Stereo and Haptic Cue Integration of Noisy and Non-Noisy Stimuli

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INTRODUCTION

- Previous research has found the combination of visual and haptic cues for 3D shapes and slants to be statistically optimal according to a maximum-likelihood estimation (MLE) model.
- However, cues from different senses such as vision and haptics have trouble combining in cases where the stimuli are noisy and unreliable.
- In this study, we looked at the combination of vision and haptic cues under noisy and non-noisy conditions for slanted surfaces.

METHODS

Haptic Stimulus: Two plexiglass boards, with a block of fom on the other side. They are separated by pink blocks, one of which connects to the rotating motor. Subjects interacted with the stimulus with a two-finger grasp.

Visual Stimulus: A random dot stereogram constrained by a square aperture. The 2D diagonal line probe is depicted to the left. Shown image is a simulation, not the actual stimulus used.

Subjects looked at or felt 3D slanted surfaces. After being cued to "Look" or "Touch" through an audio cue, subjects matched the slant angle they saw and/or felt using a 2D diagonal line probe.
The angle of the probe was gathered as a measure of the perception of slant.

EXPERIMENT 1 Non-Noisy Probe Task

EXPERIMENT 1a: Low Dot Density

EXPERIMENT 1b: High Dot Density

EXPERIMENT 1c: High Dot Density + Vertical Reference Probe

The MLE model predicts that the combination of two cues, such as vision and haptic, will produce a combined cue with a standard deviation that is less than or equal to the lowest standard deviation for the single-cues.

We do not see results confirming these predictions for experiment 1a. However, experiments 1b and 1c show that the standard deviations of the combined cue are about equal to the vision cue, which has a lower standard deviation than the haptic cue.

EXPERIMENT 2 Noisy Probe Task

*Results were split into blocks of 50 trials each for temporal analysis.
Since there were 2 sessions, there were 2 blocks per session.

LEGEND

Blue: H1, Noisy Haptic only
Red: V1, Noisy Visual only
Cyan: V1H0, Noisy Visual, Non-noisy Haptic
Green: V0H1, Non-noisy Visual, Noisy Haptic
Magenta: V1H1, Noisy Visual, Noisy Haptic

Single-cue variance comparision between experiments 1 and 2.

Analysis of the blocks shows that throughout the course of the experiment, subjects' haptic estimates decrease towards the visual estimate.
This is evidence for visual capture.

The standard deviation of the noisy singular cues from experiment 2 were shown to be equal to or lower than the standard deviations of non-noisy singular cues from experiment 1.
This may suggest that the noise conditions were weak enough to not drastically affect the variance as hypothesized.

CONCLUSIONS

- Cue combination of visual and haptic cues was not shown during this study, across both noisy and non-noisy visual and haptic cues.
- Combined cue estimates were shown to be a weighted average of the single-cue estimates weighted by their variances.
- The calculated combined cue variances were higher than predicted by the MLE model.
- The haptic cue may have been too unreliable, as visual capture was observed occurring over the course of experimental sessions. This suggests that the two-finger grasp used to estimate haptic slant was not a reliable method to measure slant.
- The values of noise used in this experiment may not have produced large changes in the variance of cues.

FUTURE DIRECTIONS

- To prove or disprove the MLE model's predictions for this study, a two-interval forced choice (2IFC) task must be performed to get the reliability and theoretical variance of each cue in the form of a just-noticable difference (JND) of slant discrimination.
- Adjustment of the haptic stimulus and the noise conditions would need to be performed to improve the haptic reliability and produce stronger noise conditions.

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