Psychometric properties of startle response modulation during threat-of-shock, affective picture viewing, and resting state tasks

Jesse T. Kaye, Daniel E. Bradford, Charles T. Rohrer, Rachel K. B. Hamilton, Austin D. Kayser, & John J. Curtin

Department of Psychology, University of Wisconsin – Madison

Study Objectives

Psychophysiology tasks are poised to become a major contributor to the National Institute of Mental Health Research Domains Criteria (RDoC) and related initiatives in experimental medicine. For these tasks to meaningfully contribute to the goals of RDoC, their psychometric properties must *first* be well understood. Are they up for the task?

We designed the current study to comprehensively evaluate key psychometric properties of **startle response modulation** in three commonly used psychophysiology tasks that can be anchored within the RDoC Negative Valence System domain.

1) Temporal stability: We quantify the temporal stability of individual differences in responses over one week with Pearson correlations between study visit 1 and study visit 2.
2) Internal consistency: We quantify the internal consistency within subjects with Spearman-Brown corrected correlations between odd and even trials (split-half reliability).
3) Effect size robustness and stability: We examine the strength and stability of each focal task manipulation by quantifying its effect size and testing for interactions with study visit (visit 1 vs. 2).

Quantification Approach: We quantified startle response in two common ways:
1) Raw scores (microvolt units)
2) Standardized T-scores.

Methods

- Participants (N=128, 64 female) completed three tasks at two study visits separated by one week.
- Participants first completed the Resting State Task.
- Participants were randomized to groups on Task Order (1st task: NPU Task or Affective Picture Viewing Task).
- Participants completed the same Task Order at both study visits.
- Participants were excluded for health conditions that contraindicate exposure to stress or current use of psychiatric medications.

Study Procedures Overview

Resting State → NPU → Affective Picture Viewing

Resting State → Affective Picture Viewing → NPU
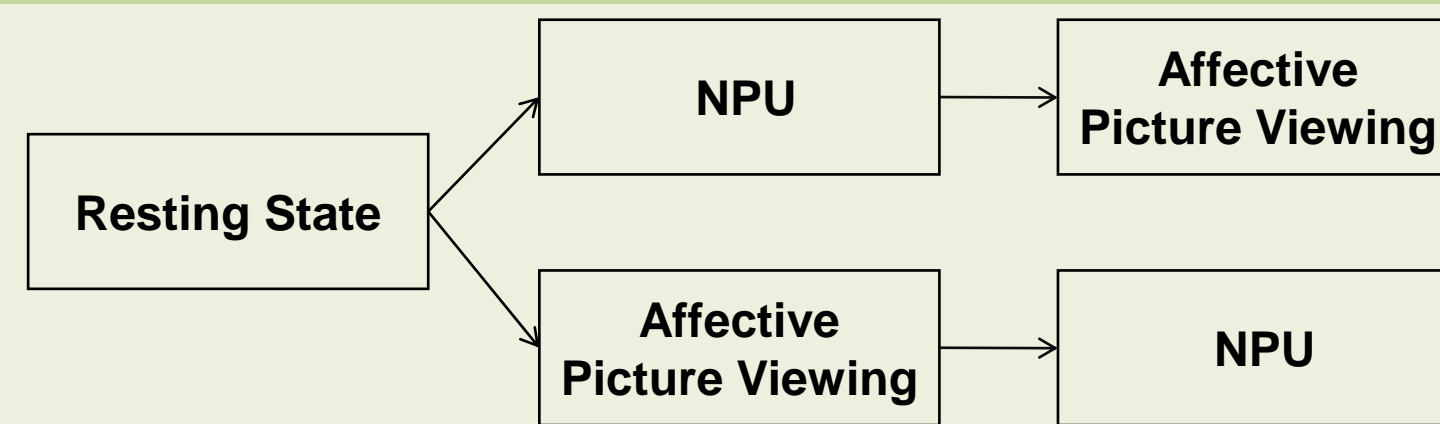
Startle Response Measurement

- The startle response is a measure of defensive reactivity that can be modulated by emotional stimuli (e.g. potentiated by threat).
- Acoustic startle probes (50ms, 102dB) were presented at 4.5s post-cue onset in the NPU Task (8-12 per condition) and 3-5s post-picture onset in the Affective Picture Viewing Task (8 per condition).
- The eyeblink startle response was measured with Ag/AgCl EMG sensors over the orbicularis oculi muscle. Startle response was quantified as the peak magnitude 20-100ms post-probe onset.
- **Raw score:** Mean startle response for each condition during cues or pictures in the NPU and Affective Picture Viewing tasks, respectively.
- **Standardized t-score:** We used trial level raw startle responses (i) to calculate participant's (j) raw startle response mean (M_j) and standard deviation (SD_j) across their trials in the task.
- $\text{T-Startle}_{ij} = ((\text{RawStartle}_{ij} - M_j) / SD_j) * 10 + 50$

No Shock, Predictable Shock, Unpredictable Shock Task

Predictable Shock Block (Acute Threat)

⚡ = Electric Shock to Fingers

Predictable shock: Shock occurs during cues only

Unpredictable Shock Block (Potential Threat)

Unpredictable shock: Shock occurs at any time.

- This task manipulates participants' affect by administering mild electric shocks under predictable and unpredictable (vs. neutral, no-shock) conditions.
- Participants viewed blocks of a series of 5 second colored square cues. Both shock and no shock conditions counterbalanced within- & between-subjects.
- To control for individual differences in shock sensitivity, participant's maximum tolerated shock at 1st study visit is used during the NPU Task at both visits.
- **Startle potentiation** = shock cues minus no shock cues (not displayed)

	Raw Scores		T-Scores	
Temporal Stability	Visit 1 to Visit 2		Visit 1 to Visit 2	
Predictable Startle Potentiation	.70 [.60, .79]		.57 [.44, .68]	
Unpredictable Startle Potentiation [a]	.76 [.67, .83]		.49 [.33, .62]	
Internal Consistency	Visit 1		Visit 1	
Predictable Startle Potentiation [a]	.87 [.81, .91]		.56 [.37, .70]	
Unpredictable Startle Potentiation [a]	.73 [.61, .81]		.52 [.31, .67]	
	Visit 1	Visit 2	Visit 1	Visit 2
Effect Size Robustness & Stability				
Predictable Startle Potentiation	40.4 [32.2, 48.6]	38.4 [31.3, 45.4]	9.4 [8.4, 10.5]	10.2 [8.9, 11.4]
Unpredictable Startle Potentiation [c]	29.2 [23.5, 35.0]	25.6 [20.3, 30.8]	7.5 [6.6, 8.5]	6.5 [5.6, 7.4]

Significant difference (*p* <.05) between: [a] raw scores and t-scores, [b] study visits for raw scores, [c] study visits for t-scores. Confidence Intervals in brackets [95% CI]. Raw score effect size reported in microvolts.

NPU Task raw startle potentiation displayed moderate to high temporal stability and internal consistency, as well as large effect sizes across study visits. Psychometric properties were generally superior for raw scores than t-scores.

Affective Picture Viewing Task

Picture Block
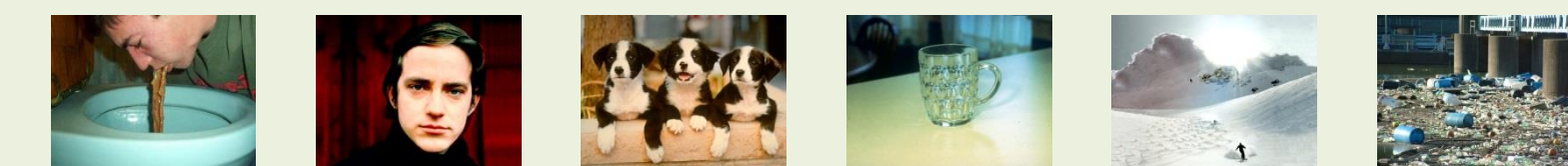
- This task manipulates participants' affect by presenting unpleasant, pleasant, and neutral pictures from the International Affective Picture System (IAPS).
- Participants viewed 36 different pictures (set) at each study visit comprising 12 pleasant, 12 unpleasant and 12 neutral pictures. Pictures were displayed for 6s each in blocks.
- Picture condition order was counterbalanced within- & between-subjects and picture set order was counter balanced between-subjects.

Two within-subject condition contrasts:
- **Pleasant startle modulation** = pleasant minus neutral pictures
- **Unpleasant startle modulation** = unpleasant minus neutral pictures

	Raw Scores		T-Scores	
Temporal Stability	Visit 1 to Visit 2		Visit 1 to Visit 2	
Pleasant Startle Modulation	.13 [-.05, .30]		.08 [-.10, .26]	
Unpleasant Startle Modulation [a]	.64 [.52, .74]		.40 [.24, .54]	
Internal Consistency	Visit 1		Visit 1	
Pleasant Startle Modulation	.10 [-.30, .38]		.16 [-.21, .41]	
Unpleasant Startle Modulation [a]	.32 [.02, .53]		.07 [-.33, .35]	
	Visit 1	Visit 2	Visit 1	Visit 2
Effect Size Robustness & Stability				
Pleasant Startle Modulation [c]	-4.8 [-7.3, -2.2]	-1.8 [-4.4, 0.7]	-1.5 [-2.3, -.7]	-0.1 [-1.0, 0.7]
Unpleasant Startle Modulation [c]	6.9 [4.5, 9.4]	9.1 [6.5, 11.7]	3.1 [2.2, 3.9]	4.9 [3.9, 5.8]

Significant difference (*p* <.05) between: [a] raw scores and t-scores, [b] study visits for raw scores, [c] study visits for t-scores. Confidence Intervals in brackets [95% CI]. Raw score effect size reported in microvolts.

Affective Picture Viewing Task unpleasant picture startle modulation displayed moderate temporal stability. Pleasant picture startle modulation displayed poor temporal stability and internal consistency across quantification approaches.

Resting State Task

- This task involves a period of time characterized by the absence of other explicit manipulations or potent experimental stimuli, often conducted at "baseline".
- General startle reactivity during this task has been suggested to index individual differences in defensive reactivity within the Negative Valence System domain of the RDoC.
- Participants viewed a fixation cross while 9 startle probes were presented at random intervals. No other distracting stimuli were presented (e.g., images or shock).
- General startle reactivity was calculated as the mean raw startle response during the Resting State Task.
- Table: Significant difference (*p* < .05) between: [b] study visits raw scores. [95% CI]

	Raw Scores	
Temporal Stability	Visit 1 to Visit 2	
	.90 [.86, .93]	
Internal Consistency	Visit 1	
	.96 [.94, .97]	
Effect Size Robustness & Stability [b]	Visit 1	Visit 2
	90.2 [78.0, 102.3]	75.0 [63.5, 86.5]

General startle reactivity habituated over 1 week, but displayed excellent temporal stability and internal consistency.

Conclusions

- NPU Task results demonstrate high temporal stability of startle potentiation consistent with previous reports (Shankman, 2013) and provide novel evidence of high internal consistency and robust effect sizes of startle potentiation across study visits.
- Unpleasant picture startle modulation had moderate temporal stability, higher than previous reports (*r*'s ~ .2 in Larson 2000, 2005, Manber, 2000, Lee, 2009), but poor internal consistency.
- Pleasant picture startle modulation displayed poor temporal stability and internal consistency. Effect sizes were small and not stable across study visits, particularly for t-scores.
- General startle reactivity displayed excellent temporal stability and internal consistency in the Resting State Task, similar to previous reports that have evaluated the psychometric properties of overall task startle (e.g., Larson, 2000).
- Quantification as raw scores generally yields superior psychometric properties than standardized t-scores across affective tasks.