The Bomb: An ERP Study Investigating Anticipatory Anxiety in Middle Childhood

Leticia Moedano, Jia Wu, Max Greger-Moser, Amanda Ng, Linda C. Mayes, Michael J. Crowley

Yale University Child Study Center, Yale School of Medicine, New Haven, CT

Abstract

We examined the role of threatening stimuli on the neural correlates of anticipatory anxiety in middle childhood with event-related potentials (ERPs) during a computer-simulated hot-potato like game, The Bomb. A high-density EEG was used to examine the event-related neural activity during events designed to induce anticipatory anxiety in children characterized with high or low trait-anxiety. The current sample consisted of participants ages 8-14. We conducted a temporal principal component analysis (PCA) to window ERP data within the medial frontal region for safe and threat conditions during the Bomb task. Data suggest the Bomb paradigm was effective in eliciting differential neural responding among trait-anxious children; the differential neural response for the threat cue suggests greater attention capture for the threat cue, with a slow wave possibly engaging emotion regulatory processes. Qualitatively the control participants did not appear to show as marked a neural differentiation for the safe and threat cue as compared to the trait anxious children

Introduction

This study contributes to the neuroscience of anxiety, specifically the effect of anticipatory anxiety on threat perception in middle childhood. Our specific aim was to investigate the impact of threat cues, on the ERP. Because these threat cues could result in an aversive event, we reasoned that ERP responses to them would reflect the early stages of threat anticipation. To this end, the research paradigm called "The Bomb" was designed to study anticipatory anxiety in children. Based on observations of children playing video games and on prior studies such as Straube et al (2009) and the Pacman-like game used by Mobbs et al. (2007), we designed a hot-potato type game called "The Bomb". In this way, we can begin to understand whether or not contextual threats are processed differently at early temporal stages. Based on previous work in which anticipation of various arousing stimuli, including aversive noise (Crowley, Wu, Bailey, & Mayes,2009; Regan & Howard, 1995) and shocks (Baas, Kenemans, Bocker, & Verbaten, 2002) modulated frontal slow wave activity, we expected frontal slow waves would be modulated by escape.

Method

Participants: The sample consisted of eleven participants ages of 8-14. The high trait-anxiety group consisted of 8 participants, while the low anxiety-trait group consisted of 3 participants (recruitment in progress) The data from one high trait-anxious participant was unusable. Participants played The Bomb while electroencephalogram (EEG). Participants were screened with the SCARED (Self-report for Child Anxiety Related Emotional Disorders) (child and parent report). All participants and parents provided assent and consent, respectively, to participate in the study, which was approved by the Human Investigation Committee of Yale University School of Medicine.

Procedure: Each participant sat 36 in. before a 19 in. LCD monitor in a dimly lit (60w bulb) sound attenuated room and wore a 128 electrode dense array EEG cap to measure ERPs. Briefly, during play of The Bomb, a ball was passed between the participant (glove at blue arrow, Figure1) and three other computer players. The game began with a white ball (safe) which then became a bomb and changed colors from yellow, to orange, and then red (indicating an imminent explosion). The object was to get rid of the bomb before it exploded. Explosions in the child's glove led to a loss of a cherry (Figure 1).

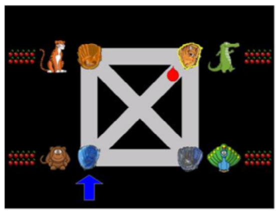


Figure 1. Screen Shot of the Bomb

Results

We used temporal principal component analysis (PCA) with a correlation matrix and varimax rotation to identify slow wave neural activity. We conducted a PCA on 129 channels of EEG data for two conditions (safe and threat). The temporal PCA yielded three components accounting for 85.54% of the variance in the ERP signal. Temporal Factor 1 (F1) accounted for 66.70%, of the variance and consisted of a slow wave apparent in time interval 313-900 ms. Temporal Factor 2 (F2) accounted for 10.07% of the variance and appeared as P2 168—296 ms time interval. Temporal Factor 3 (F3) accounted for 8.77% variance, but it had too few data-points (2 data points) and was dropped from further analysis.. We then averaged amplitude over the factor . A paired sample t test on safe and threat revealed that F1: $t(6)= -2.67$, $p= 0.037$, during 312 to 900 ms time interval window, the safe condition ($M = -5.42$ μV, $SE = 1.49$) had a more negative brainwave than the threat condition ($M= -2.51$ μV, $SE = 1.51$) with a mean difference = -2.91 μV, SE = 1.09. For the second factor, F2: $t(6) = -3.62$, $p = 0.011$, during 168-296 ms, the Safe condition ($M = -2.15$ μV, $SE = 1.12$) had a more negative brainwave than the threat condition ($M = 0.62$ μV, $SE = 0.66$) with a mean difference = -2.78 μV, SE = 0.77. All seven participants in high trait-anxiety displayed similar results. Average of control subjects are displayed for comparison.

Figure 2. Bomb task events and segmentation.

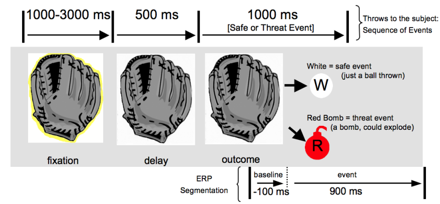


Figure 3. Channel Layout

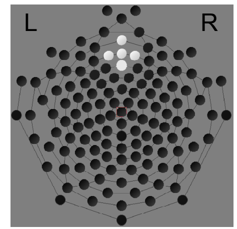
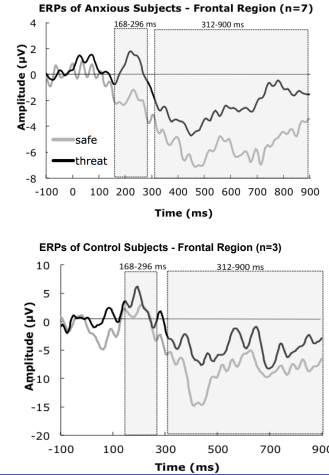


Figure 4.



Discussion and Future Directions

We aimed to investigate the neural correlates of anticipatory anxiety due to threat perception in middle childhood among children with high vs. low trait-anxiety. We observed differentiation of the threat and the safe cue among the anxious children for a slow wave and also a P2 ERP component. Slow wave patterns have been observed of distress-based ERP research studies in the past; however, frontal negative slow waves have been observed in automatic affective responses to threatening stimuli, such as frightening images and electric shocks in adults (Baas et al, 2002, Bublatzky et al., 2010). Preliminary data suggest that control children were not as responsive to the threat cue (bomb). Overall, our data suggest "The Bomb" is a promising paradigm for studying threat detection in child anxiety.

Conclusions

- Data suggest the Bomb paradigm was effective in eliciting differential neural responding among trait-anxious children for the safe and threatening cues.
- The pronounced frontal P2 component suggests the threat stimulus engaged early frontal attention.
- The differential neural response in a frontal slow wave for the threat cue suggests a more sustained impact for the threat cue, possibly engaging emotion regulatory processes.
- Qualitatively the control participants did not appear to show as marked a neural differentiation for the safe and threat cue as compared to the high trait anxious children.

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For questions, email leticia.moedano@yale.edu or michael.crowley@yale.edu

Yale Child Study Center
SINCE 1911
childstudycenter.yale.edu