

The influence of haptic stimulation on social threat perception in virtual reality

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Objective

Investigating the effect of haptic stimulation on the response to threatening and neutral avatars in a virtual reality (VR) environment.

Background

Perceiving and judging threat accurately are important skills for the survival of an organism. An important aspect of threat perception is the distance between the observer and the threat, and a critical issue is whether the threat invades the personal space or the peripersonal space (PPS), an area surrounding one's body where interactions between the body and the environment occur [3,8]. Virtual reality offers an opportunity to study social threat perception in relation to the PPS while being safe for the participant [10].

Various factors influence the PPS including the facial [1,9] and body expressions [2,3,7], and level of control over the interaction [6]. In this study we used haptic stimulation as a proxy for social presence [4] and we tested the hypothesis that it would influence the experience of threat and its closeness.

Methods

Participants

40 healthy participants with normal or corrected to normal vision were tested and data of 31 participants (5 males, 25 females, and 1 non-binary/third-gender person; age range = 18-28 years, mean age = 21.9 years) were included. 9 participants were excluded from the analysis due to responding on fewer than 12% of the trials.

Experimental Procedure

Participants were fitted with a haptic belt sitting comfortably around their waist before they entered the VR environment (Figure 2).

The VR scenario shown with a head-mounted display (HMD) presented a dark alley (see Figure 1) and participants were approached by a human avatar with either an angry or a neutral expression, as in Lu et al. [6]. They were instructed to press the space bar as soon as the approaching avatar made them feel uncomfortable.

The experiment had a 2 x 2 x 3 within subject design with two emotional conditions (angry or neutral avatar), 2 haptic stimulus conditions (stimulation or no stimulation), and within the stimulation condition, three intensity conditions (three different speeds at which the belt tightened: 50 rotations per minute (rpm), 70 rpm, and 90 rpm).

There were 6 blocks with one wrapping speed for each block, randomized for each subject (2 blocks with 50 rpm, 2 blocks 70 rpm, 2 blocks 90 rpm) and 40 trials per block equaling 240 trials overall. During the experiment the space bar press stopped the avatar on 50% of the trials.

Haptic belt

Based on the device presented by Hecquard et al. [5], we controlled the speed and depth of a rotating motor to wrap an elastic band around the user's torso. The motor wrapped at 3 speeds of 50, 70, 90 rpm.

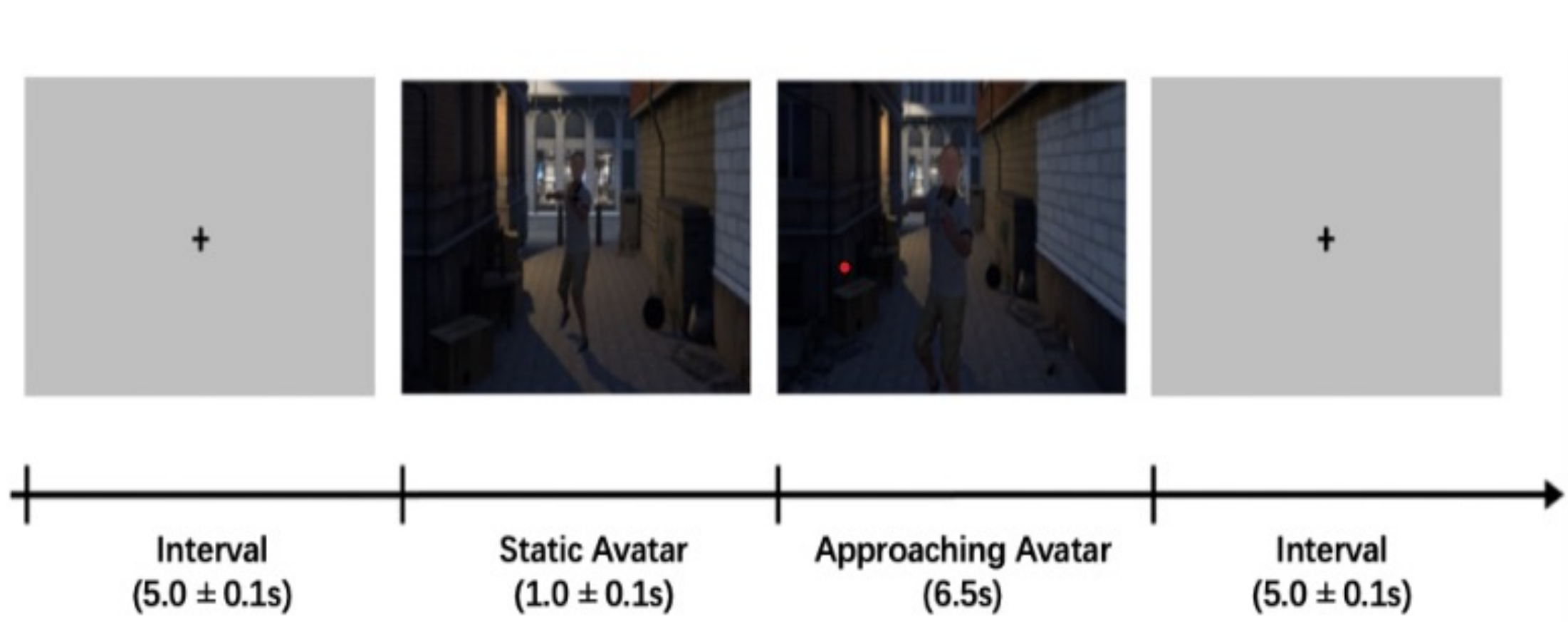


Figure 1. Timeline of the approaching avatar in VR



Figure 2. Haptic stimulation belt

Results

Our results showed that participants felt uncomfortable sooner when the avatar was threatening (average RT = 5.99 s, CI = [5.65, 6.34]) than when it was neutral (average RT = 6.24 s, CI = [5.90, 6.59], $p < .001$). Additionally, the haptic stimulation also led to a faster reaction time (average RT = 6.02 s, CI = [5.68, 6.37]) than no haptic stimulation (average RT = 6.21 s, CI = [5.86, 6.56], $p < .001$). Only the higher belt speeds (70, 90 rpm) led to a significant effect (see Figure 3a). Additionally, a significant interaction showed that the belt had a greater effect on responses, when the avatar was neutral than when it was threatening (see Figure 3b).

The results indicate that the angry avatar led to a faster response compared to the neutral avatar, suggesting an enlargement of the PPS for the threatening avatar. Additionally, we showed that the haptic stimulation also decreased the RT but more so for the neutral compared to the angry avatar condition.

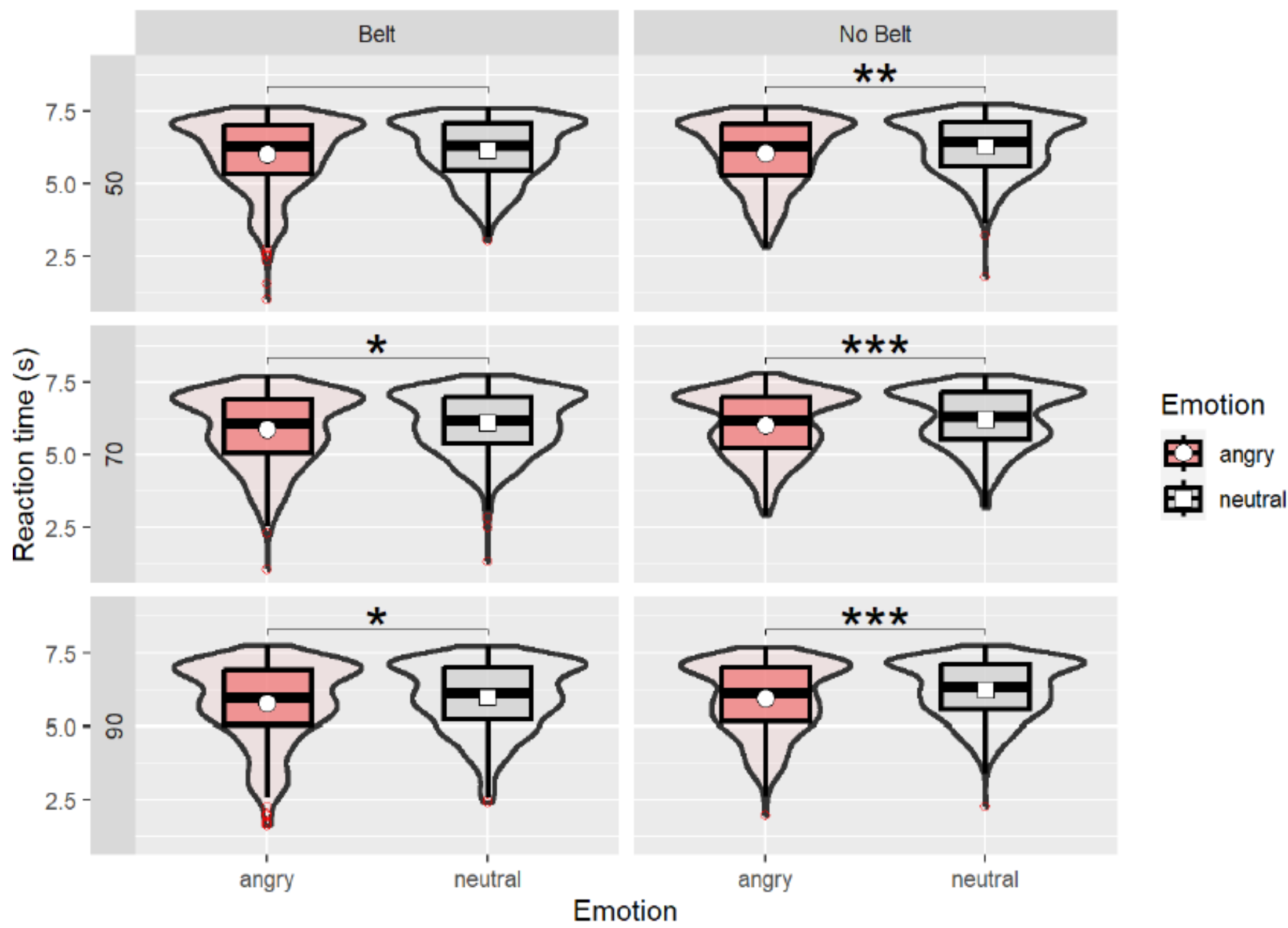


Figure 3a. The influence of the haptic stimulation on reaction time

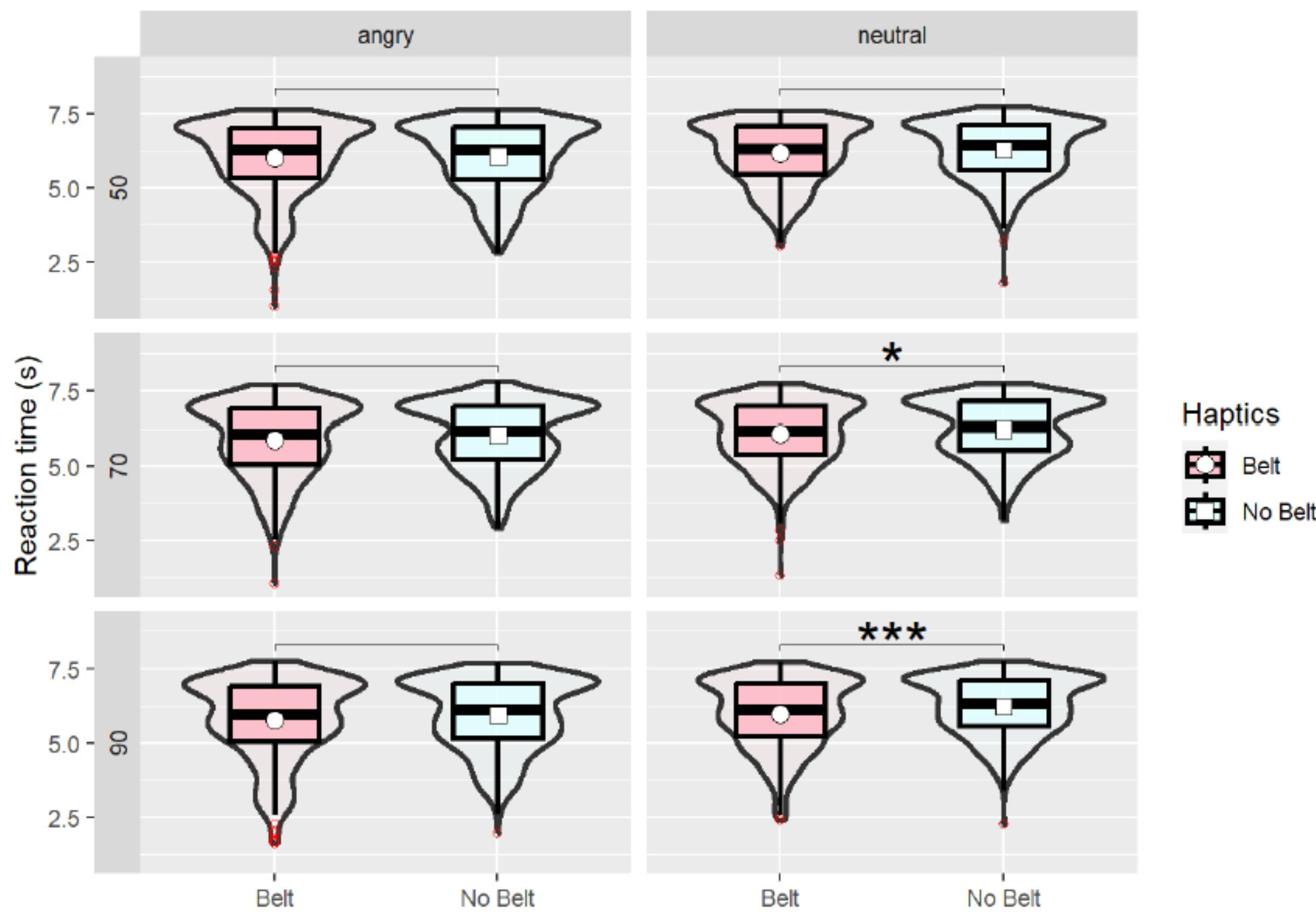


Figure 3b. The influence of the avatar's emotion related to reaction time

Conclusion

Our results show that haptic stimulation plays an important role in threat perception and decreases the reaction time significantly compared to no haptic stimulation. We also show a significant interaction between haptic stimulation and avatar emotion, as the effect of the belt was greater when the approaching avatar was neutral. The decrease in RT indicates a preference for a larger distance between the participant and the avatar especially when the angry avatar is displayed or when there is haptic stimulation provided. This indicates that the haptic stimulation and the angry avatar increased the size of the peripersonal space.

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