A COORDINATE SYSTEM FOR VISUAL PERCEPTION OF MOTION DIRECTION

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INTRODUCTION

Programming reaches to visual targets is thought to involve transformation of information between visual and kinesthetic coordinate systems to specify an upper limb orientation for target acquisition (e.g., Flanders et al. 1992). For static visual perceptions, human subjects apparently use earth-fixed vertical and trunk-fixed a/p axis to specify orientations (Darling et al. 1996, 1997). Programming reaches to moving objects must involve specification of the direction of motion. Whether the coordinate system perceiving direction of motion is the same or different to that for static visual perceptions is the focus of this study.

PROCEDURES

Six young adults with no history of neuromuscular disorders participated. The subject sat in a dark room in front of a dim visual display with a white dot moving along an oblique axis presented on a black background. In one experiment, the subject aligned the axis of dot motion parallel to earth-fixed vertical (i.e., dot moving straight up/down), to head and trunk longitudinal axes and to an oblique white line presented on the display (vertical plane). Arrow keys were used to control axis of dot motion and another key was pressed when the perceived motion was aligned to the desired axis. In another experiment, the subject aligned the axis of dot motion parallel to head and trunk a/p axes and to an oblique white line presented on the display (horizontal plane). Orientation of the line and of the head and trunk were varied on different trials. Subjects performed 5 trials with the head and trunk in comfortable erect (standard) positions and 20 trials in each condition with head, trunk and line orientation varied in each experimental condition. Orientation (3D) of the head and trunk were measured with an electromagnetic system (Minibird – Ascension technologies). Axis of dot motion was computed from the specified pixels of the endpoints of dot motion. Errors for single trials were computed as the angular difference between axis of dot motion and the desired axis for that condition. Constant (mean of single trial errors), absolute constant (magnitude of constant error) and variable (s.d. of single trial errors) errors for each axis were computed for each subject and were submitted to two-way (axis, orientation) repeated measures ANOVAs for each experiment. Regression analyses were used to determine whether single trial errors were biased towards alternative axes in each subject.

RESULTS & DISCUSSION

Accuracy of aligning the axis of the moving dot to vertical was clearly better than to internal axes or to an external line. Single trial errors for aligning the dot motion to head and trunk axes often exceeded 0.2 rad while such errors rarely exceeded 0.1 rad when aligning to vertical. Absolute constant and variable errors were significantly lower when aligning the moving dot to earth-fixed vertical than to any of the other axes (Fig. 1A; $p < 0.05$ for post-hoc comparisons). Regression analyses showed that the single trial errors were not biased toward alternative axes (head or trunk) when aligning the moving dot to earth-fixed vertical ($p > 0.05$). These results strongly suggest that earth-fixed vertical provides one axis for visual perceptions of motion.

Accuracy of aligning the axis of the moving dot to horizontal head and trunk a/p axes provided less clear results. When head orientation was varied, subjects aligned the moving dot to the trunk-fixed a/p axis most accurately ($p < 0.05$). However, when trunk orientation was varied, errors were high when aligning the dot's motion to both head and trunk a/p axes (Fig. 1B). Aligning the dot's motion to the external line was quite accurate when both head and trunk orientations were varied (in a single condition). These data suggest that moving objects are perceived most accurately relative to external axes rather than body-fixed axes, if such axes are available. Otherwise, perceptions are accurate relative to the trunk a/p axis if its orientation is stable and not rotated about its longitudinal axes. Regression analysis did not show clear perceptual biases toward trunk or head a/p axes in any condition.

SUMMARY

These findings strongly suggest that the earth-fixed vertical is one axis used for visual perceptions of axis of motion of moving objects. This is consistent with previous findings concerning static visual perceptions. Such accurate visual perceptions of vertical presumably depend on inputs from the vestibular otoliths that specify head orientation relative to earth-fixed vertical. Perception of motion direction in the horizontal plane appears to be related best to external visual axes, if such axes are available, or to the trunk a/p axis if there is no trunk rotation. Previous work on static visual perceptions did not consider external visual axes for perceptions. Thus, additional study of use of such axes in perception is needed. Provision of external visual axes may be useful to assist visual and, perhaps, kinesthetic perceptions, and movement control in microgravity environments.

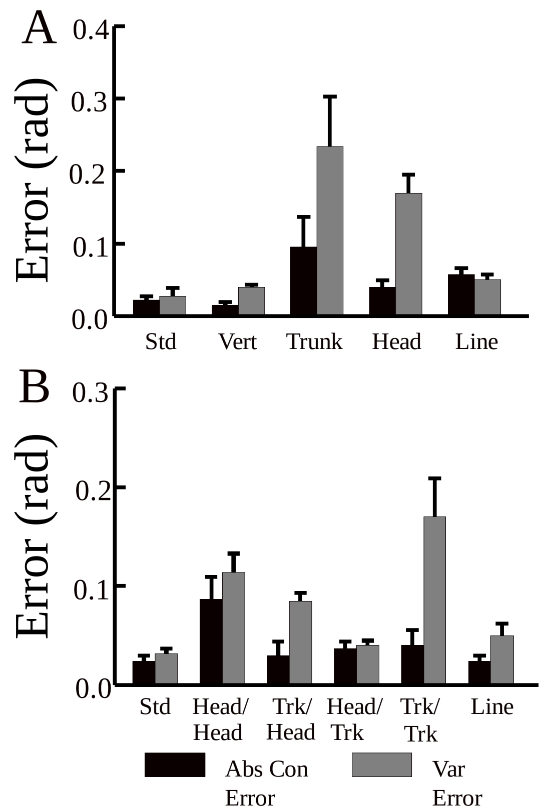

Figure 1: Perceptual errors in vertical (A) and horizontal (B) planes. Conditions on abscissae (segment moved/perceptual axis in B). Each bar is the mean error for six subjects. Error bars are 1 S.E.

References

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