

Time Perception Manipulation in Virtual Reality: Prospects and Implications of Combining Causality Violations with Body Ownership Illusions

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ABSTRACT

Premise: Using perceptual time delay adaptation (ca. 250 msec) in flight simulators we've induced illusory causality violations: the pilot perceives that the aircraft maneuvers before he moves the controls (Cunningham *et al.*, *Psychological Science*, 2001). Recently, body ownership illusions – which are marked by a strong negative reaction to the avatar's harm – have been studied using avatars in virtual reality environments. We predict that combining these two illusions will create illusory premonitions of death. The study of such causality illusions should illuminate poorly understood aspects of time perception. **Methods:** Using an Oculus Rift system, we had an operator control an avatar as he ran a maze. The avatar is pursued by a drone, which fires on the avatar. The avatar being shot is experienced by the operator as an irritating punch in the back, delivered by a tactile vest with pistons on the operator's front and back. The idea is to gradually introduce a time delay between the operator's movements and the avatar's movements. When the delay reaches 250 msec and the operator is sufficiently adapted that the avatar maneuvers well, the time delay will be removed and after one more maneuver, the avatar will be abruptly killed, and the operator will experience the harm to the avatar by a combination of front-to-back tactile vest activation and appropriate sound effects. We hypothesize that the time delay aftereffect (causality violation) coupled with the body ownership effect during the avatar's death will lead the operator to feel that he knew the avatar was about to die. **Preliminary Results:** Establishment of a body ownership illusion is initially very strong and was experienced in two ways: (1) The virtual smoke emitted by the drone made the operator nauseous, to the point that we had to redesign the experiment so that the drone produced less smoke! (2) While eluding the drone in the maze, the operator accidentally ran the avatar off a cliff; the operator could feel his own body falling as the avatar disappeared. However, as the ramped-up time delay becomes large, the body ownership illusions disappear – an interference effect. We are currently redesigning the experiment to create a stronger body ownership illusion that may survive large time delays. The next iteration of the experiment will have the operator running on an omni-directional treadmill and will employ body posture sensing to more tightly couple the operator and avatar. **Discussion:** Premonitions – including premonitions of death – are poorly understood cognitive phenomena that are difficult to study. Being able to induce premonitions at will under laboratory conditions should make the scientific study of premonitions feasible. **Acknowledgements:** This research was funded in part by the Templeton Foundation's New Agendas for the Study of Time program and was initiated with the help of the late Lynn Olzak.

BIO

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Vincent Billock earned B.S. and M.S. degrees in physics at Miami University, and a Ph.D. in sensory biophysics at Ohio State. He did postdoctoral work in clinical color and spatial vision. He followed

this with research in sensory neuroscience and psychophysics at the U.S. Army Aeromedical Research Laboratory. He gradually came to realize that there were many problems in perception that can't be tackled using standard methods, so he used a two year National Research Service Award to study complexity theory. The complexity theory approach transformed everything he did subsequently. As a result, he spent many years with General Dynamics and Northrup Grumman at the US Air Force Research Laboratory studying the failure modes of human vision and modeling neural information processing. In 2013 he moved his research to the Ohio State University College of Optometry, where he is an Associate Professor, but he maintains a Faculty Fellowship at AFRL. He has been elected a Fellow of the American Academy of Optometry and the Ohio Academy of Science and was designated as a Diplomate in Binocular Vision and Perception by the American Academy of Optometry. His research has been published in Science, PNAS, TINS, Scientific American, Psychological Bulletin and many other venues. He has about 120 research publications and is writing a book for Springer called "Chaos Reigns When Vision Fails". His recent work in color vision, theoretical neuroscience and virtual reality has been supported by the NSF, the US Air Force, and the Templeton Foundation.