Cognitive Effects of Gaze Input and Stereoscopic Depth on Human-Computer Interaction

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We conducted an experiment to compare the performance and cognitive workload in visual tasks using a hybrid eye gaze interface (a gaze selection followed by a manual confirmation) and a traditional mouse controlled interface displayed in 2D and 3D stereo modes. Our intention was to investigate human performance and cognitive processing while under pressure to react quickly and accurately. In our experiment, the computer screen displayed a virtual world, where different objects flew towards the subjects, some of the objects were harmless and the others were dangerous. The subjects had to destroy the hazardous objects as soon as possible and leave the harmless objects to fly by freely. While using the mouse, the subjects first operated it to select the target and then clicked the mouse button to eliminate the target. While using eye gaze, the subjects first used their gaze to select the target and then clicked a designated button on a game pad to eliminate the target.

In order to investigate what effects "stress," i.e., cognitive workload, had on performance and cognitive processing, we also assigned two different speeds to the flying objects. To create a 3D depth perception, stereo image pairs of the scenes were displayed on the screen. A 3D virtual world was observed on a DTI auto-stereoscopic 3D monitor, and the subjects perceived the objects being created far back inside the screen and flying towards them. To ensure the similarity between the experimental conditions, in another condition we displayed the same 3D scene in a 2D display. Consequently, in the 2D display the subjects only saw the size of the objects increase on the screen and had no stereoscopic depth information.

Ten students were tested individually. Figure 1A shows that in the fast speed condition the subjects had significantly bigger pupil sizes than in the slow speed condition $F(1;9)= 1580.9$, $p<0.001$. In 3D stereo, the subjects had smaller pupil size than in 2D, $F(1;9)=1250.26$, $p<0.001$. Using eye gaze to eliminate the targets also made the subjects pupil size significantly smaller than when using a mouse to eliminate the targets $F(1; 9)=1043.09$, $p<0.001$. As indicated by the pupil sizes (Pomplun & Sunkara 2003), the cognitive workload using eye gaze was less than when using a mouse to eliminate the targets, and the cognitive workload in 3D stereo was significantly lower than in 2D. As shown in Figure 1B, the object speed apparently had a very strong effect on the subjects' performance $F(1;9)=238.13$, $p<0.001$. The subjects also missed significantly more targets using the mouse than when using the eye gaze $F(1;9)=26.6$, $p<0.005$. This suggests that 3D gaze interfaces could be designed to reduce the workload level of operators and improve their performance.

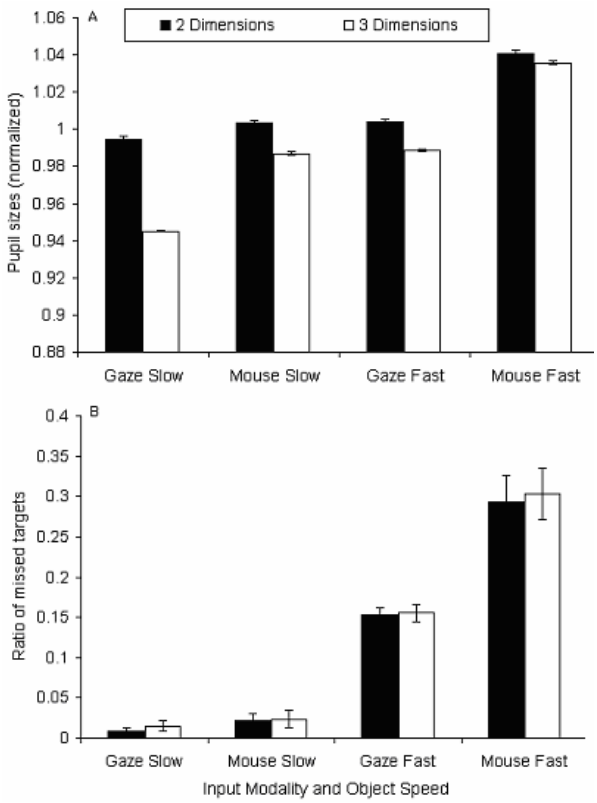

Figure 1: (A) normalized pupil size for each of the eight conditions; (B) ratio of missed targets.

References

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