The freezing rotation illusion

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I use the term “freezing motion illusion” to designate a strong decrease in the perceived velocity of a moving object. Accordingly, the term “freezing rotation illusion” denotes a strong decrease in the perceived angular velocity of a rotating object. In 1977, Pavard and Berthoz were the first to report freezing motion illusions: Subjects sitting on a sled observed a strong decrease in the perceived velocity of a moving scene, when the sled was accelerated (Pavard and Berthoz, 1977). Mesland and Wertheim found that a similar freezing motion illusion emerged when the subjects stayed stationary and the display with a continuously shifting sinusoidal grating was swayed before the observer (Mesland and Wertheim, 1996). In our laboratory, my colleague Stefan Hegemann noticed a freezing motion illusion while wearing virtual reality goggles displaying a rotating scene and turning his head back and forth. I observed a strong freezing motion illusion while swaying a laptop with a shifting scene in front of me (figure 1). I experienced an even more striking freezing rotation illusion when I turned a laptop with a rotating scene back and forth around its roll axis (figure 2). Perceiving a decreased motion without moving the head indicated rather a visuo-visual than a vestibulo-visual interaction between a foreground object and its surround.

Figure 1

Figure 2

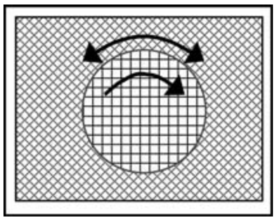

Figure 3

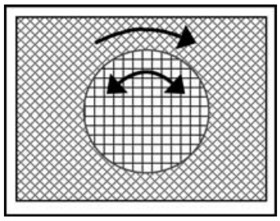

Figure 4

To test the hypothesis of a pure visuo-visual interaction further (Dürsteler, 2005a) I used an experimental design described by Karl Duncker in his thesis on induced motion (Duncker, 1929). He was using a small and a large disk made out of cardboard mounted on the same axis. The small and the large disk could be rotated independently from each other. I used virtual cardboards on a computer display (Figure 3). The surround was rotating back and forth around the gaze axis of the observer whereas the inner disk (the foreground object) was continuously rotating in one direction. When the rotational speed of the foreground object was lower than the maximal speed of the surround, the continuously turning inner disk was perceived to slow down or even to stop when the surround was rotating in the same direction and to turn normally when the surround was rotating in the opposite direction. The freezing motion illusion appeared stronger when the foreground object and the surround were interleaved. When the foreground was turning sinusoidally clockwise and counter-clockwise and the surround was rotating continuously in one direction (figure 4), the perception of the surround rotation was not influenced by the foreground motion (Dürsteler, 2005b).

The accompanying movie demonstrates the following conclusions:

1. If the foreground object and its surround are turning in the same direction and if their rotational velocities differ by more than one JND (just noticeable difference) from each other, the perceived velocity of the foreground object is much lower than its physical velocity. This is true for foreground objects rotating either slower or faster than their surround. The same mechanism may be operative as in Duncker’s induced motion illusion.
2. If the surround and the foreground object are turning in opposite directions, the perceived velocity of the foreground object is the same or slightly higher than its physical velocity.
3. If the retinal rotational velocity of the surround and the foreground object differ by less than one JND, the perceived velocity of the foreground object is that of the surround, i.e. the perceived relative rotational velocity between foreground and background is zero (Wertheim et al., 2005). This is reminiscent of the phenomenon of motion capture (Murakami and Shimojo, 1993).
4. The freezing rotation illusion reveals an asymmetric mechanism: the surround rotation influences the foreground object rotation, but not vice versa.
5. At the more peripheral field, JNDs for motion differences increase. In a display with several identical scenes with continuously rotating foreground objects on surrounds turning back and fore, we may see freezing rotation in the scene at the center of gaze together with motion capture phenomena in the more peripheral scenes.

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