# “New” UROP Proposal

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| **Title of Proposal:** | The Influence of IPD Mismatch in a Near-Space Blind Reaching Task within Virtual Reality |

**STATE THE PROBLEM/TOPIC**

Head-mounted displays (HMDs) are rising tools that allow the greater public to explore varying virtual reality (VR) technologies/programs. Despite its growing ubiquity, many HMDs do not fully encompass wide enough ranges of inter-pupillary distances (IPDs), restricting some subgroups’ accessibility to the tool and, subsequently, the VR experience (Dodgson, 2004). Although the IPD mismatches can be mathematically shown to impact image projection on the retina, there is very little research empirically demonstrating the effects of mismatched IPD on perception and, in turn, behavior (Creem-Regehr et al., 2023; Utsumi et al., 1994; Williemsen et al., 2008). While there is a myriad of visual depth cues to consider, previous investigations on IPD mismatch have demonstrated a greater impact on particular depth cues: convergence, accommodation, and binocular disparity. Each of these impacted depth cues, coincidentally, are the predominant cues used to perceive depth in near space (i.e. distances closer than 3 m or arm’s-length distances) (Cutting & Vishton, 1995). This research aims to further contribute to current efforts in exploring the impact IPD mismatch has on perception and its interplay with behavior, particularly in near space through observations of reaching behaviors within VR.

**RELEVANT BACKGROUND/LITERATURE REVIEW Background/Literature Review**

VR, more recently, has become an area of modern technology gaining mass popularity. The commercial production and retail of HMDs have made accessing VR programs seamless and convenient. Despite this growing prevalence, modern HMDs have a notable limitation: a severely limited Inter-pupillary distance (IPD) range. IPD, or the distance between the pupils' centers, is a metric used to align HMD lenses with users’ eyes. While the human IPD ranges from 45 - 80 mm, most HMDs today are limited to only a fraction of that range (roughly 60-70 mm), contributing to IPD mismatch (Dodgson, 2004). Although IPD mismatch spans only a few millimeters, it contributes to a large mass of experiential implications.

With particular regard to the perceptual implications, IPD mismatch propagates visual discomfort, eye strain, and poor visual performance (e.g., blurred vision, fatigue, and inaccurate depth perception). Women whose IPDs fell outside the range of particular HMDs, for example, suffered a longer history of motion sickness and longer recovery times after VR use (Stanney et al., 2020). Depth-matching tasks in mixed reality, too, have demonstrated underestimations of depth with IPD mismatches (Utsumi et al., 1994). Evidently, there exist numerous factors that limit the immersiveness of VR and, consequently, produce poor visual performances (Creem-Regehr et al., 2023).

The failure to create a fully immersive experience with HMDs further highlights the technological restrictions of the tool. Human depth perception is a combinatory process involving oculomotor, monocular, and binocular cues (Jacobs, 2002). Particularly, with the primary depth cues (i.e. binocular disparity, convergence, and accommodation), IPD mismatch and the current nature of HMDs can significantly distort the perceptual experience in VEs.

Binocular disparity (the difference in the images between the left and right retinas) forms the foundation of stereoscopic depth perception, specifically stereopsis. Under real-world conditions, the human brain processes disparities between objects/points relative to a fixation point and its corresponding surface (i.e., the horopter) (Goldstein & Brockmole, 2016, pp. 234-236). With IPD mismatch created by modern HMDs, significant stereoscopic depth cues may not be realistically constructed for stereopsis. To add, convergence (inward eye movements when looking at nearby objects) and accommodation (changes in the shape of an eye’s lens when focusing on objects at different distances) work in conjunction to indicate when the object in focus is within near space (Goldstein & Brockmole, 2016, pp. 228-229). However, commercial HMDs are produced using collimating optics, transforming multi-directional light rays to be parallel. This parallelization focuses projections at an optical infinity regardless of an object's nearness (Finney, 2024). The inherent functions of convergence and accommodation directly contrast with what is presented by HMDs, creating visual discomfort, blurred vision, and perceptual inaccuracies exacerbated by IPD mismatch.

Considering the expanding ubiquity and utility of VR and HMDs, it becomes increasingly important to understand their implications on a user’s experience. The ultimate aim of HMDs is to offer individuals a means to immerse themselves in a virtual environment. With consequential faults, like IPD mismatch, virtual reality only remains a reality for a select few. While IPD mismatch presents theoretical implications on perception and behavior in different spaces (i.e., near, action, and vista), research has yet to quantify whether these implications have practical influences. This research aims to contribute to these efforts in recognizing and quantifying the impact of IPD mismatch on perception and behavior in near space.

## SPECIFIC ACTIVITIES AND TIMELINE

### Activities and Timeline Before Fall 2024 (June - early August)

Before the fall 2024 semester, my supervising graduate student will develop a VR program that places the user in a VE with functionalities that measure and record reaching behaviors. Following the development of the program, testing and debugging will ensure that the program runs without faults for seamless integration when running participants.

### Weeks 1 - 10

If necessary, continued testing will occur in the first week of the semester. The SONA system for the psychology department participant pool will be available for students. Time slots will be provided for student sign-ups, and each participant will run through the experience for observation and data collection until a sufficient number of participants (about 30 students).

### Weeks 11 - 12

Collected data will be reviewed, noting any anomalies from the pool. Recorded data will be formatted for analysis. At the same time, review and additional training will be completed for data analysis, including procedures and software required for data analysis (e.g., SPSS).

### Weeks 13 - 16

The completed analysis will be interpreted and written for a report on the project findings. The last weeks will be dedicated to drafting the project poster and ensuring that the findings accurately reflect the experiment's data.

## RELATIONSHIP OF WORK TO THE EXPERTISE OF THE MENTOR

Dr. XXX is a professor specializing in cognition and neural science in the Department of Psychology at the University of Utah. She is one of the principal investigators (PIs) of the Vision, Audition, and Action in Space and Time (VAAST) lab. Her work primarily focuses on spatial cognition, navigation, and perception in natural, virtual, and low-vision environments.

I have been working in the VAAST lab since January of 2023, working under XXX, one of the PhD students in the lab. XXX and Dr. XXX have guided me through the process of certification and running participants for VR experiments. Previously, I helped test and run VR programs for distance perception experiments in action space with IPD mismatch, reciprocally supporting Hunter in collecting data for his dissertation.

## RELATIONSHIP OF THE WORK TO YOUR FUTURE GOALS

I am a junior at the University of Utah majoring in psychology and computer science, hoping to form a greater foundation in the human factors (HF) aspect of computer science and technology. My focus is to understand human-computer interactions (HCI) and find ways to elevate user experiences through front-end software design or overall project development/management. My goal is to continue to develop my expertise in these two fields in graduate school, emphasizing cognition and neural science. The VAAST lab and this project have/will broaden my perspective of the experimental side of graduate school work and deepen the connection between my fields of study.

**REFERENCES (Works Cited)**


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