Incomplete compensation for self-motion in the visual perception of object velocity during a visual-vestibular conflict

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When observing a moving target while an observer is moving, the same retinal speeds can correspond to vastly different physical velocities. When an observer moves in the same direction as the target, the retinal speed of the object is partially cancelled out, and vice-versa. Observers must thus obtain an accurate estimate of their own velocity, and subtract it from or add it to the retinal speed elicited by the target to obtain an accurate estimate of the object velocity. Estimates of an observer's speed should be facilitated when visual and vestibular cues are congruent and can be integrated without multisensory conflict (Harris, Jenkin, & Zikovitz, 2000). When self-motion is experienced only visually while undergoing no physical motion, compensation is likely to be incomplete, leading to biases in judgments of object speed (Hypothesis 1). Furthermore, it has been argued that self-motion information is noisier than retinal information concerning object motion (Dokka, MacNeilage, DeAngelis, & Angelaki, 2015), especially when observers have only visual information about their own movement at their disposal (Fetsch, Deangelis, & Angelaki, 2010). Subtracting noisy self-motion information from retinal motion in order to obtain an estimate of target velocity should thus decrease precision (Hypothesis 2). To test these hypotheses, we presented two motion intervals in a 3D virtual environment and asked participants which motion was faster; one in which a target moved linearly to the left or to the right in the fronto-parallel plane, and one that consisted of a cloud of smaller targets travelling in the same direction. The single target moved at one of two constant speeds (6.6 or 8m/s, 6m from the observer), while the speed of the cloud was determined by a PEST staircase. While observing the single moving target, participants were moved visually either in the same direction, in the opposite direction, or remained static. In support of Hypothesis 1, we found differences in accuracy between static, congruent and incongruent motion; target motion during congruent self-motion was judged as slower than in the static condition and faster in the incongruent condition, indicating inadequate compensation for the observer's motion. Self-motion during target motion observation decreased precision compared to the static condition in support of Hypothesis 2. Further research is necessary to determine how the availability of vestibular cues can remedy accuracy or precision losses during self-motion.

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