Cyberball3D+ for fMRI: Implementing Neuroscientific Gaming

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This research presents an innovative real-time, interactive gaming system called Cyberball3D+ incorporating virtual characters, to be played interactively in Functional Magnetic Resonance Imaging (fMRI) for the study of empathy, social exclusion and ostracism. For the first time, neuroscientific correlates of believability and emotional engagement with synthetic characters are acquired. Such output is non-obtrusive derived at the same time as the experience occurs. 3D characters are used in films and games but it is still undetermined how design, stylization and behavioral factors interweave to make a character believable. When using synthetic characters in neuroscientific experiments, the aim is that people emotionally respond to them in a similar manner to humans. Although research has shown that users show empathy for 3D characters, it is challenging to identify at which level of anthropomorphism such emotional experiences occur. Anthropomorphism refers to the attribution of a human form and behavior to non-human entities such as robots, animals, etc. However, uncanny valley effects – ie negative dips in user impressions – can arise: behavioural fidelity expectations increase alongside increases in visual fidelity and vice versa. Previous research into evaluating whether virtual characters fulfill their role acquired ratings of pleasantness through subjective self-report (McDonnell et al. 2012). The aim of this work was threefold: To create a *3D interactive* gaming paradigm based on the original Cyberball for the secluded space of an fMRI scanner; To study whether the emotional response of inclusion and exclusion of self and other will be modulated by the level of anthropomorphism of the players, establishing neuroscientific believability metrics; to investigate whether exclusion of others will activate similar networks (social pain matrix) to watching exclusion of self, therefore, eliciting empathy and social pain.

fMRI experiments usually employ photos because of the scanner's secluded space and infrastructure. The use of synthetic scenes in cognitive neuroscience may undergo growth because such experiences may not be limited by ethical constraints. The presented framework puts forward a sophisticated interactive real-time gaming system for the fMRI allowing for user interactivity via button boxes controlled by users while lying in an fMRI scanner. The Cyberball3D+ game is a virtual ball-toss game in which the participant is either excluded or not from ball tossing played by three virtual players and the participant (Meyer et al. 2013). The participant may alter playing behavior based on who is excluded by, for instance, demonstrating empathy towards the excluded players throwing more balls to them. In simple sketch mode, it has been shown to reliably evoke the experience of social exclusion and produce feelings of distress during exclusion.

We implemented Cyberball3D+ in the Unreal Development Kit.

One user in the fMRI scanner plays with three players modeled in one of three levels of anthropomorphism (low, medium and high, Figure 1) while undergoing an fMRI scan. The neural basis of empathy for social exclusion as an effect of level of anthropomorphism is examined. 10 healthy adult volunteers (8 female, 2 male) underwent fMRI at Brighton and Sussex Medical School. In a block design they participated in 14 rounds of the Cyberball3D+ task (combinations of low and high anthropomorphism, inclusion of all avatars, exclusion of self and exclusion of other, simulating social exclusion or empathy for social exclusion). Each round was 75 seconds long. 2 buttons from a 4-button interface were used to throw the ball left or right. User interactions were synchronized to the fMRI scanner by using trigger information. A frequency modulated audio signal was generated at prescribed times within the experimental phase. The audio signal was fed into a biometric recorder, which also recorded heart beat, scanning synchronization etc. A log was generated marking the exact time the sync pulses were sent to the biometric recorder as well as logs for user interactions. The neuroscientists used a dedicated user interface to select the level of anthropomorphism of all avatars, the gender of each avatar and the fairness of the game. Participating in a high anthropomorphism environment rather than a low anthropomorphism environment activated both frontal cortex and superior temporal gyrus. This suggests that compared to more human like avatars, playing the non-anthropomorphic avatars is less subjectively rewarding and potentially anxiogenic. When studying complex emotional responses, a high level of anthropomorphism of synthetic characters engages neuroscientific patterns of brain activation as in real-world circumstances. Interactive gaming while in fMRI is a promising research tool studying human emotional response.

Figure 1. *Cyberball game with three levels of anthropomorphism*

McDonnell, R., Breidt, M., and Bülthoff, H. H. 2012. Render me real?: investigating the effect of render style on the perception of animated virtual humans. *ACM Transactions on Graphics (TOG) 31*, 4, 91.

Meyer, M. L., Masten, C. L., Ma, Y., Wang, C., Shi, Z., Eisenberger, N. I., and Han, S. 2013. Empathy for the social suffering of friends and strangers recruits distinct patterns of brain activation. *Social cognitive and affective neuroscience 8*, 4, 446-454.

SIGGRAPH 2014, August 10 – 14, 2014, Vancouver, British Columbia, Canada.

ACM 978-1-4503-2958-3/14/08