase: noise alone (NA)
  • 3 blocks of four trials of each type: NA, CS+, CS- (i.e., 12 total trials in each block)
  • CS+ paired with UCS (airblast)

• Extinction session (25 minutes)
  • 5 blocks of four trials of each type
  • CS+ no longer paired with UCS

Results

Demographic and PTSD Symptomatology Data Immediately Following the Mass Shooting Event

<table>
<thead>
<tr>
<th>Demographic</th>
<th>PTSD+ (n=42)</th>
<th>PTSD- (n=33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race (White)</td>
<td>83.3%</td>
<td>71.9%</td>
</tr>
<tr>
<td>Age (M, SD)</td>
<td>25.18 (1.57)</td>
<td>25.72 (2.75)</td>
</tr>
</tbody>
</table>

PTSD Symptomology

<table>
<thead>
<tr>
<th>Score (M, SD)</th>
<th>PTSD+ (n=42)</th>
<th>PTSD- (n=33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-experiencing</td>
<td>3.38 (1.50)</td>
<td>.79 (1.02)</td>
</tr>
<tr>
<td>Avoidance</td>
<td>3.71 (1.73)</td>
<td>.67 (1.05)</td>
</tr>
<tr>
<td>Hyperarousal</td>
<td>3.52 (1.11)</td>
<td>1.09 (1.10)</td>
</tr>
</tbody>
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PTSD symptoms were modeled as a count variable (count of the number of 17 items on the DEQ endorsed as moderate or high); M = mean; SD = standard deviation

Results

• Level of symptomatology over time in the full sample
  • Probable PTSD
    • T1: 19%
    • T2: 52% mass shooting referent, 53% any
    • T3: 13%, 15%
    • T4: 10%, 14%
    • T5: 6%, 10%
    • T6: 5%, 10%
    • T7: 5%, 8%
  • Subsample (n = 75)
    • Probable PTSD at T2/mass shooting referent: 56%
      • No PTSD (n = 33), Yes PTSD (n = 42)
    • Current probable PTSD at time of FPS:
      • No PTSD (n = 42), 1 participant with probable PTSD at FPS
      • Yes, PTSD (n = 42) 5 participants with probable PTSD at FPS

• Data analysis
  • Mixed ANOVA design with the with-in-subject factor of Block (3 levels for Acquisition/6 levels for Extinction), trial type (2 levels: CS+, CS-), and the between-groups factor of diagnosis (2 levels: PTSD+ and PTSD-)
Results: Acquisition

Results: Extinction

Development of FPS and CS+/CS− discrimination during early, mid, and late Acquisition in PTSD− and PTSD+ participants. FPS = (Mean startle response to the CS) − (Mean startle response to the noise alone [NA]). Non-significant Block x Trial Type interaction (F(2,146)=0.92, p > .05).

Results: Extinction

Extinction of FPS and CS+/CS− discrimination during early, mid, and late Extinction in PTSD− and PTSD+ participants. FPS = (Mean startle response to the CS) − (Mean startle response to the noise alone [NA]). Non-significant Block x Trial Type interaction (F(2,142)=0.54, p > .05).

Results

• During fear acquisition:
  • No significant differences in baseline startle responses
  • No significant differences during late Acquisition between PTSD− and PTSD+ groups

• When examining PTSD symptoms continuously:
  • Women with higher levels of PTSD symptoms, compared to those with lower levels of PTSD symptoms, demonstrated greater FPS responses to both the CS+ (r = .230, p = .043) and CS− (r = .268, p = .020) during late Acquisition
  • Women with higher levels of PTSD symptoms, compared to those with lower levels of PTSD symptoms, demonstrated greater FPS responses the CS+ (r = .260, p = .025) during early Extinction; the relationship between frequency of PTSD symptoms and FPS to the CS− during early Extinction was trending (r = .199, p < .10)

Results – Symptom Clusters

• Women with high re-experiencing symptoms showed greater levels of fear to the CS+ (r = .280, p = .013) and CS− (r = .244, p = .035) during late Acquisition
• Women with high avoidance symptoms showed greater levels of fear to the CS+ (r = .233, p = .044) and CS− (r = .282, p = .014) during late Acquisition
• Women with high re-experiencing symptoms showed greater levels of fear to the CS+ (r = .267, p = .021) during early Extinction
• Women with high avoidance symptoms showed greater levels of fear to the CS+ (r = .319, p = .006) during early extinction
• No symptoms clusters predicted FPS to the CS− during extinction
Conclusions – Acquisition

- During fear acquisition, women with and without probable PTSD did not differ in their baseline startle responses.
- When look at PTSD symptoms categorically, groups did not differ in their FPS responses during late Acquisition.
  - However, when examining frequency of PTSD symptoms, women with higher levels of PTSD symptoms demonstrated greater FPS responses to both the CS+ and CS- during late Acquisition.

Conclusions – Extinction

- Similar to the findings during fear acquisition, women with and without probable PTSD did not differ in their baseline startle responses during fear extinction.
- When PTSD symptoms were modeled as a continuous variable, higher levels of PTSD symptoms were associated with greater FPS responses to the CS+ during early Extinction.
  - Supports the notion that individuals with high levels of PTSD symptoms at time of trauma are more likely to have greater fear load that persists for years after trauma, even in the absence of current symptoms.

Discussion/Future Directions

- Previous research has suggested that there are sex differences in FPS responding and that these differences may be attributed to estrogen levels (Glover et al., 2012).
  - High levels of estrogen may enable women to successfully regulate anxiety and fear.
  - Therefore, it is possible that estrogen acts as a moderator, such that women with low levels of estrogen and probable PTSD may exhibit greater FPS responding than women with higher levels of estrogen and probable PTSD.
  - An additional explanation for the lack of significant between-subjects differences may be that PTSD symptomatology naturally decreased from immediately following the campus mass shooting to the time that participants engaged in the FPS paradigm.
  - Majority of the women in the NTS study experienced a PTSD trajectory of resilience (Orcutt et al., 2014).

- Although the study did not assess FPS prior to the shooting, the fact that heightened fear responses are seen 5 years later suggests that fear load may either be:
  1.) A pre-existing risk factor that in the immediate aftermath of the trauma increased the frequency of symptoms.
  2.) A long-term consequence of high PTSD symptoms.
- Future studies of fear load using a prospective approach could tease apart these two hypotheses.
Thank you!