Controllable Threat is Still Threat: A Virtual Reality-EEG-ECG Study

Juanzhi Lu, Selma K. Kemmerer, Beatrice de Gelder

Department of Cognitive Neuroscience, Faculty of Psychology and Neuroscience, Maastricht University, Maastricht, Limburg 6200, MD, The Netherlands

Introduction

Threat signals are often provided by the behavior of conspecifics. Many studies have investigated agent characteristics, proximity, social attributes etc., on social threat perception [1,2]. Yet, electrophysiological research on whole body signals of aggression and virtual reality studies on realistic social threat interactions are still scarce [3]. Furthermore, an important aspect of threatening social interactions is how the ability to exert some control of the threat influences the threat perception. To this end, we used the virtual reality (VR) environment, including an angry or a neutral approaching avatar and measured electroencephalography (EEG) and electrocardiogram (ECG) with BrainVision Product (63 channels covering the whole cap) to investigate 1) the brain activity underlying social threatening signals, 2) how it was influenced by the controllable ability.

Method

N = 27, age range: 18-29.

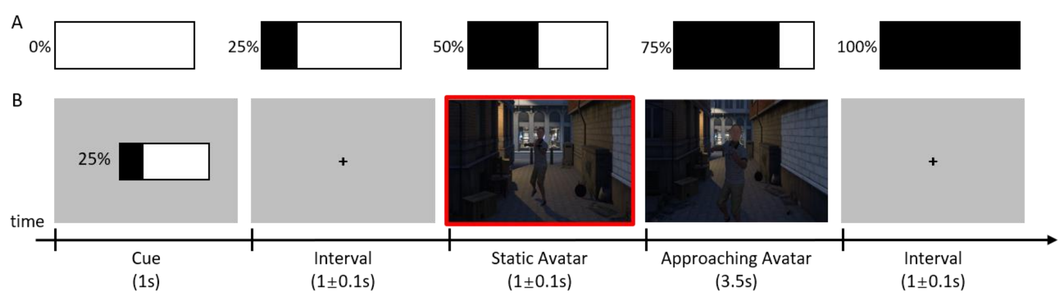

Figure 1: (A) Five kinds of controllable cue. (B) A trial procedure. All trials were preceded by a cue before the avatar's appearance. Participants were given the opportunity to stop the avatar from coming closer by pushing a button. However, each trial was preceded by a cue presented 1000±150ms before the avatar's appearance, indicating the chances of successful control over the avatar's movement (0%/25%50%/75%100%). ERP analysis focus on the static avatar.

Results

Occipital N1

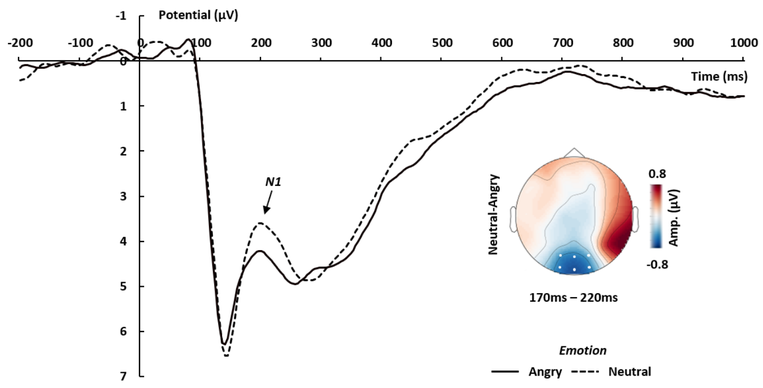

Figure 2: Grand-averaged ERPs and topographic maps per emotion condition of N1 component.

Right temporal N2

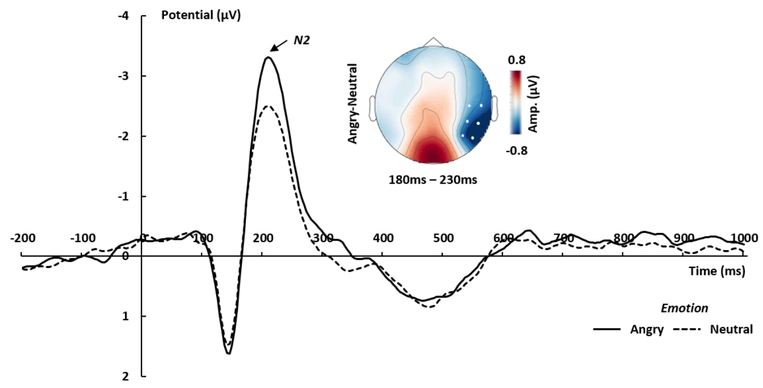

Figure 3: Grand-averaged ERPs and topographic maps between emotion conditions of N2 component

Center-parietal P2

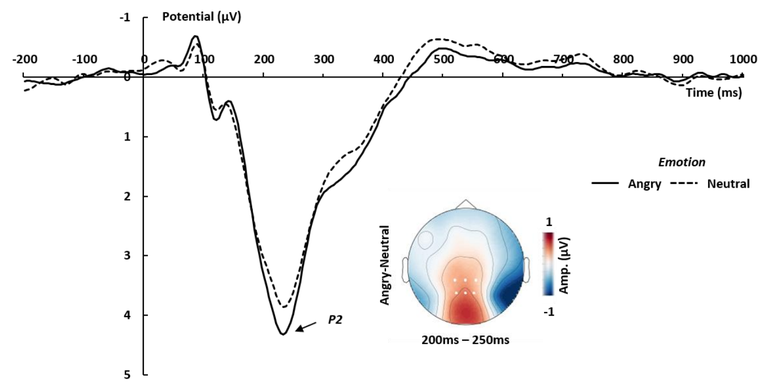

Figure 4: Grand-averaged ERPs and topographic maps between emotion conditions of P2 component.

Frontal-center N3

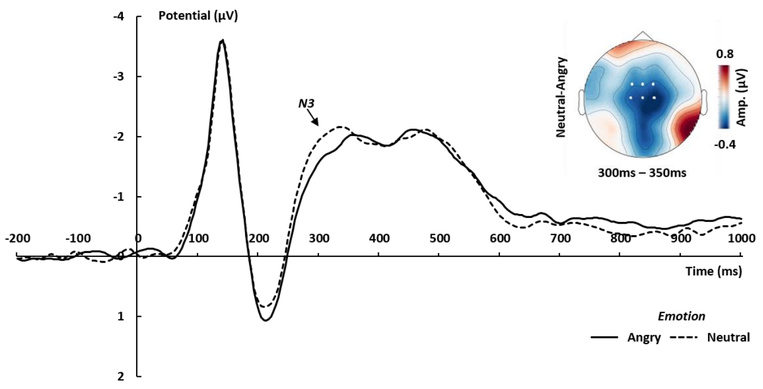

Figure 5: Grand-averaged ERPs and topographic maps between emotion conditions of N3 component.

Parietal P3

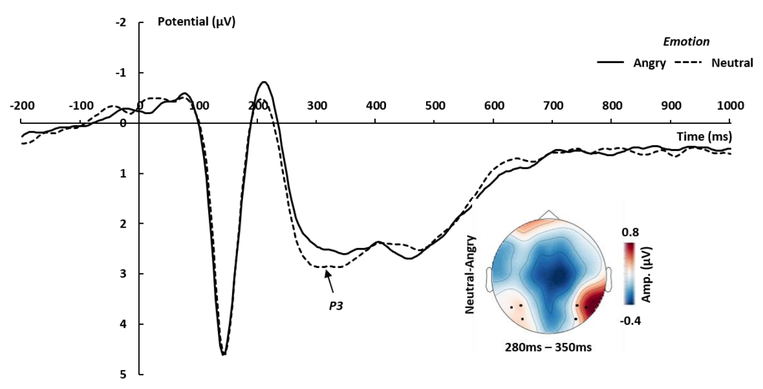

Figure 6: Grand-averaged ERPs and topographic maps between emotion conditions of P3 component.

The main effect of emotion was significant on early and middle/later components.

- N1: Angry < Neutral.
- N2: Angry > Neutral.
- P2: Angry > Neutral.
- N3: Angry < Neutral.
- P3: Angry < Neutral.

The main effect of controllable cue and interact effect were significant on later LPP components.

- Controllable cue : 75% < 100%.
- 0%: Angry > Neutral.

The main effect of emotion was significant on ECG.

- Heart rate: Angry > Neutral.

Frontal-center LPP

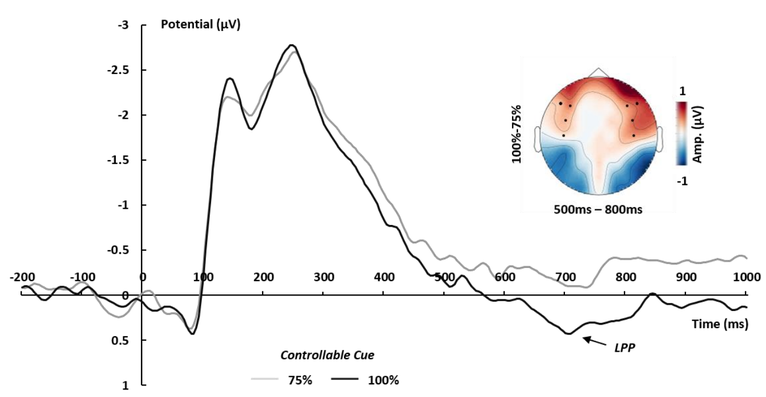

Figure 7: Grand-averaged ERPs of 75% and 100% controllable cue of LPP component.

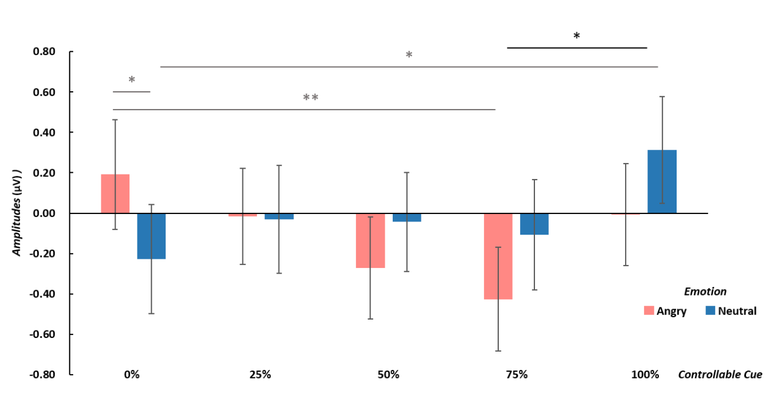

Figure 8: Means and Standard Error of LPP component per condition. * $p < 0.05$, ** $p < 0.01$

ECG

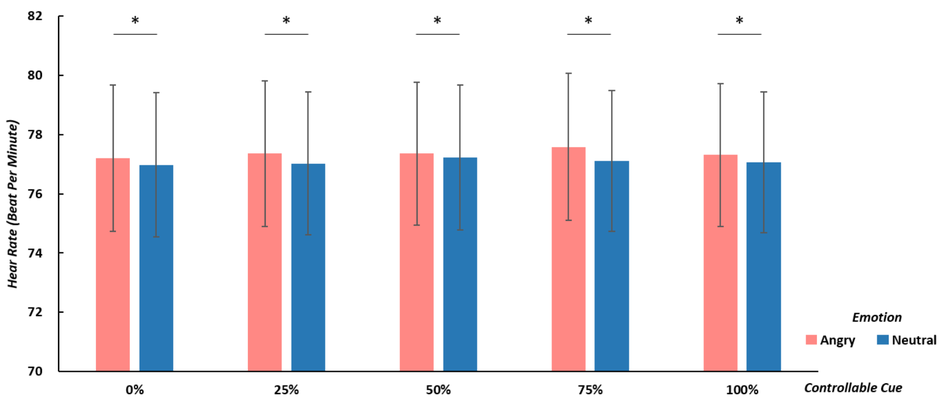

Figure 9: Means and Standard Error of heart rate per condition. * $p < 0.05$

Conclusions

Here we propose a three-stage theory for processing of social threat. 1) In the first stage, threatening body expressions are rapidly and automatically detected (bottom-up attention), which is confirmed by the effect of avatar emotion on early attention components N1, N2, and P2. 2) In the second stage, voluntary (top-down) attention is directed to the avatar to rationally and more deeply process the body expression. This is indicated by the effects of avatar emotion on the middle/later cognitive components N3 and P3. 3) In the third stage, the ability to control the threat modulates threat perception in the later evaluation stage as reflected by the LPP effects.

Acknowledgements

This work was supported by China Scholarship Council (CSC), European Research Council (ERC) Synergy Grant, and Programme MINDSPACES.

Correspondence: Juanzhi Lu (PhD student), Juanzhi.Lu@maastrichtuniversity.nl

References

[1] de Borst, A. W., & de Gelder, B. (2022). Threat Detection in Nearby Space Mobilizes Human Ventral Premotor Cortex, Intraparietal Sulcus, and Amygdala. Brain Sciences, 12(3), 391.

[2] de Borst, A. W., Sanchez-Vives, M. V., Slater, M., & de Gelder, B. (2020). First-person virtual embodiment modulates the cortical network that encodes the bodily self and its surrounding space during the experience of domestic violence. Eneuro, 7(3).

[3] Mello, M., Dupont, L., Engelen, T., Acciarino, A., de Borst, A. W., & de Gelder, B. (2022). Human freezing responses to virtual characters in immersive virtual reality are impacted by body expression, group affiliation, and threat proximity. Current Research in Behavioral Sciences, 100075.