An ERP investigation of the effects of acute stress on memory formation and judgments of learning (JOLs)

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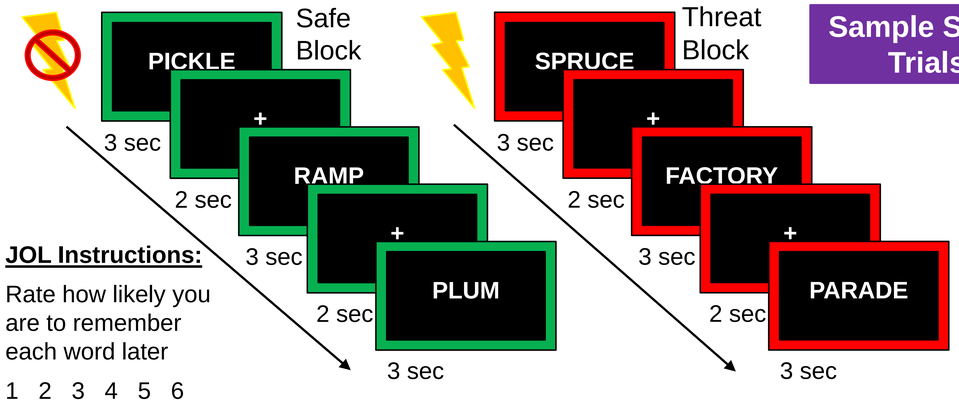
Background and Hypotheses

- Acute anxiety impairs top-down control over attentional processes[1], which may impair memory formation for threat-neural information[2]
- Acute anxiety may also impair metamemory processes, such as judgments of learning (JOLs)
- We used the threat-of-shock paradigm to test the hypotheses that acute anxiety during encoding will:
  1. impair subsequent memory for neutral words
  2. decrease the magnitude and accuracy of trial-by-trial JOLs
  3. Have opposite effects on stimulus- vs task-driven ERP components:
     1. N100[3] and P200[4] will be enhanced under threat
     2. N400[5] and late frontal positivity[6] (LFP) will be attenuated under threat

Experimental Design

- **Stimuli and Procedures:**
  - 144 neutral nouns presented in 2 blocks of 72, *each followed by free recall*
  - Assignment of words and blocks to conditions counterbalanced
  - Trial-by-trial judgments of learning (JOLs) made on 1-6 scale
  - Tonic skin conductance levels (SCLs) recorded to measure anxiety
- **Exp. 1** (N = 40 healthy adults, 29 F, mean age = 20)
  - 36 words presented in 48-tp font; 36 in 18-pt font[1]
  - Shocks delivered randomly on 12 threat trials (excluded from analysis)
- **Exp. 2** (N = 28 healthy adults, 17 F, mean age = 20)
  - Continuous EEG recorded during study from 32 channels
  - All words presented in 35 point font
  - Shocks delivered randomly on 8 threat trials (excluded from analysis)



Sample Study Trials

JOL Instructions:

Rate how likely you are to remember each word later

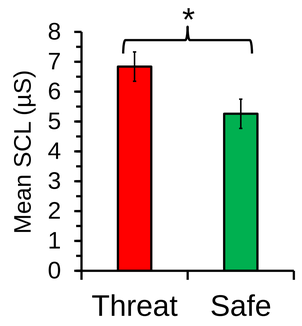
1 2 3 4 5 6
LEAST MOST

[1]The font size manipulation was initially included in Exp1 to examine the effects of acute anxiety on the use of font size as a cue to judgments of learning. No interactions involving threat and font size were significant.

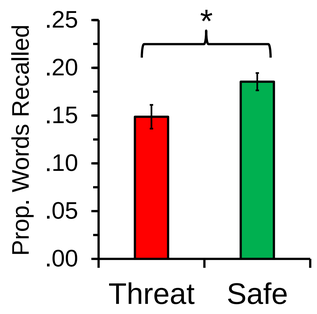
Exp 1 - Acute anxiety impaired memory formation; No impact on JOLs

- The threat manipulation led to higher skin conductance and worse recall, but JOLs were not affected.

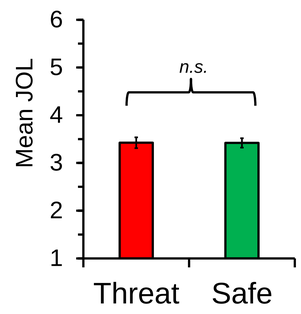
Physiological Anxiety: Skin Conductance



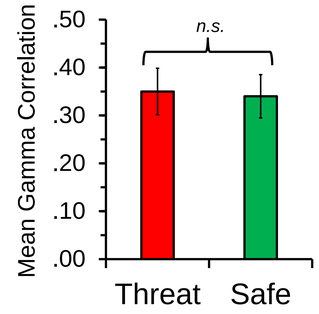
Memory Accuracy: Words Recalled



JOL Magnitude: Mean Rating

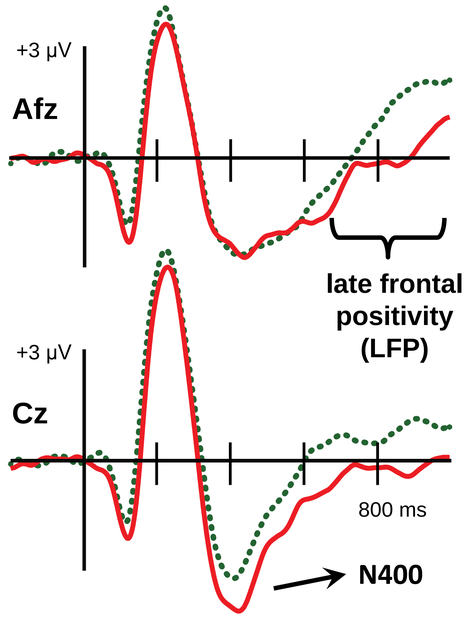


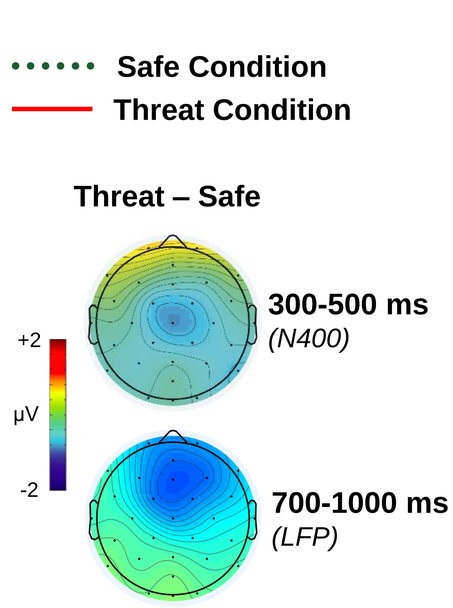
JOL Accuracy: Gamma Correlation



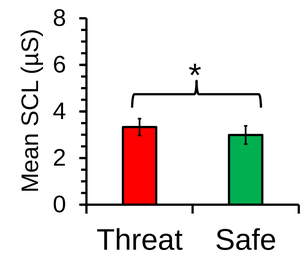
Exp. 2 – Acute anxiety during study impacted N400 and late frontal ERPs

- Study phase ERPs showed larger N400s and smaller late frontal ERPs during threat vs safe blocks.
- Unlike in Experiment 1, however, threat in Experiment 2 did not lead to worse subsequent free recall.
- Threat did not impact the amplitudes of early ERPs, specifically N100 and P200.





Skin Conductance



Words Recalled

Summary and Conclusions

- Exp 1 demonstrated that acute threat can impact memory, but not metamemory, for neutral words.
- Exp 2 showed that threat modulates ERPs (N400 and LPC) related to semantic processing, suggesting that threat-induced anxiety may specifically disrupt the use of deep, elaborative encoding strategies[5,6].
- Additional research is necessary to understand why threat did not reduce recall accuracy in Exp 2.

1. Basanovic & Macleod, 2017, *Cognition and Emotion* 2. Guez et al., 2016, *Frontiers in Psychology* 3. Shackman et al., 2011, *Journal of Neuroscience* 4. Laretzaki et al., 2010, *Journal of Psychopharmacology* 5. Schleepen et. al, 2014, International Journal of Psychology 6. Mangels et al., 2001, *Cognitive Brain Research*