**Supplement 1:** Eye data analysis

SMI-ETG is a binocular eye-tracker with automatic parallax compensation providing a sampling rate of 60 Hz, an accuracy of 0.5 deg, and a gaze tracking range of 80 deg horizontal x 60 deg vertical. Eye-tracking data is acquired by 2 cameras computing the reflection of infrared light in the cornea. The SMI-ETG also records an egocentric view of the environment with an infrared camera at a resolution of 1280 x 960 pixels, with an environment tracking range of 60 deg horizontal x 46 deg vertical at 24 Hz. Both eye and environment videos were acquired with the associated software iView ETG. Eye data (binocular point of regard and blink) were extracted from the eye video with BeGaze ETG then low-pass filtered by a second order Butterworth filter (cut-off frequency: 20 Hz). Gaze data was recorded in synchrony with the visual stimulus presentation using the scene camera. The visual stimuli of the CRT screen were automatically extracted from the scene camera video using computer vision (OpenCV Library version 3.0). If the target was detected, the position of its center relative to the video frame was computed over time and saved for further analysis.

Eye velocity was computed over a 1s period including the haptic stimulus period (i.e., 400 ms) avoiding blink period if any. The average eye pursuit velocity was for Exp1 = 2.78±0.02 cm/s; Exp2: *Rough* = 2.68±0.02 cm/s, *Smooth*: 2.75±0.02 cm/s; Exp3: *Black* = 2.24±0.04 cm/s, *One edge* = 2.00±0.05 cm/s, *Low frequency* = 1.91±0.05 cm/s, *High frequency* = 1.89±0.05 cm/s). Trials with saccade during that 1 s period were removed with a 30 deg/s amplitude criterion on 50 ms span and a visual check (Exp. 1: 3%; Exp. 2: 11%; Exp. 3: 16%). Subjects with more than 50% of saccades were not included in the analyses (1 subject in Exp.3). Trials where the estimate of the eye velocity was not possible due to signal noise (Exp.1: 4%; Exp.2: 1%; Exp.3: 4%) were kept in response analyses after we showed that it did not influence the results. Statistical effects were the same without eye noisy trials for all the conducted analyses. Trials were not discarded based on the speed of eye pursuit. Indeed, while the direction of eye pursuit induced a bias in the perception of visual background velocity (i.e., Filehne illusion), no evidence was found of a bias modulation with eye speed (Freeman et al. 1998; 2.5 deg/s to 20 deg/s). This relationship neither appeared here: correlations between bias (PSE difference between *Right* and *Left*) and computed eye velocity did not reach significance (Exp.1: R²=.24, p=.08; Exp.2: R²=.01, p=.82) with no visual background. In addition in Exp3, the effective eye pursuit velocity differed due to the structure of the background (i.e., eye pursuit with the Black background was faster than the other backgrounds) but no evidence was found that this difference was linked to the perceptive bias (i.e., non-significant correlation between bias vs. eye velocity: R²=.04, p=.22).