# Making Virtual Reality "More Real" and the Perception of Potential Collisions

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# Abstract (Updated)

**Purpose:** To see if making the experience in virtual reality closer to the "real world" experience (e.g. actually walking, rather than standing or sitting, in a walking simulator) affects task performance. Improved experience of "presence" might make performance in the virtual reality similar to real-world performance, whereas poor presence or an incorrect rendition might impair performance.

**Methods:** We measured perception of a potential collision with stationary obstacles using four experimental situations to compare: standing or walking; walking with or without participant speed control; and correct or incorrect viewpoint. Participants stood or walked on a treadmill 75cm in front of a 95-degree-wide screen that displayed a "shopping mall" corridor with textured floor and shop fronts. Adult-man-size obstacles appeared for 1 second and participants indicated whether they would collide if they continued on the same path. Data for 14 participants were analyzed to find the participant's perceived safe passing distance and decision quality.

**Results**: When standing, participants had a slightly smaller perceived safe passing distance ($p=0.07$) and made better decisions ($p=0.01$) than when walking. Walking with and without participant speed control provided equivalent performance. The incorrect viewpoint biased the results to one side ($p=0.08$).

**Conclusions**: Our attempts to increase realism did not alter perception of potential collisions. Our with-participant-speed-control walking condition required that the participant exert effort to propel the treadmill (i.e. not motorized), which might reduce task performance compared to a feedback-controlled motorized system. An incorrect viewpoint (rendition) caused a bias - so obstacle side should be considered in data analysis. Other issues that might affect the experience of presence, including head-tracking and binocular view (stereo cue of flat screen), are under investigation.

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# Introduction

Presence has been defined as the feeling that you are really there (i.e. in a real world rather than in a simulator) (Witmer and Singer, 1998). Many research groups are developing virtual environments (e.g. driving, walking) that incorporate features designed to increase presence. An inherent assumption is that with increased presence, participant performance in the virtual environment will be closer to real world performance.

Many studies have reported perceptual judgments of self heading or collisions made while moving in a virtual environment, when participants were seated in front of a computer screen (e.g. Cutting, Vishton & Braren, 1995) or fixation was constrained (e.g. Li & Warren, 2000). Could sitting in front of a screen affect the perceptual judgments?

We reported no relationship between a participant's physical size and the perceived distance required to avoid a collision (Woods, et al., 2003). Do "greater realism" factors affect such task performance?

## Question: Does it matter if the virtual environment is more 'real'?

**Figure 1: In many studies using virtual environments, the participant is seated when making perceptual judgments about moving in the environment.**

**Figure 2: In our virtual environment, the participant may walk and eye movements are not restricted.**

# General Methods

- **Physical:** Participants walked or stood on a treadmill and viewed the scene projected in on a 95-degree wide projection screen. Eye movements were not constrained. We attempted to increase realism by having participants walk with visual feedback related to the pace of locomotion. Walking occurred at a set speed (motorized) or at participant-set speed (variable, non-motorized).
- **Virtual Environment:** Along an infinitely long virtual corridor, participants followed a non-symmetric zig-zag walking path (Figs. 3 & 5). On each path segment, a 70 cm-wide square pillar with an image of a person appeared 5 meters away for 1 second (Fig. 4).
- **Task:** Participant indicated if a collision would occur, had they continued on that path.

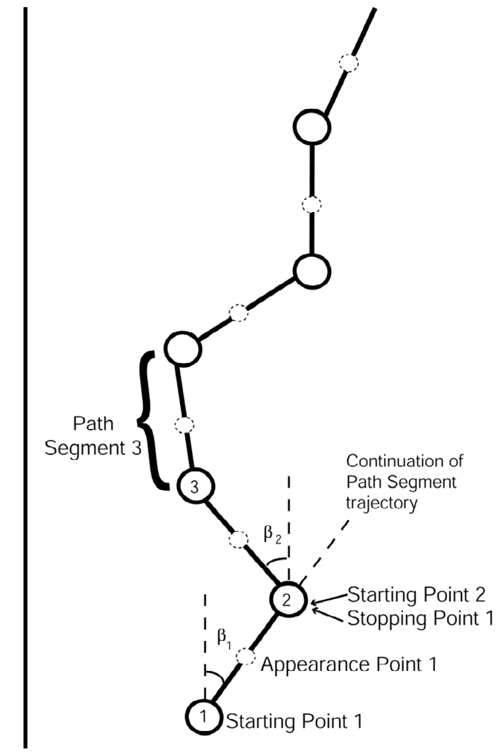



**Figure 3: Zig-Zag path along the mall corridor. Vertical scale is highly compressed compared to horizontal scale.**

Figure 4: Example screenshot of an obstacle that appeared near the center of the scene. The mall corridor walls were mapped with storefront photographs. 3-D objects were placed near storefronts to provide additional spatial (motion parallax) cues.

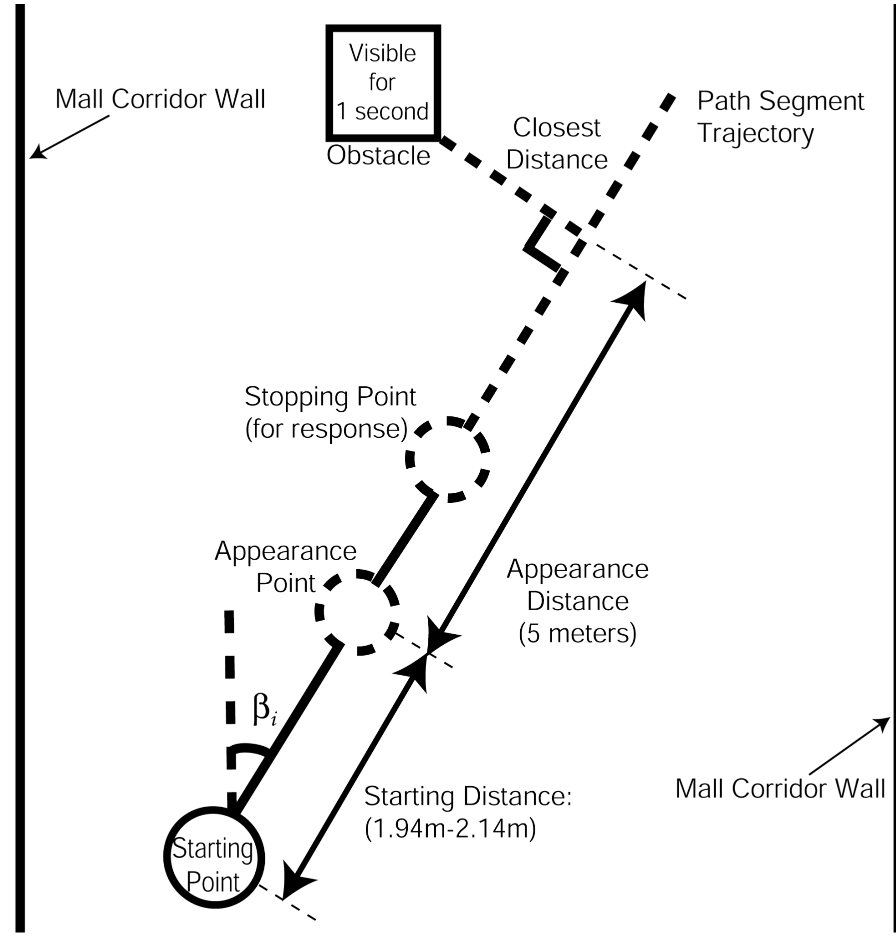



Figure 5: Relative locations of corridor walls, participant starting point, point of obstacle appearance, closest distance to path within a single path segment. Figure is not to scale.

# Data Analysis

Frequency of yes response ("*Yes, I would collide with the obstacle*") was fitted to a cumulative Gaussian curve (see Fig. 7 through 9).

We defined:

**1. *Perceived safe passing distance* as the mean (μ) of the participant's response function.**

**2. *Decision quality* as the standard deviation (σ) of response function. Note: smaller is better.**

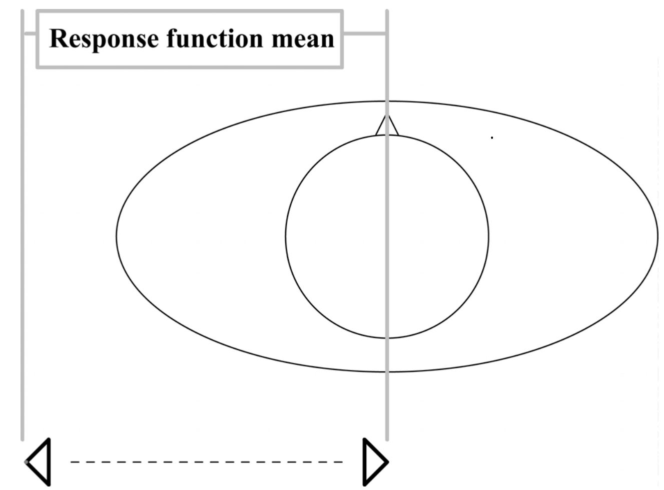
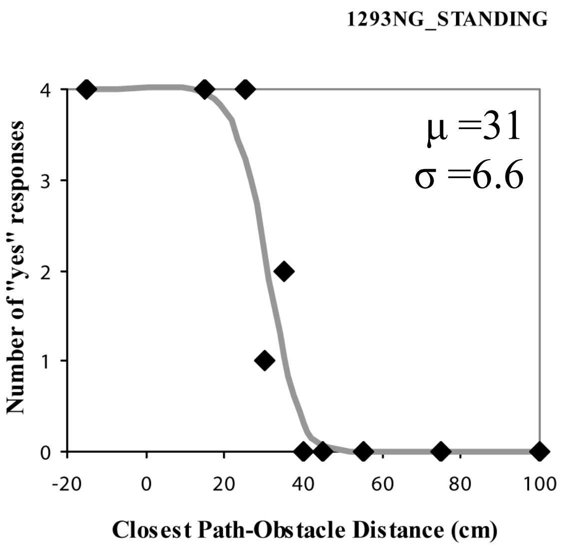


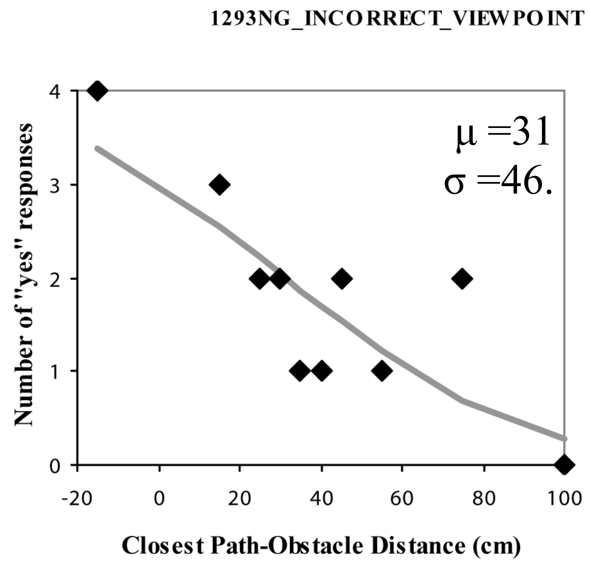

**Figure 6: The participant's perceived safe passing distance (denoted with a set of arrow heads) may be larger or smaller than the person's actual size.**

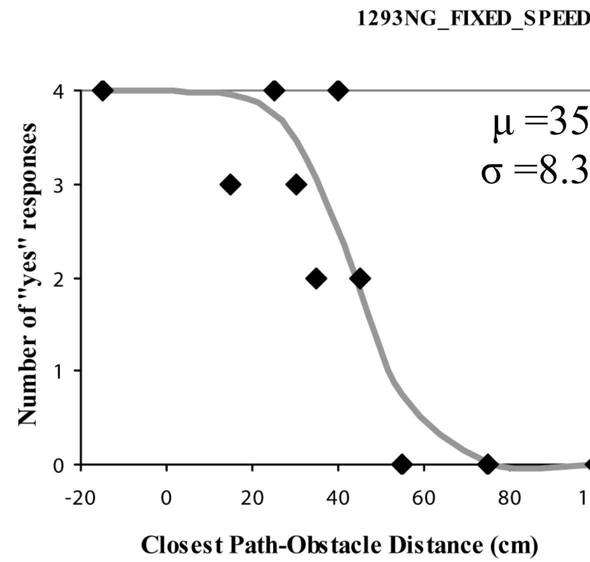
**Figure 7: A highly confident decision (low standard deviation) with perceived safe passing distance of 31 cm**

**Figure 8: Similar perceived safe passing distance to Fig. 7, but worse decision quality**

**Figure 9: Larger perceived safe passing distance than Figure 6 or 7**



# Question 1: Does walking matter?

Walking before a projected scene that advances at the participant's pace should make the experience more "real".

# Finding 1: Yes, walking reduced decision quality.

When walking, participants had a slightly smaller perceived safe passing distance and worse decision quality than when standing (Fig. 10: $t_{13}$=2.0, p = .07) (Fig. 11: $t_{13}$=2.9, p = .01).

Note: In all following bar charts the error bars indicate 95% confidence intervals and lower decision quality scores indicate better decision

**Figure 10: Perceived safe passing distance**

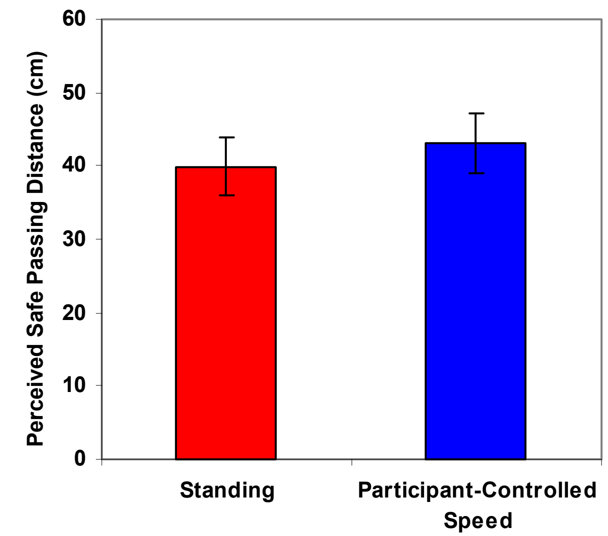
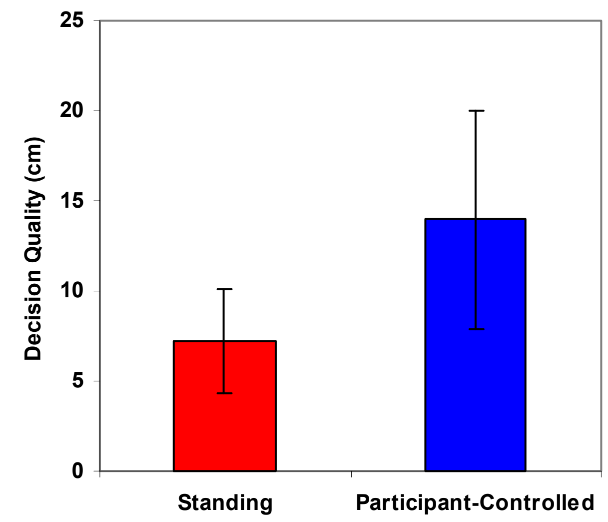



**Figure 11: Decision quality**



## Question 2: Does participant control of walking speed matter?

Walking at self-determined speed should make the experience more realistic than walking at a fixed (externally dictated) pace.

## Finding 2: Participant-controlled walking speed did not alter task performance.

With participant control of walking speed, perceived safe passing distance and decision quality were similar when walking speed was fixed (Fig. 12: $t_{13} = 1.1$, $p = .28$) (Fig. 13: $t_{13} = 0.8$, $p = .46$).

Figure 12:
Perceived safe passing distance

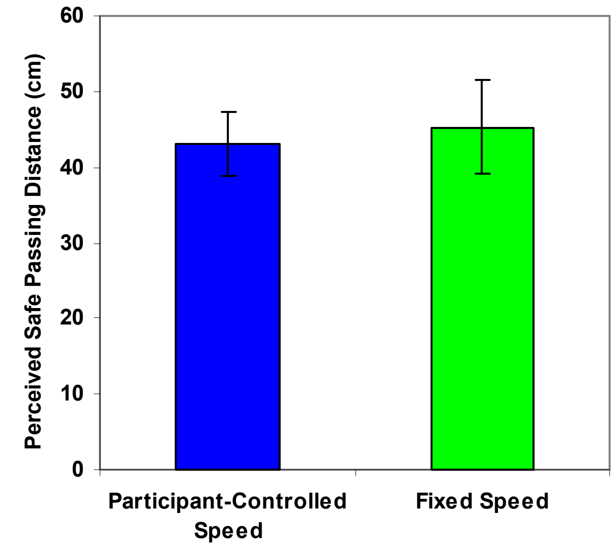
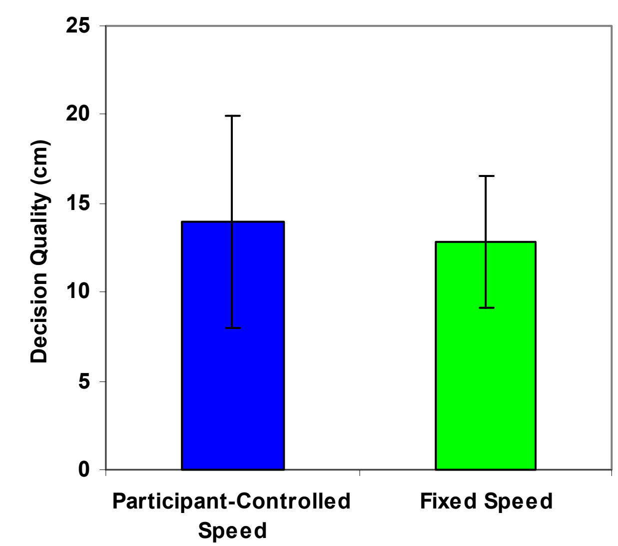



Figure 13: Decision quality



# Question 3 – Does accurate viewpoint representation matter?

Presenting the virtual mall from a viewpoint that was offset by 80 cm to the right may reduce the realism, and therefore reduce task performance.

This may result in a change in perceived safe passing distance or decision confidence. Also, these might be biased to one side.

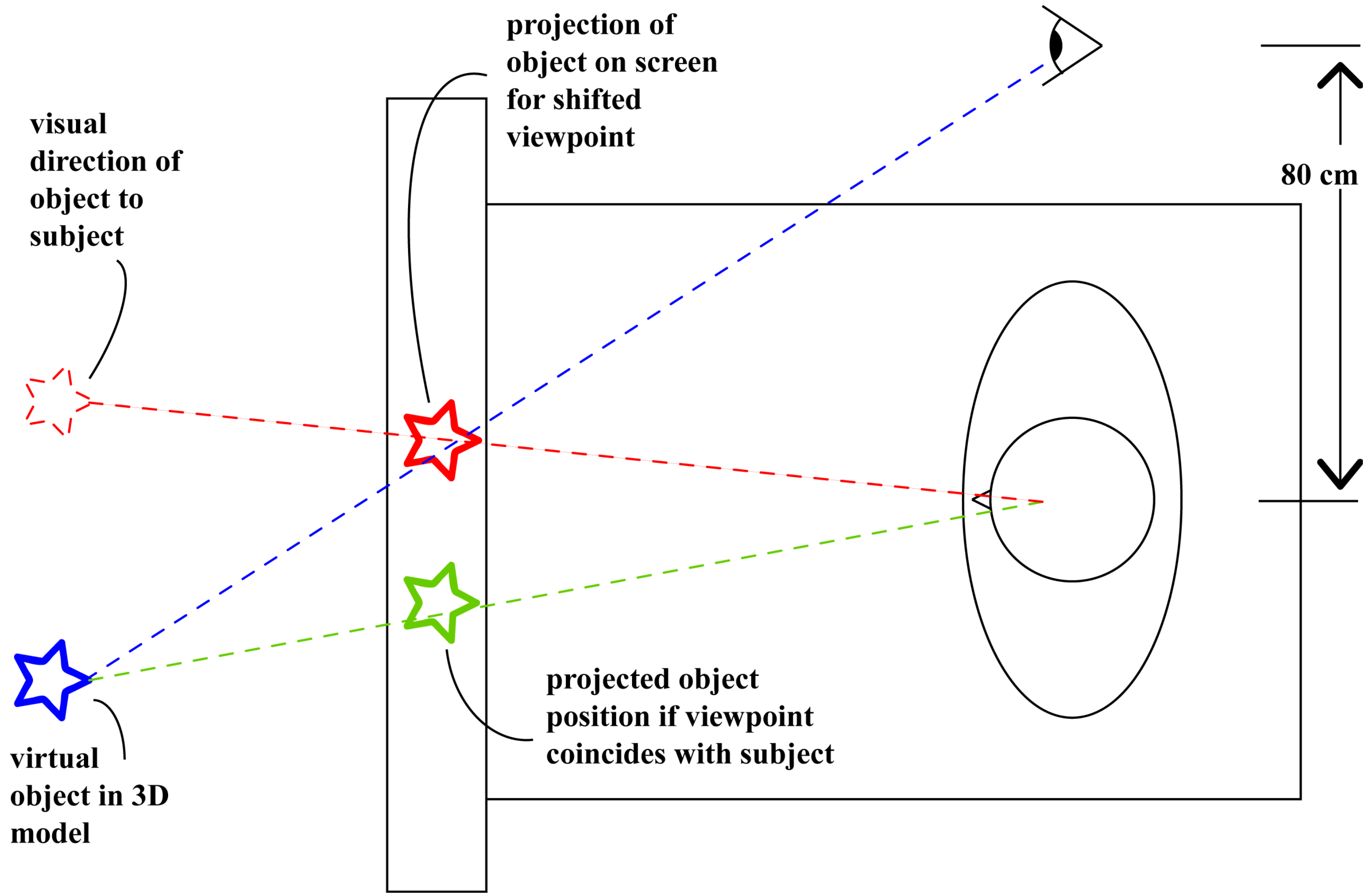



**Figure 14: The solid blue star is an object in the 3-D scene, and the dashed red star represents its perceived location if the viewpoint is incorrectly placed (by 80 cm in our study). That occurs because the object is represented on the screen at a location (solid red star) offset from the screen location required if the 3-D location is to be correctly shown (green star).**

# Finding 3: An accurate viewpoint matters slightly, but there was an effect of obstacle side.

An incorrect viewpoint had no significant effect on perceived safe passing distance or decision quality (Fig. 15: $F_{1,13} = 0.84$, $p = .38$) (Fig. 16: $F_{1,13} = 2.25$, $p = .16$). There was a tendency for better decision quality for obstacles to the left. When the viewpoint was incorrect the perceived safe passing distance was biased slightly to one side ($F_{1,13} = 3.65$, $p = .08$).

**Figure 15: Perceived safe passing distance**

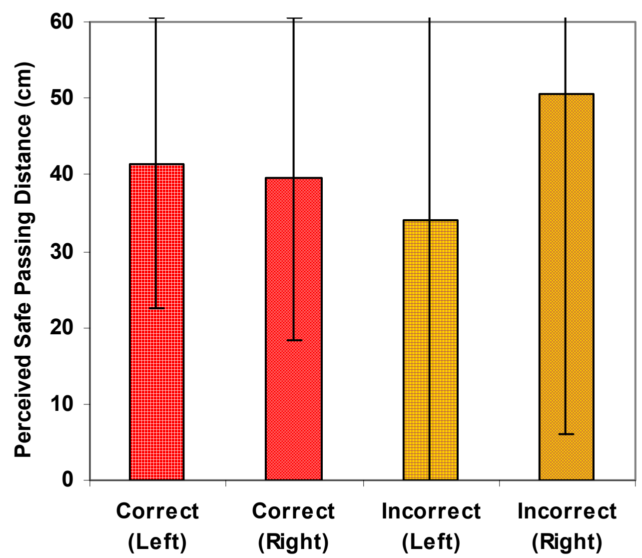
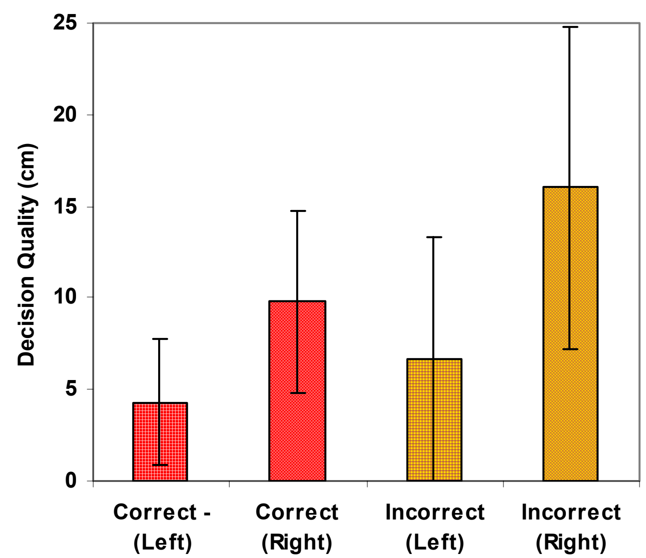



**Figure 16: Decision quality**



# Discussion

Head movement may have influenced findings 1 and 2:

1. Walking produces more head movement than standing.
2. In the participant controlled-speed condition the treadmill was not motorized, requiring that the participants exert effort to propel themselves. This may have caused more head movement than in the fixed speed condition (motorized treadmill).

Extra head movement may make determination of heading more difficult when the virtual display does not correct for head movement. Parallax provided by head movements may be a useful cue. We are examining this issue.

We are planning to use participant speed and its variation to measure mobility performance (e.g. with visual impairment or visual aids). For example, if an obstacle appears and a participant slows down this may indicate the participant is wary of colliding with the obstacle.

# Conclusions

Our attempts to increase realism did not alter perception of potential collisions.

Walking (rather than standing) did not improve task performance.

Participant control of walking speed did not improve task performance.

Our implementation of the walking conditions may have influenced these outcomes (e.g. head movements).

Incorrect viewpoint affected perception of potential collisions.

## Acknowledgments

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