Biomechanical constraints on escape from threat in virtual reality: Preliminary findings

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Introduction

Humans exhibit complex and diverse movements when encountering threats. In this study, we examined spatio-temporal parameters, trunk segment angle, and movement intensity during escape behavior in virtual reality (VR) scenarios.

Research question

What biomechanical constraints influence human escape decisions during VR threat scenarios?

Methods

We analyzed the data from our previous study by Sporrer et al. [1], where a fully-immersive VR environment was designed with a 5 x 10 m physical space in which participants could move freely. Participants (n=29) were instructed to forage for fruit on a bush and to avoid contact with various threats over 68 independent episodes. Participants were given a safe shelter to avoid the approaching threat (Fig. 1a.). Threat distances and speeds were such that at assumed escape speed, participants had at least 1.5 s time to start escaping. Participants were equipped with a VR headset (HTC Vive Pro Eye HMD), hand controllers, and three position-tracking sensors on the waist and each foot. The waist tracker was used to derive velocity and acceleration; head and waist trackers were used to estimate the trunk segment angle; and all of the trackers were used to calculate movement intensity [2] (Fig. 1b.).

Results

Participants who were caught by the threat had a lower maximum velocity within the first 1.5 seconds of the threat appearing (0.19±0.02 m/s) compared to those who escaped (0.63±0.02 m/s). Participants who were caught by the threat also leaned forward more ($p<0.001$) within the first 1.5 seconds after the threat appeared. Movement intensity was higher in all trackers during the first 1.5 seconds after the threat appeared in successfully escaped trials (Fig. 1c.). However, in the last 1.5 seconds before the end state, the participants who were caught by the threat exhibited higher velocity ($p<0.001$), acceleration ($p<0.001$), and overall movement intensity than the escaped participants, which may indicate that they were still trying to escape.

Discussion

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Our findings suggest that although participants had at least 1.5 s decision time in all scenarios, moving less quickly during this period would make later virtual death more likely. The forward trunk inclination during this period may also have imposed a biomechanical constraint that affected their ability to move, walk, or run in another direction. Overall movement intensity across all body parts may also predict if the participants will successfully escape from the threat. Further studies are required to elucidate biomechanical constraints on human escape.

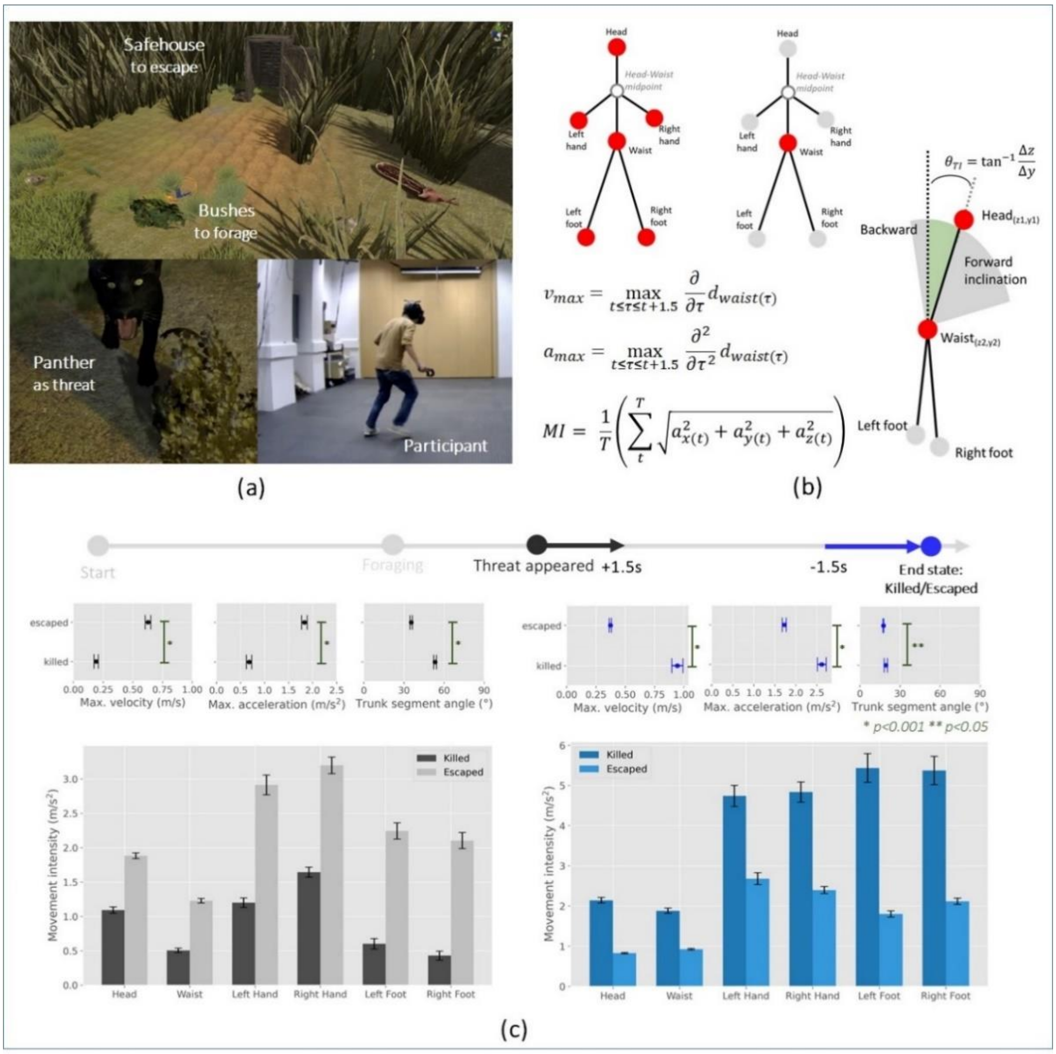

Figure 1. (a) Example scenario of the VR environment featuring bushes for foraging, a safehouse for escaping, and a panther as a predatory threat. **(b)** Location of the position-tracking sensor and the equations used to calculate relevant variables. **(c)** Results from the first 1.5 s after threat appeared (black plot), and the previous 1.5s before the end state (blue plot).

References

[1] Sporrer, J.K., Brookes, J., Hall, S., Zabbah, S., Hernandez, U.D.S. and Bach, D. Computational characteristics of human escape decisions. Psyarxiv, 2022.

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