Integration of visual-haptic shape information

MAX-PLANCK-GESELLSCHAFT

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Introduction

Humans integrate multimodal information (e.g., visual & haptic size) statistically optimal according to a maximum likelihood estimator [1].

Exp1: Integration seems to be broken if there is a spatial discrepancy between the signals [2]. Are signals combined when observers have knowledge about the signals belonging to that same objects, even when there is a spatial discrepancy?

Exp2: Previous studies used virtual setups to study multimodal integration. Here we apply real objects, i.e. more naturalistic conditions, to examine whether humans integrate visual and haptic shape information statistically optimal.

Experiment 1

* **Purpose:**

Do humans still integrate visual and haptic shape information when they look through a mirror?

* **Setup and Stimuli**

H haptic stimulus

40 x 20 mm

V visual stimulus

40 x 40 mm

Participants look at an object through a distortion lens while touching the object

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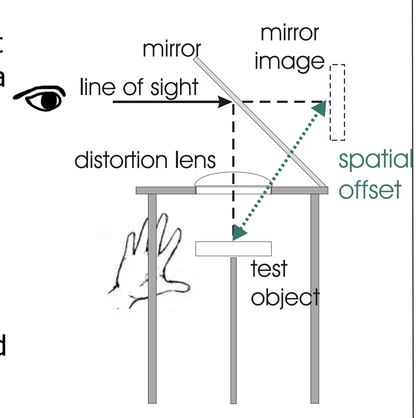
Conflict between visually and haptically perceived



* **Conditions:**

'**mirror**': subjects look at the object through a mirror while touching it (spatial offset)

'**direct vision**': subjects look directly through the lens while touching the object (mirror removed, no spatial offset)

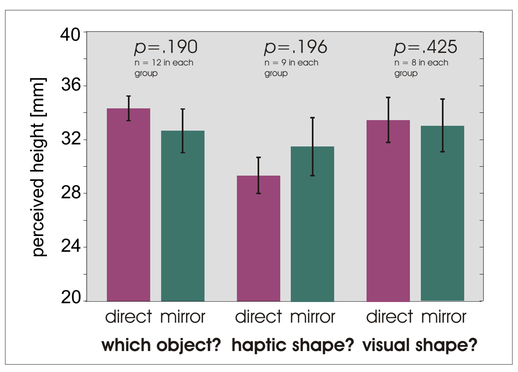
* **Task:**

Participants report the perceived shape by matching it to a reference object (which object?, haptic shape?, visual shape?).

reference objects: width: 40 mm
height [mm]: 20 (H) 24 28 32 36 40 (V)

* **Results:**

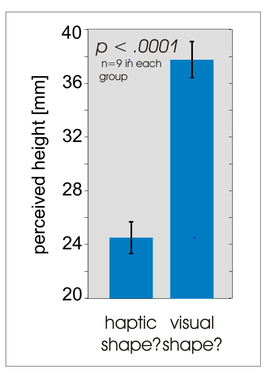
The reported shape percept was in-between the haptically and visually specified shapes. No significant difference between the two conditions (direct vision /mirror).



Control Experiment:

Spatial discrepancy (25 cm) and no reason to assume that the signals belong together.

- Integration breaks. The reported shape percept is determined by the task.



* **Conclusions:**

Visual and haptic signals are integrated when subjects know that the signals belong to the same object, even when there is a spatial discrepancy.

References:

[1] Ernst, M.O. and Banks, M. (2002). Nature, 415, 429-433.
[2] Gepshtein, S., Burge, J., Banks, M. and Ernst, M. (submitted). Current Biology

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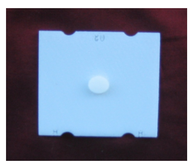
Experiment 2

* **Purpose:**

Do humans integrate visual and haptic shape information statistically optimal?

* **Stimuli**

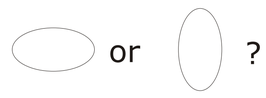
Stimuli are raised ellipses that can be seen on the front-side and felt on the back



size: max. elongation 10 mm

* **Task**

Is the ellipse horizontally or vertically elongated?



* **Experimental Conditions:**

Combined Estimate: S_{VH} $w_V S_V$ $w_H S_H$

Single Modalities:

The predicted weights for optimal integration are calculated from the unimodal JNDs (JND_H, JND_V):

$$w_v \quad \frac{JND_H^{\ 2}}{JND_H^{\ 2} \quad JND_V^{\ 2}}$$

According to the MLE rule, the combined estimates should have lower JNDs (JND_{VH}):

$$JND_{VH}^{\ 2} \quad \frac{JND_H^{\ 2} \quad JND_V^{\ 2}}{JND_H^{\ 2} \quad JND_V^{\ 2}}$$

Bimodal:

In the bimodal condition we introduce a conflict between the visual and haptic size stimulus. The shift of the PSE towards the haptic/visual input is a measure of the haptic/visual weight:

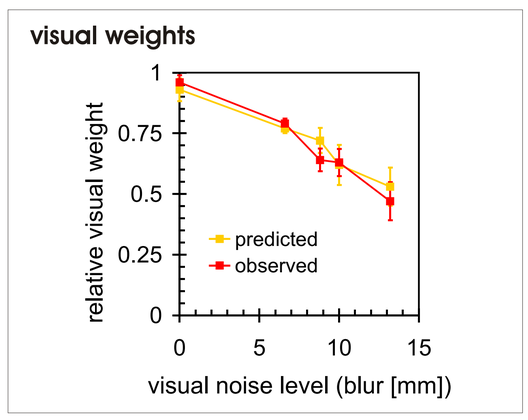
$$w_v \quad \frac{PSE \quad H}{V \quad H}$$

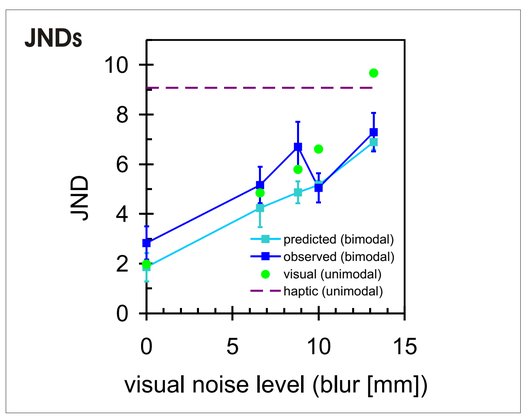
modify reliability of the visual cue:

blur 0 mm, 6.6 mm, 8.8 mm, 11.0 mm, 13.2 mm

* **Results:**

data from the bimodal conditions





The visual weights decrease when vision is degraded. The weights correspond to the predictions from the MLE rule for optimal integration.

Adding visual noise results in a decrement in discrimination performance. The bimodal JNDs do not differ sign. from the predicted JNDs.

* **Conclusions:**

In accordance with the MLE rule, the visual weights and the discrimination performance decrease when vision is degraded.

These findings suggest that the participants do indeed integrate visual and haptic shape information.

Future Research

fMRI studies on Visual-Haptic Cue Integration

- Which brain regions are involved in visual-haptic cue integration?
- Correlations between signal change and cue weighting?