Understanding Differences in Depth Perception in Virtual Spaces: A Pilot Study

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Introduction

Accurate visual perception of 3D is essential for the success of VR systems. Humans use multiple visual cues when detecting dimensionality, including ocular disparity, ocular accommodation, shape from shading (SFS), motion parallax, occlusion, and optic flow[7][3][8]. Traditional VR systems only appeal to a few of these cues and neglect the rest. Most current systems are limited to monocular cues, favoring optic flow.

Recent reports from transsexuals undergoing hormone treatment have indicated that various aspects of vision change as a function of specific hormone levels[2]. The interaction between vision and sexual hormones is supported by the discovery of hormones in the rat retina[10]. A variety of visual and ocular changes across the menstrual cycle have been documented[9].

Based on this research, we hypothesize that there may be a prioritization of visual cues for 3D understanding that is dependent on sex differences.

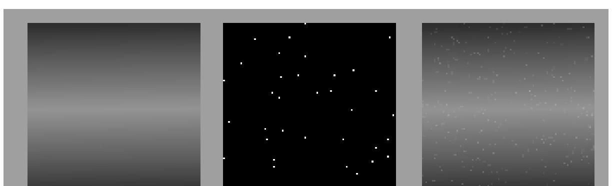
Methods

We use SFS and optic flow because we believe they may illustrate the hypothesized discrepancy between visual functioning in hormone-differentiated groups of individuals.

In our pilot study, we tested five men and five women. We provide three situations with similar setup. For each, the subject is presented with 500 milliseconds the appropriate cue. In each case, two versions of the cue appear, one on each side of the screen. In all cases, the image is some form of a side view of a cylinder with no edge information and minimal other cues. The subject is wearing an eye patch, eliminating binocular disparity. After being presented with the information, the subjects is required to give a force choice response indicating which presentation was more curved.

We provide three situations: In the first, only SFS cues are given. This is done through rendered images with top-down light sources (see Picture 1). In the second situation, there is no shading on the cylinders, but there are dots scattered randomly (see Picture 2). These dots move parallel to the cylinders, and the dots closer to the observer move faster than the more distant dots. While this is not realistic, it has shown to be effective[1][4][11].

Finally, we combine the two cues in realistic and physically impossible combinations, creating cue conflicts (see Picture 3). By providing contradictory SFS and optic flow information simultaneously, the subject must rely on the more dominant cue[5].



Picture 1 just shading | Picture 2 just flow | Picture 3 both

We expected to find individual variations with potential sex-based performances where males respond to the moving dots (optic flow) and females respond to the shading (SFS.).

Results

In our pilot study, we found that when given conflicting visual stimuli, men depended on the shading 32% of the time while women depend on shading 55% of the time. While this is not statistically significant ($p = .233$), it is correlated closely enough to warrant further study.

Performance on the individual cues validated the idea that people are pretty poor at shading-only cues. While performance on the flow-only cue was poor, people were relatively accurate.

Individual performance varied tremendously but only the females relied more heavily on the shading than on the flow.

Conclusions

Men's reliance on flow and women's reliance on shading are in line with what we could have expected. Individual differences in performance are also as to be expected.

Our findings recommend that this subject deserves more attention. While this was only a pilot study, the evidence is clear that a full investigation is important. There appears to be both individual and sex-based preferences for 3D detection.

If virtual reality engineers continue to base their rapid progress upon faulty or biased assumptions, their errors will weaken the entire structure. We suggest two methodological considerations: 1) that formal cognitive-based user studies be implemented to further understand the perceptual differences illustrated; and 2) that VR designers consider recommendations from psychophysical models and attempt to make necessary cues available.

This pilot study was successful. We learned that we have a reason to believe that our hypothesis might be accurate. In addition, we found various methodological concerns with our experiment that can be fixed for the formal study (i.e.: need to eliminate pure lighting and speed from the potential cues). Thus, it is now imperative that a formal study be explored.

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