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Visual sensitivity to acceleration: Effects of motion orientation, velocity, and size

Dorita H. F. Chang[1] & Nikolaus F. Troje[1,2]

[1]Centre for Neuroscience Studies and [2]Department of Psychology, Queen's University, Canada

5dc16@queensu.ca

Queen's UNIVERSITY

INTRODUCTION

- Traditional studies of acceleration perception have characterized acceleration in terms of:
  - ratio of final to initial velocity (V_f/V_i)[1]
  - proportion of change in velocity relative to the average velocity (V_f-V_i)/V_{ave}[2,3]
- It is unclear as to how acceleration sensitivity is affected by stimulus properties such as motion orientation, base velocity, and size.
- The perception of local animate motions is dependent on accelerations contained in the motions[4].
  - variations in acceleration sensitivity according to base velocity and size may predict size-dependent differences for the perception of local animate motions

Here, we measured visual sensitivity to acceleration by parameterizing acceleration as it is defined: the change in velocity per unit time.

METHOD

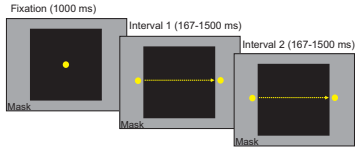
Participants

- 18 naive observers with normal/corrected vision (18 - 25 years).

Stimuli and Apparatus

- Each trial consisted of two consecutive displays, each comprised of a stimulus of a single dot that traveled along a straight path.
- Design factors:
  - sign of acceleration (positive or negative)
  - orientation (vertical or horizontal)
  - direction (up or down; left or right)
  - path size (1.6 deg or 4.8 deg)
  - base velocity (3.2 deg/s or 9.6 deg/s)
- Resultant stimulus durations ranged from 167-1500 ms.
- Observers discriminated an accelerated stimulus from a constant velocity stimulus equated for base velocity and size.
- Acceleration adjusted according to QUEST to obtain thresholds at 82% - correct level.
- Stimuli were displayed with a Tektronix Inc. oscilloscope.
- One of two cardboard masks were superimposed on the screen such that the dot's trajectory began and ended just outside of the aperture[3] (Figure 1).

Figure 1



RESULTS

- Acceleration thresholds did not differ per direction of motion for both vertical and horizontal motion (p > 0.06 for both) and did not differ per sign of acceleration (p = 0.89).
- Thresholds were generally worse for the faster base velocity of 9.6 deg/s than the slower base velocity of 3.2 deg/s (main effect of base velocity, p < 0.001), were generally worse for the smaller size of 1.6 deg than for the larger size of 4.8 deg (main effect of size, p < 0.001), and were generally worse for the vertical as compared to the horizontal orientation (main effect of orientation, p < 0.001) (Figure 2).

Figure 2

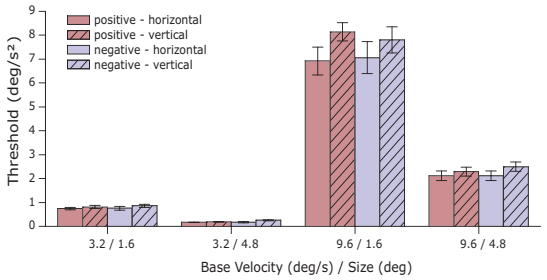
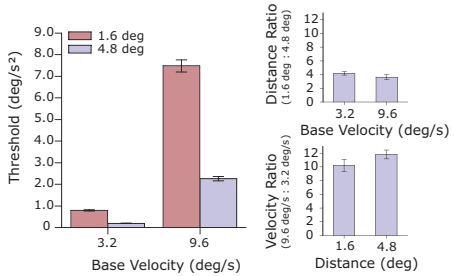
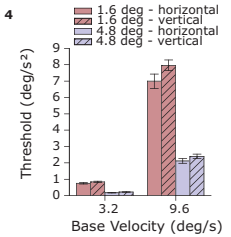


Figure 3



- Absolute thresholds for the base velocities depended on size (base velocity x size interaction, p <0.001). Critically however, the ratio of thresholds of the two sizes did not differ between the two base velocities, and the ratio of thresholds of the two base velocities did not differ between the two sizes (p > 0.20 for both comparisons) (Figure 3).
- Thresholds were worse for the vertical orientation as compared to the horizontal orientation only at the faster base velocity and smaller size (orientation x base velocity x size interaction, p = 0.034). (Figure 4).

Figure 4



DISCUSSION

- Acceleration sensitivity varies with stimulus velocity and size in a manner analogous to Weber's law.
  - this predicts that the perception of local biological motions is not size-dependent[4]
- As absolute thresholds depend on base velocity, the current results cannot reject models of acceleration perception based on comparisons of final and initial velocities (c.f., Ref. 3).
- The lack of a directional anisotropy in acceleration sensitivity in particular along the vertical axis mirrors previous findings[3] and is surprising given the gravity-based environment in which humans must operate.
  - human observers employ gravitational assumptions for the interpretation of visual events[5,6]
  - the recognition of inanimate and animate (point-light) visual events has been associated with the identification of characteristic changes in the velocity profile of motion and is subject to an inversion effect[4,7]
  - the present results suggest that orientation anisotropies for the perception of visual events cannot be reduced to direction-dependent differences in acceleration processing

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