The Impact of Mindfulness Meditation on Fear Load and Fear Inhibition: Examining Parasympathetic Activation as an Underlying Mechanism

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Overview
- Fear-potentiated startle (FPS)
- FPS and psychopathology
- Neurological correlates of FPS
- Autonomic regulation
- Mindfulness and autonomic regulation
- The current study

Fear Learning
- Classical conditioning

Unconditioned stimulus (US) → Unconditioned response (UR)
**Fear Learning**

- Classical conditioning

Unconditioned stimulus (US) \( ightarrow \) Conditioned stimulus (CS) \( ightarrow \) Unconditioned response (UR)

**FPS Paradigms**

- Based upon classical conditioning
- Rodent models
  - Fear inhibition (CS+ vs. CS-)
  - Velocity of cage movement
  - US = electric shock
  - Greater FPS to CS+ than to CS-, difference increased with time
  - Demonstrated fear learning and inhibition

Myers & Davis, 2004

**Fear Learning**

- Classical conditioning

Conditioned stimulus (CS) \( ightarrow \) Conditioned response (CR)

**FPS Paradigms**

- Validated in human studies
  - Replicated CS+/CS- findings
  - Acoustic startle (eyeblink)
  - US = Airblast to larynx
  - Indicator of fear extinction
  - Reduction in FPS from acquisition to extinction

Jovanovic et al., 2005; Norrholm et al., 2011
**FPS Clinical Findings**

- Among individuals with PTSD:
  - Greater overall FPS magnitude to CS+ (exaggerated startle)
  - Greater FPS to CS- (poor fear inhibition)
  - Greater FPS to CS+ during early (fear load) and late (fear inhibition) extinction

  Jovanovic et al., 2009, 2010; Norrholm et al., 2011

- Relations with other symptoms:
  - Panic - greater overall FPS magnitude; poor fear inhibition
  - State anxiety – greater FPS to CS+
  - Induced worry – greater FPS to CS+ and CS- during extinction

  Gazendam & Kindt, 2012; Grillon et al., 1993; Lissek et al., 2009

**Neurological Correlates**

- Amygdala is central to fear learning
- Prefrontal cortex (PFC) is central to fear extinction – suppresses amygdala
  - Supported in rodents and humans
- Top-down process
- Self-regulation (i.e., inhibition) is important

  Jovanovic et al., 2013; Sotres-Bayon et al., 2006; Walker & Davis, 2002

**Autonomic Regulation**

- Physiological indication of self-regulation (without use of brain measures)
- Autonomic regulation
  - Sympathetic nervous system (SNS)
    - Fear learning (amygdala)
  - Parasympathetic nervous system (PNS)
    - Fear inhibition (PFC)
  - Output from PFC and amygdala sent through neurons to regulate HR

  Porges et al., 1994, 2007; Thayer et al., 2009
**Autonomic Regulation**

- **Respiratory Sinus Arrhythmia (RSA)**
  - Variability in HR relevant to respiration
  - High RSA = better regulation
  - Low RSA is associated with:
    - Negative affect
    - Less effective/flexible emotion regulation
    - Low emotional intelligence
    - High startle responding
    - Poor fear extinction
  - Can RSA be increased?

*Beauchaine, 2001; Berntson et al., 1997; Demaree et al., 2004; Pappens et al., 2014; Porges et al., 1994*

**Mindfulness Meditation**

- **Mindfulness**:
  - Non-judgmental, present-centered awareness; acceptance of experiences
- **Trait or state variable**
- **Supported as a psychological intervention**
  - Anxiety ($g = .63 - .97$)
  - Depression ($g = .59 - .95$)
  - More effective than relaxation ($d = .36 - .66$)
- **Associated with higher levels of RSA**

*Ditto et al., 2006; Hofmann et al., 2010; Jain et al., 2007; Kabat-Zinn, 1990; Khoury et al., 2013; Mankus et al., 2013; Vinci et al., 2014*

**Summary**

- FPS paradigms provide insight into fear learning and fear inhibition
  - Demonstrated clinical differences and neurological correlates
- RSA represents self-regulatory abilities
- Mindfulness is associated with better autonomic functioning
- Can mindfulness (as compared to relaxation) influence fear inhibition via increased RSA?

**Hypothesis 1 – Manipulation Checks**

- **Hypothesis 1a**: Among individuals in the mindfulness condition, levels of state mindfulness will be increased following the mindfulness exercise.
- **Hypothesis 1b**: Among individuals in the relaxation condition, levels of tension will be decreased following the relaxation exercise.
- **Hypothesis 1c**: Post-exercise, individuals in the mindfulness condition will report significantly higher levels of state mindfulness than those in the relaxation condition. Conversely, individuals in the relaxation condition will report significantly lower levels of tension than those in the mindfulness condition.
Hypothesis 2 – Fear Load and Fear Inhibition

- **Hypothesis 2a**: Membership in a mindfulness condition will predict lower FPS to the CS+ during blocks 1 and 2 of extinction as compared to a relaxation condition.
- **Hypothesis 2b**: Membership in a mindfulness condition will predict lower FPS to the CS+ during blocks 5 and 6 of extinction as compared to a relaxation condition.

Hypothesis 3 – RSA

- **Hypothesis 3a**: Membership in a mindfulness condition will predict higher RSA values.
- **Hypothesis 3b**: Higher levels of RSA will predict lower fear load.
- **Hypothesis 3c**: Higher levels of RSA will predict better fear inhibition.
- **Hypothesis 3d**: RSA will demonstrate a significant indirect effect on the association between study condition and fear load.
- **Hypothesis 3e**: RSA will demonstrate a significant indirect effect on the association between study condition and fear inhibition.

Method

- **Participants**
  - 54 female psychology students ($M_{age} = 20.26$)
  - 18 years or older and fluent in English
  - Race and ethnicity
    - 32 (59.3%) participants identified as White
    - 14 (25.9%) as Black
    - 4 (7.4%) as Asian
    - 2 (3.7%) as “Other”
    - 2 (3.7%) declined to respond
  - 88.9% identified as non-Latina/Hispanic
**Method**

- **Study Flow**
  - Informed consent and online questionnaire
  - All participants invited to FPS portion
  - Verbal consent to FPS portion
  - Physiological set-up and FPS procedure, including mindfulness or relaxation
  - Debriefing

- **Measures**
  - Demographics
  - Five Facet Mindfulness Questionnaire (FFMQ)
    - Higher trait mindfulness associated with high RSA
  - Traumatic Life Events Questionnaire (TLEQ)
  - PTSD Checklist – 5 (PCL-5)
    - PTSD symptoms associated with FPS
  - Toronto Mindfulness Scale (TMS)
    - Decentering and Curiosity subscales
  - State-Trait Anxiety Inventory (STAI) – state items

- **Psychophysiological equipment**
  - EMG
  - HR
  - Respiration
  - Headphones (startle probe)
  - Vest with airblast
  - Keypad

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**Method**

- **Measures, cont.**
  - Pain item:
    - “Please rate the level of pain that you experienced as a result of the airblast by circling a number on the scale below”
    - 1 = absolutely no pain to 10 = extreme pain
  - Tension item:
    - “Please rate your level of tension/arousal at this moment by circling a number on the scale below”
    - 1 = absolutely no tension to 10 = extremely tense

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**Method**

- **Measures**
  - Demographics
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**Method**

- **Psychophysiological equipment**
  - EMG
  - HR
  - Respiration
  - Headphones (startle probe)
  - Vest with airblast
  - Keypad

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Vinci et al., 2014; Baer et al., 2006; Kubany et al., 2000; Lau et al., 2006; Spielberger, 1983; Vinci et al., 2014; Weathers et al., 2013
**Method**

- **Stimuli**
  - CS+
  - CS-

**Conditions**

- **Mindfulness**
  - Guided meditation asking participants to focus on the present moment while paying attention to their breath and other sensations in a nonjudgmental and accepting manner
- **Relaxation**
  - Guided relaxation instructing participants to physically relax each muscle group
- **TMS and tension item administered again**

**Data Analysis**

- Based on previous research, a desired effect size of \( f^2 = .16 \) was chosen
- Using G*Power 3.1 software:
  - 80% power
  - Alpha = .05
  - Effect size \( f^2 = .16 \)
  - 52 participants total (26 in each group)
**Data Analysis**

- **Data screening**
  - Outliers – one on fear load
  - Missing data
  - Skewness and kurtosis
  - Log transformations were conducted on the following variables:
    - Fear load, RSA, PCL-5 Negative Alterations in Cognitions and Mood, PCL-5 Hyperarousal, the second tension item, and the pain item
- **Study condition coded as 0 = relaxation, 1 = mindfulness**

**Physiological data**

- EMG and HR cleaned in MindWare
- FPS obtained from EMG (CS+ – NA)
- RSA calculated in MindWare; change from baseline to last minute of exercise

**Results**

- **Identification of covariates**
  - RSA
    - Significantly negatively related to pain item and the PCL-5 Intrusions scale
  - Fear load
    - Significantly positively related to FFMQ-Non-reactivity scale, negatively related to relationship status (coded as 1 = coupled, 0 = not coupled)
  - Fear inhibition
    - Significantly positively related to race (coded as 1 = White, 0 = Black or African American/Asian or South-Asian /American Indian or Alaskan Native/Native Hawaiian or Pacific Islander)

- **Hypotheses 1a and 1b:**
  - 1a partially supported: significant increase in TMS-Decentering ($t[26] = -5.60, p < .001$), but not TMS-Curiosity ($t[26] = -.79, p = .44$) among mindfulness
  - 1b supported: significant decrease on the tension item among relaxation ($t[26] = 9.80, p < .001$)
Results

- Hypothesis 1c:
  - Two one-way ANOVAs
  - Not supported
  - Mindfulness condition did not experience greater levels of state mindfulness ($F[1,53] = .02, p = .90$ for TMS-Curiosity; $F[1,53] = .71, p = .40$) for TMS-Decentering)
  - Relaxation condition did not experience significantly lower levels of tension ($F[1,53] = 1.54, p = .22$)

- Hypotheses 2 and 3
  - Two mediation models
  - Bootstrapping with 5,000 re-samples
  - 95% confidence interval (CI)
  - Covariates included
    - Model 1: relationship status, FFMQ-Non-reactivity, PCL-5 Intrusions, and the pain item
    - Model 2: race, PCL-5 Intrusions, and the pain item

Mediation Model 1

Hypothesis 2a

- RSA
- Fear Load

Condition: Mindfulness (1) vs. Relaxation (0)

$B = .14, t(41) = 1.28, p = .21$

Mediation Model 2

Hypothesis 2b

- RSA
- Fear Inhibition

Condition: Mindfulness (1) vs. Relaxation (0)

$B = 5.10, t(39) = .87, p = .39$

Preacher & Hayes, 2004
Hypothesis 3a*

Mediation Model 1

B = .84, p = .01

RSA
Condition: Mindfulness (1) vs. Relaxation (0)

Fear Load

Hypothesis 3a*

Mediation Model 2

B = .77, p = .02

RSA
Condition: Mindfulness (1) vs. Relaxation (0)

Fear Inhibition

Hypothesis 3b

Mediation Model 1

B = .06, p = .36

RSA
Condition: Mindfulness (1) vs. Relaxation (0)

Fear Load

Hypothesis 3c

Mediation Model 2

B = -4.57, p = .12

RSA
Condition: Mindfulness (1) vs. Relaxation (0)

Fear Inhibition
Discussion

- Hypotheses 1a – 1c partially supported
- Hypotheses 2a – 3e not supported
  - 3a and 3e – significant but opposite direction
- Interpretations of null findings:
  - 1) the test does not measure the construct variable
  - 2) the theoretical framework from which the hypothesis was generated is incorrect
  - 3) the experiment failed to test the hypothesis properly

Cronbach & Meehl, 1955

Discussion – Null findings

- 1) The test does not measure the construct variable
  - RSA is not an accurate measure of autonomic regulation
  - FPS variables are not reliable indicators of fear load and fear inhibition
  - TMS may not be accurately measuring state mindfulness
  - Single item for tension

Beauchaine, 2001; Grillon, 2002; Jovanovic et al., 2005; Khoury et al., 2013; Rash & Prkachin, 2013; Rothbaum et al., 2014; Vinci et al., 2014
**Discussion – Null findings**

2) The theoretical framework from which the hypothesis was generated is incorrect
- Faulty theoretical framework regarding mindfulness and parasympathetic activation
- No link between FPS/startle and parasympathetic activation

Ditto et al., 2006; Gorka et al., 2012; Libby et al., 2012; Pappens et al., 2014

**Discussion – Null findings**

3) The experiment failed to test the hypothesis properly
- Manipulation checks:
  - Exercises too similar
  - TMS and tension are self-report
  - Tension may not be specific enough
  - TMS-Curiosity is a more advanced skill
- Most participants were novice

Linehan, 1993

**Discussion – Clinical Implications**

- Limited due to mixed findings
- Generally supportive of relaxation, but not un-supportive of mindfulness
- Mindfulness a challenge?
- Dosage may be important for physiological effects
Discussion – Limitations/Future Directions

- Short mindfulness session
  - Exacerbated by novice sample
  - Need to examine impact of longer/more frequent sessions

- Female undergraduate sample
  - Low levels of psychopathology
  - Limited racial/ethnic diversity
  - Need to examine gender and racial/ethnic differences
  - Need to examine among clinical sample – RSA likely to be lower, FPS higher

Thank you!