Predicting Human Perceptual Performance in Motion Judgments from the Eye Movements

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BACKGROUND

• State-of-the-art heads-up displays and virtual environments create new human-factors problems because it is difficult to ensure that an intended percept is achieved and/or that information provided is adequate for accurate visuomotor control. Indeed, visual and visuo-motor errors are a significant safety problem for both aviation (e.g. air traffic control) and space exploration (e.g. tele-operated docking). The ability to identify perceptual errors during uninterrupted task performance is critical for evaluating the effectiveness and safety of new displays or procedures.

OBJECTIVES

• The goal of this project is three-fold: 1) to help develop and test new technologies that enhance the precision of video-based human eye-movement measurements, 2) to develop and validate analysis tools that allow the use of eye-movements to make non-intrusive yet quantitatively accurate measurements of perceptual performance, and 3) to develop models of human vision to guide future display design that match human perception and visuomotor control.

ACCOMPLISHED

• We tested a new high-temporal resolution (240 Hz) infra-red video-based eye-tracker (supplied by ISCAN Inc.) and optimized our set-up to achieve spatial precision < 0.1° with unconstrained horizontal and ±10° vertical range.

• We developed a computational model that quantitatively predicts observer direction judgments from their pursuit eye movements. The model not only predicts perceptual performance but also captures intersubject variability (Fig. 1).

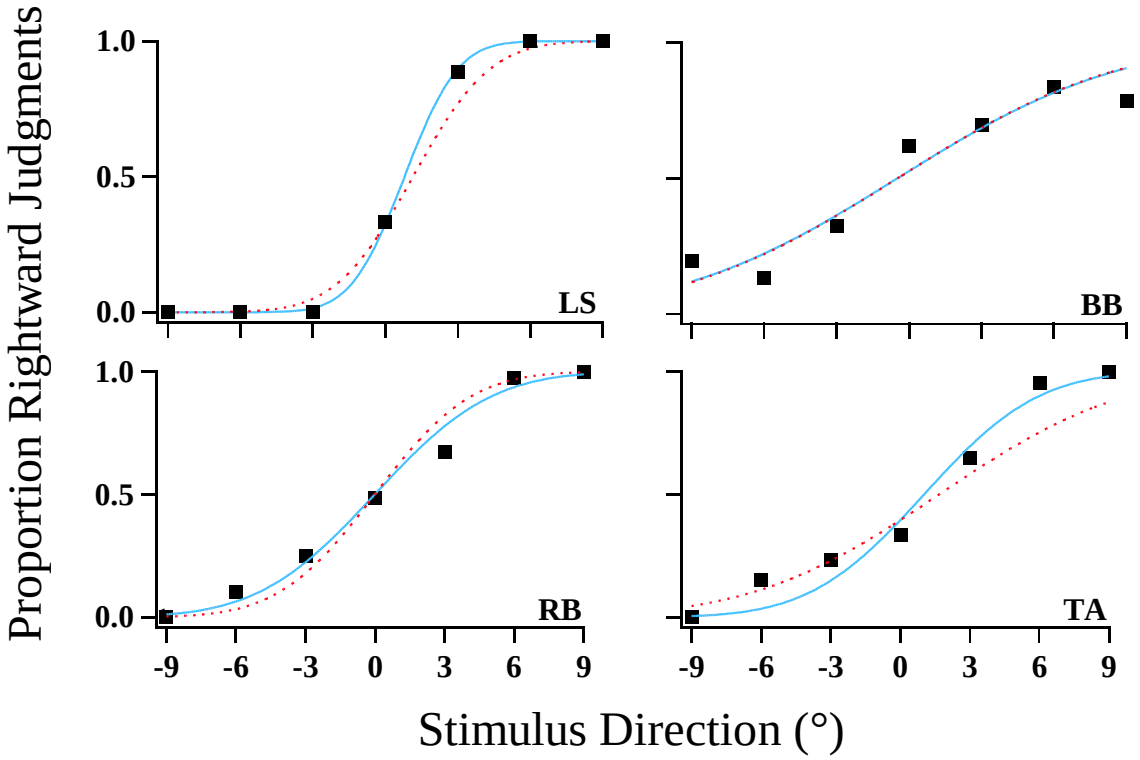

Fig. 1. Direction judgments of four observers (2 naive). The solid squares indicate the perceptual data gathered using standard rigorous psychophysical procedures. The solid blue line indicates the best-fitting psychometric curve. The dashed red line indicates the model prediction of the perceptual data from the eye movements with a single fixed parameter for all observers.

• We disproved the current view that human pursuit is a velocity-servo control system that minimizes retinal motion.

FUTURE PLANS

• Our future plans include:

- extending our eye-tracker technologies to allow binocular measurement and free head movement,
- extending our visuomotor paradigms to include manual control and other applied tasks,
- developing and validating new biologically-based models of human motion perception and visuomotor performance.