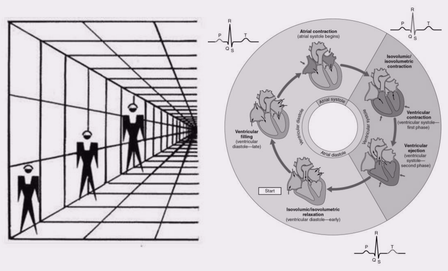
Investigating the effects of cardiac activity on perceived distance to threatening objects in VR

Paweł Motyka*[1,2], Felix Klotzsche*[3,4], Aleksander Molak[2,5], Václav Sahula[6], Barbora Darmová[6], Conor Byrnes[4], Iveta Fajnerová[6], Michael Gaebler[3,4]

[1] Polish Academy of Sciences, Institute of Psychology, Warsaw, Poland
[2] University of Warsaw, Faculty of Psychology, Warsaw, Poland
[3] Max Planck Institute for Human Cognitive and Brain Sciences, Department of Neurology, Leipzig, Germany
[4] Humboldt-Universität zu Berlin, Berlin School of Mind and Brain, Berlin, Germany
[5] Lespire.io, CausalPython.io
[6] National Institute of Mental Health, Klecany, Czech Republic
* equal contribution; contact: klotzsche@cbs.mpg.de, pmotyka@psych.pan.pl

INTRODUCTION

- Detecting threats and appropriately reacting to them supports an organism's physical integrity and survival.
- Fear-evoking objects are perceived as physically closer and approaching more quickly than neutral objects. (Cole et al., 2013; Fini et al., 2020; Tabor et al., 2015; Witt & Sugovic, 2013; Vagnoni et al., 2012)
- The processing of threat-related signals is enhanced during cardiac systole (i.e., when the heart contracts and ejects the blood into the arteries). (Azevedo et al., 2017; Garfinkel et al., 2014; cf. Leganes-Fonteneau et al., 2021)

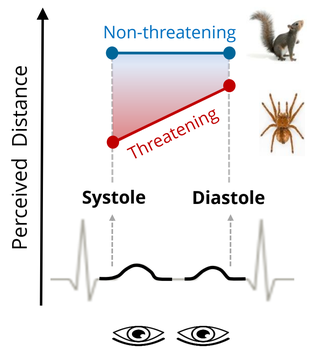


HYPOTHESES

Threatening stimuli are:

(1) perceived as closer than non-threatening ones

(2) perceived as closer during earlier vs. later phases of the cardiac cycle.



METHODS

- Participants:
n = 41 (24 ♀, *M* = 28.8 ± 4.4 years)
with normal or corrected vision and no medical conditions.

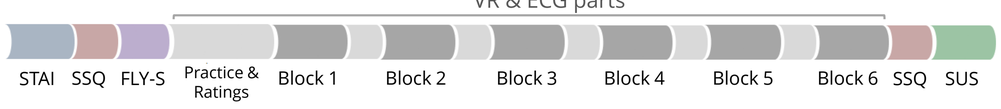
- Stimuli: threatening and non-threatening animals (2 x 4) based on the results of an online study on an independent sample (n = 91) in which participants rated images of 14 computer-generated animals (feelings of fear, disgust, expected movement speed).

- Setup & measurements:
Virtual Reality head-mounted display (HTC Vive)
Electrocardiogram (ECG; BrainProducts GmbH)
Distance estimation task (each trial)
Threat ratings and recognition task (prior to each block)
Disgust and expected movement speed ratings (once)
Visual acuity (Fly-S Stereo Acuity Test)
Questionnaires (STAI-anxiety, SSQ-c-sickness, SUS-presence).

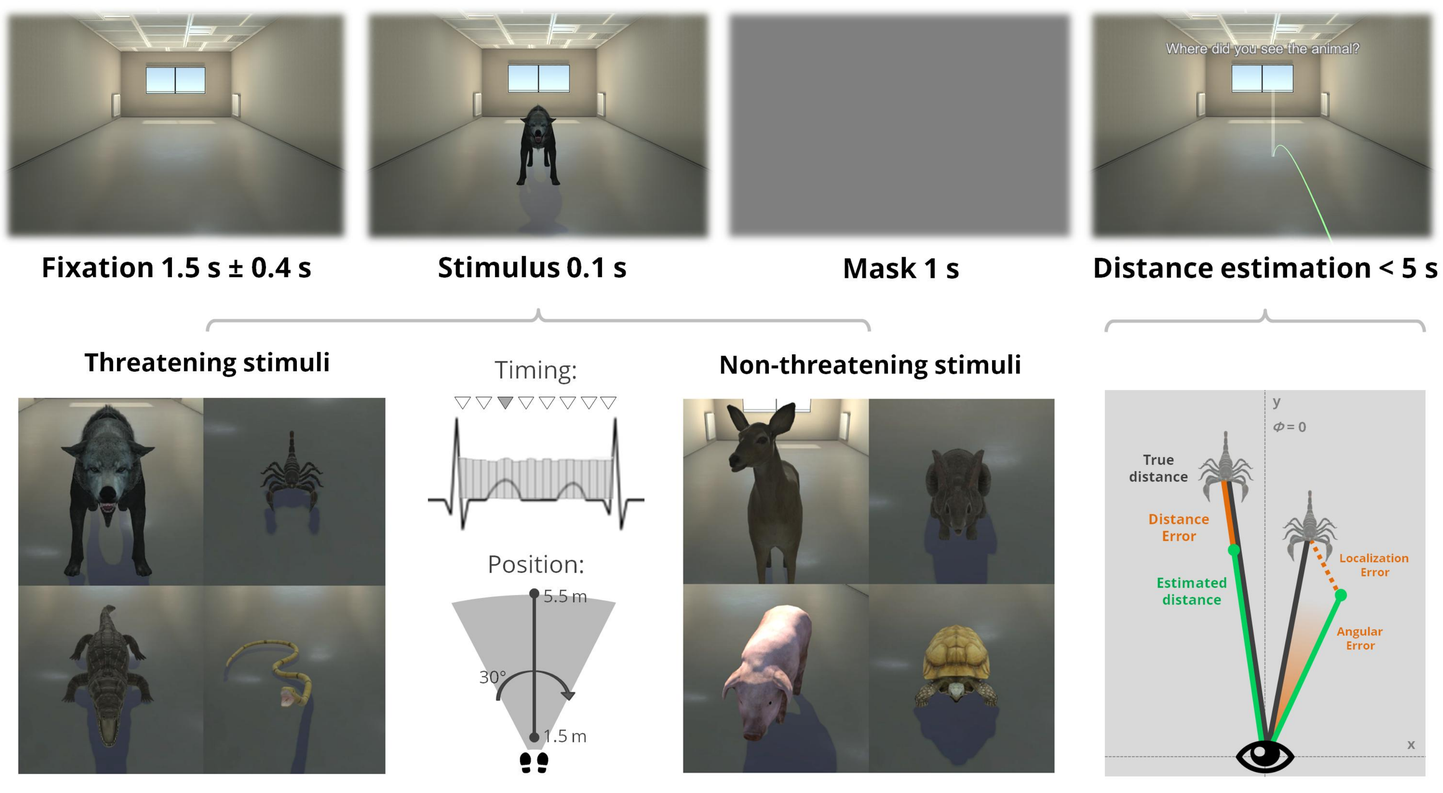
- Within-subject design (Threat/Non-threat & Cardiac phase):
720 trials divided into 6 blocks; ~29k trials in total.

Preregistration OSF

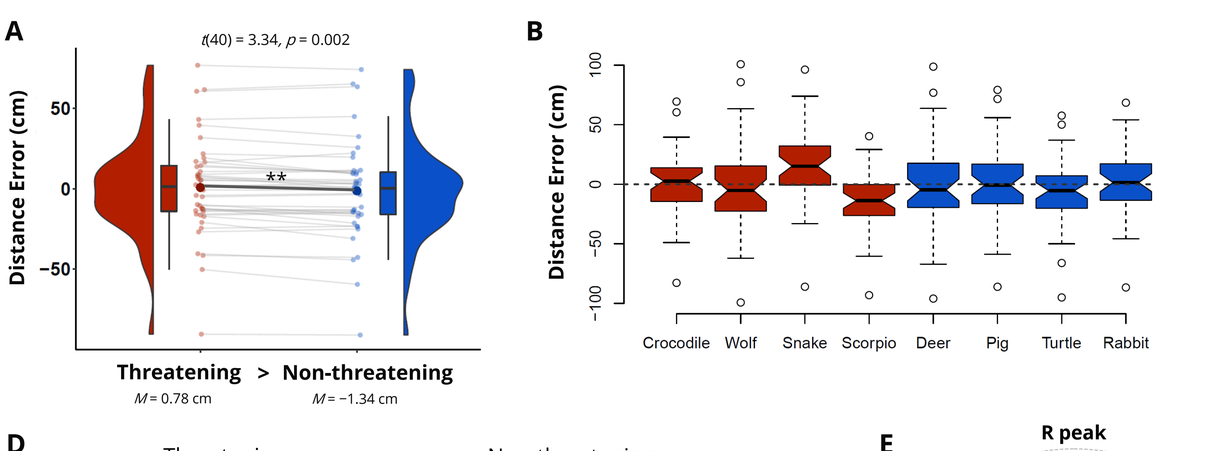
Experimental session (~2h)

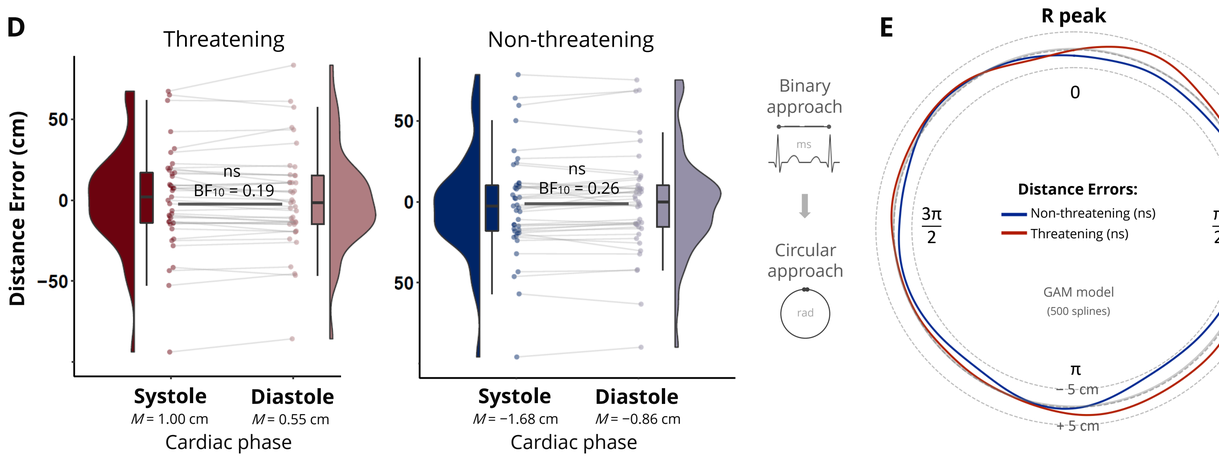


Trial structure



RESULTS





SUMMARY

- Unlike previous studies, which used less naturalistic setups and verbal or declarative distance measures, we did not find evidence for a reduction in the subjectively perceived distance to threatening objects (Fig. A, B, C).
- Perceived distances to neither threatening nor non-threatening animals differed significantly between cardiac phases (Fig. D, E, F). Our findings suggest that the cardiac phase-related variation in threat processing might not generalize across different paradigms.
- In an exploratory analysis, we found that perceived distance to all animals decreased with increasing levels of trait anxiety (Fig. G).

References

Azevedo, R. T., Garfinkel, S. N., Critchley, H. D., & Tsakiris, M. (2017). Cardiac afferent activity modulates the expression of racial stereotypes. *Nature Communications*, *8*, 13854.
Cole, S., Balcetis, E., & Dunning, D. (2013). Affective signals of threat increase perceived proximity. *Psychological Science*, *24*(1), 34–40.
Fini, C., Verbeke, P., Sieber, S., Moors, A., Brass, M., & Genschow, O. (2020). The influence of threat on perceived spatial distance to out-group members. *Psychological Research, 84(3)*, 757–764.
Garfinkel, S. N., & Critchley, H. D. (2016). Threat and the Body: How the Heart Supports Fear Processing. *Trends in Cognitive Sciences*, *20*(1), 34–46.
Garfinkel, S. N., Minati, L., Gray, M. A., Seth, A. K., Dolan, R. J., & Critchley, H. D. (2014). Fear from the Heart: Sensitivity to Fear Stimuli Depends on Individual Heartbeats. *J. Neurosci.*, *34*(19), 6573–6582.
Leganes-Fonteneau, M., Buckman, J. F., Suzuki, K., Pawlak, A., & Bates, M. E. (2021). More than meets the heart: Systolic amplification of different emotional faces is task dependent. *Cogn Emot*, *35*(2), 400–8.
Tabor, A., Catley, M. J., Gandevia, S. C., Thacker, M. A., Spence, C., & Moseley, G. L. (2015). The close proximity of threat: altered distance perception in the anticipation of pain. *Frontiers in Psychology, 6*.
Witt, J. K., & Sugovic, M. (2013). Spiders appear to move faster than non-threatening objects regardless of one's ability to block them. *Acta Psychologica*, *143*(3), 284–291.
Vagnoni, E., Lourenco, S. F., & Longo, M. R. (2012). Threat modulates perception of looming visual stimuli. *Current Biology*, *22*(19), R826–R827.

This research was supported by the CENTRAL-Kollegs framework and the Max Planck Society
PM was supported by the Polish National Science Centre (2022/44/C/HS6/00068)