

# Visual-haptic integration during tool use: perceived size from haptics is rescaled to take account of tool geometry

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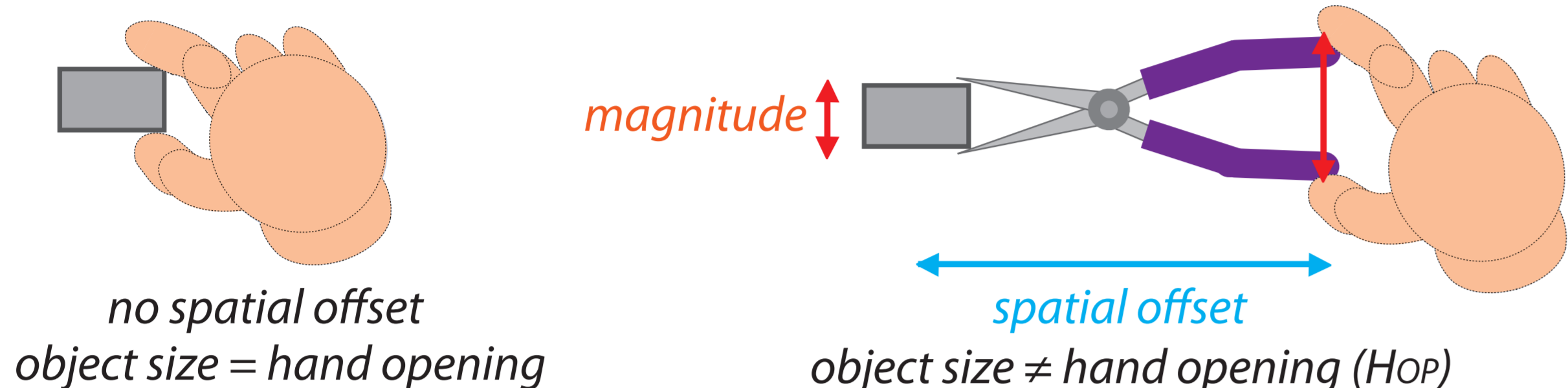
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## Background

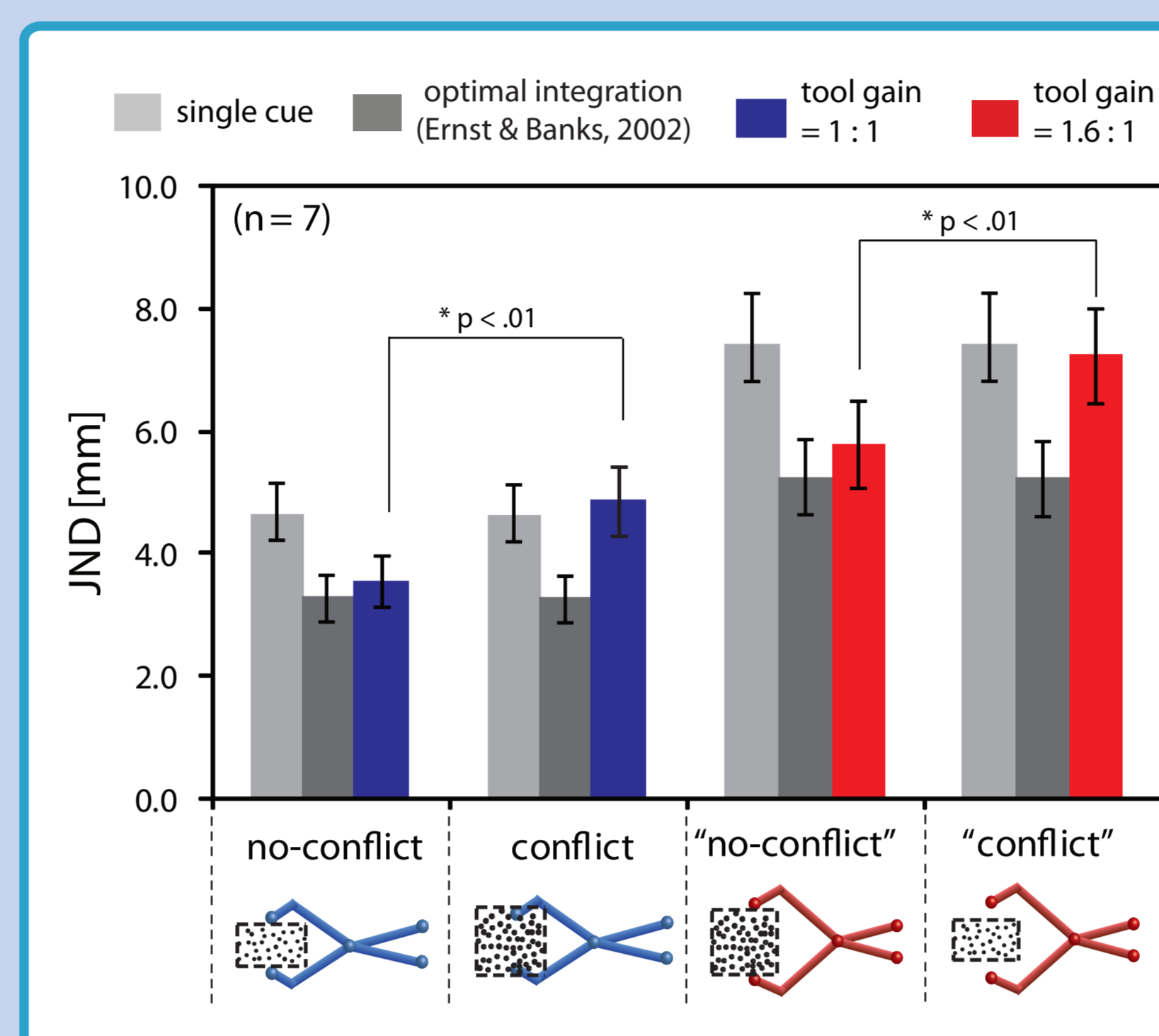
- Visual and haptic information should only be integrated when it refers to the same object—the brain must solve a “correspondence problem”.
- We have previously shown that during tool use the brain solves this problem correctly despite (i) spatial offset in visual and haptic signals, and (ii) conflict between visual size and hand opening (Takahashi et al., 2009, *Journal of Vision*; Takahashi et al., VSS 2009).

### The visual-haptic “correspondence problem”

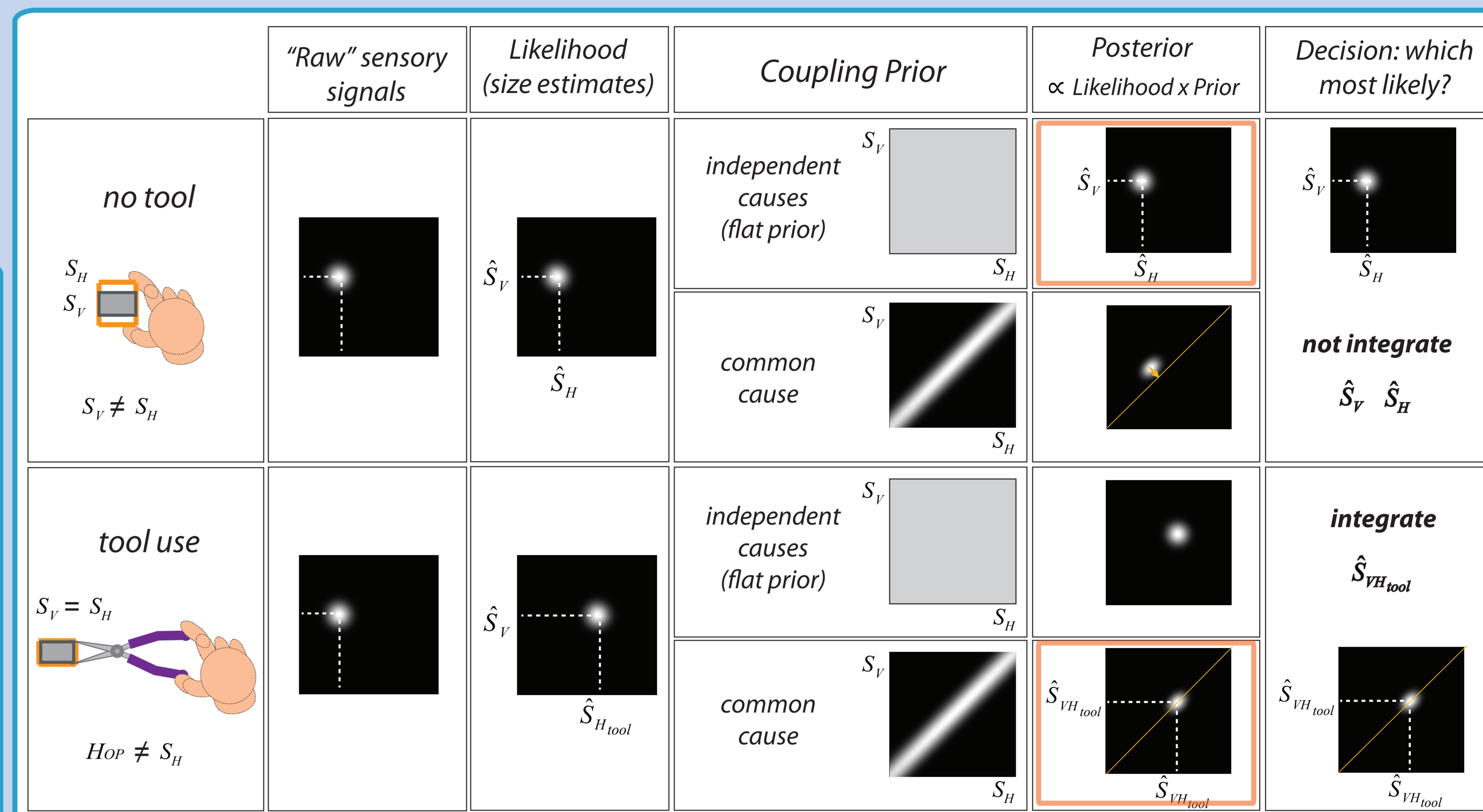


- This could be achieved by considering the similarity of the signals in terms of spatial coincidence, magnitude etc. (Ernst, 2007; Körding et al., 2007).
- Here we ask, are haptic estimates ‘rescaled’, taking account of tool geometry, to allow the correspondence problem to be solved, and size to be estimated correctly?

### Visual-haptic integration during tool use (Takahashi et al., VSS2009)

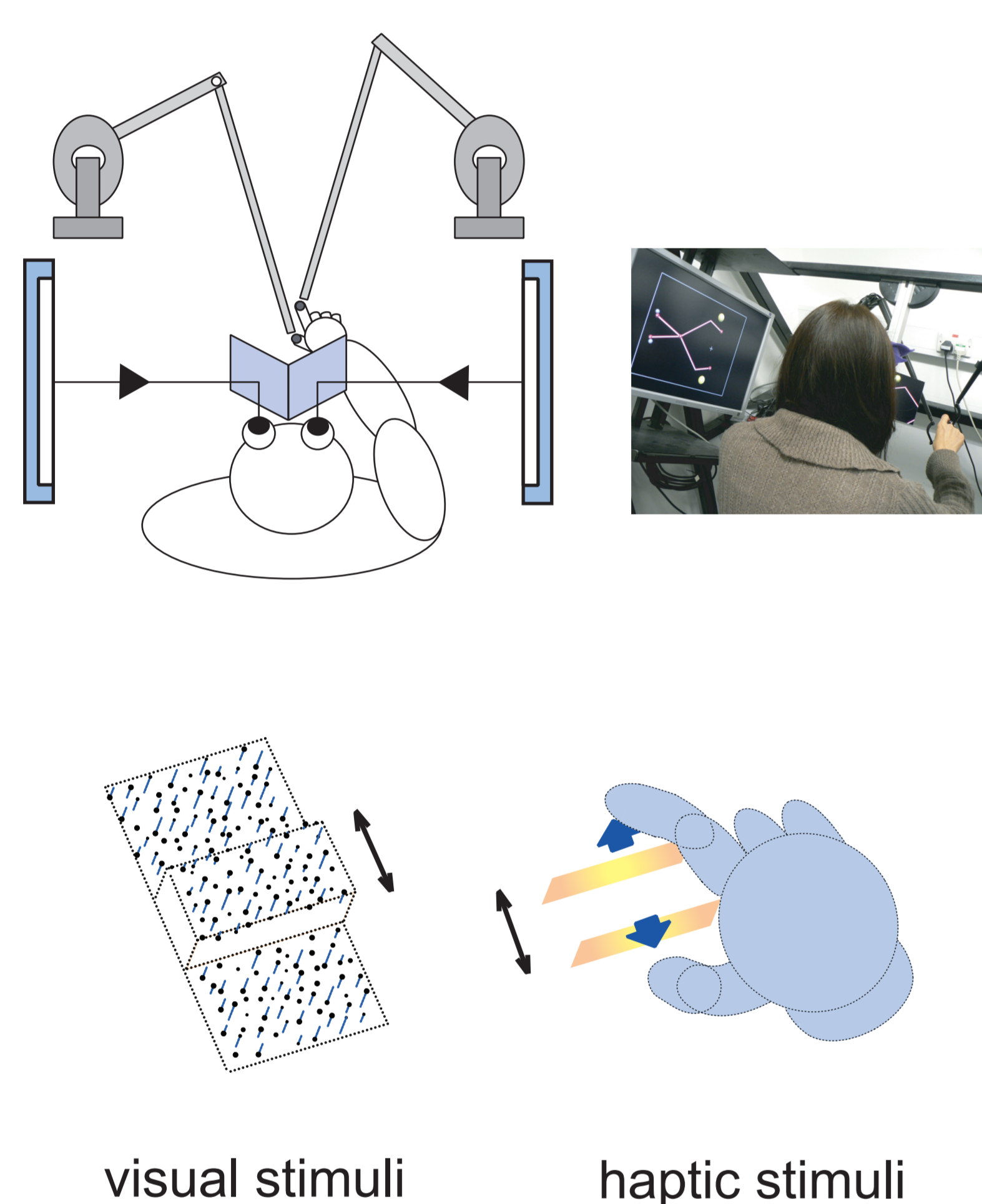


### Bayesian model of common-cause decision (after Ernst, 2007; Körding et al., 2007)

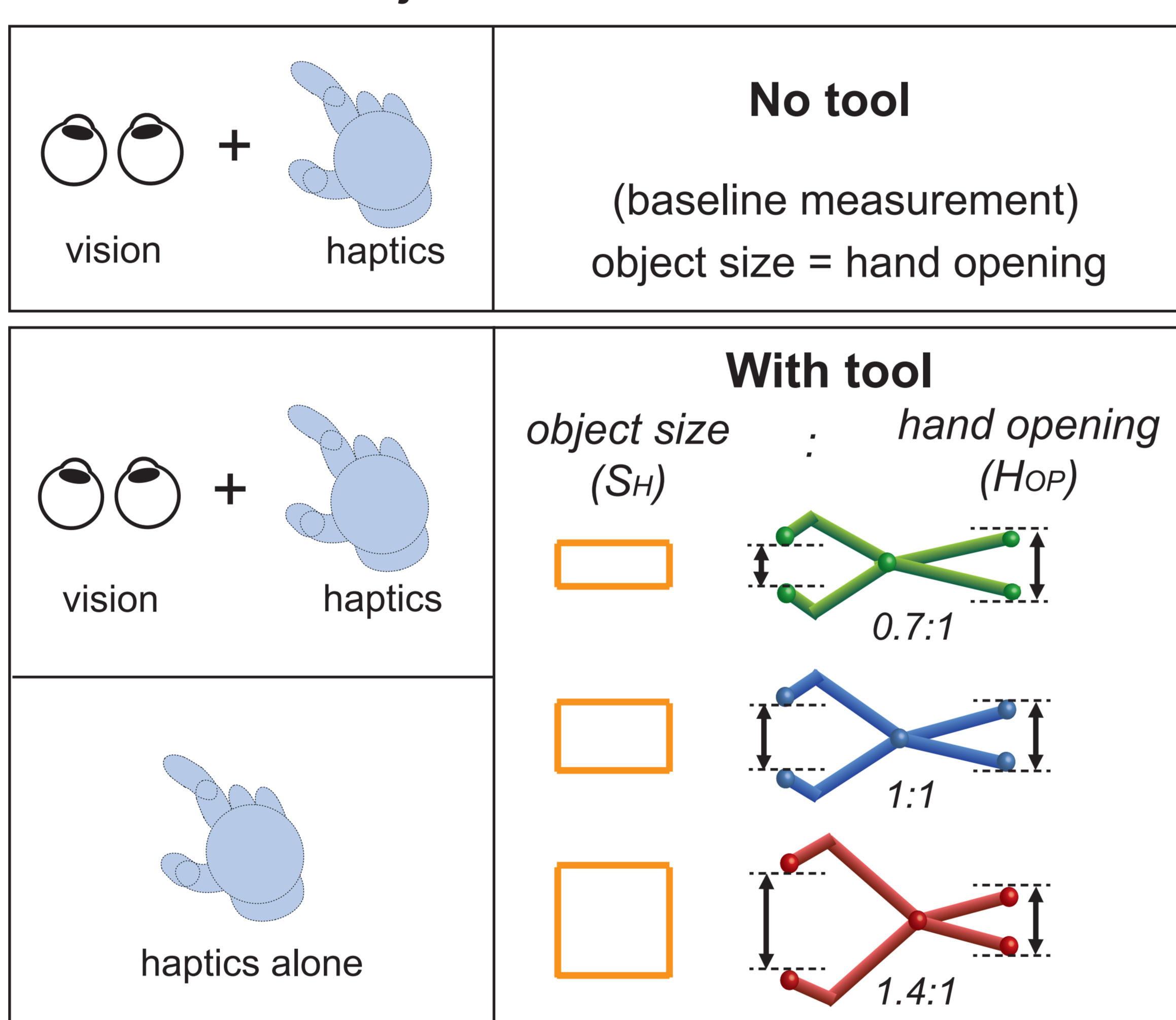


## Method

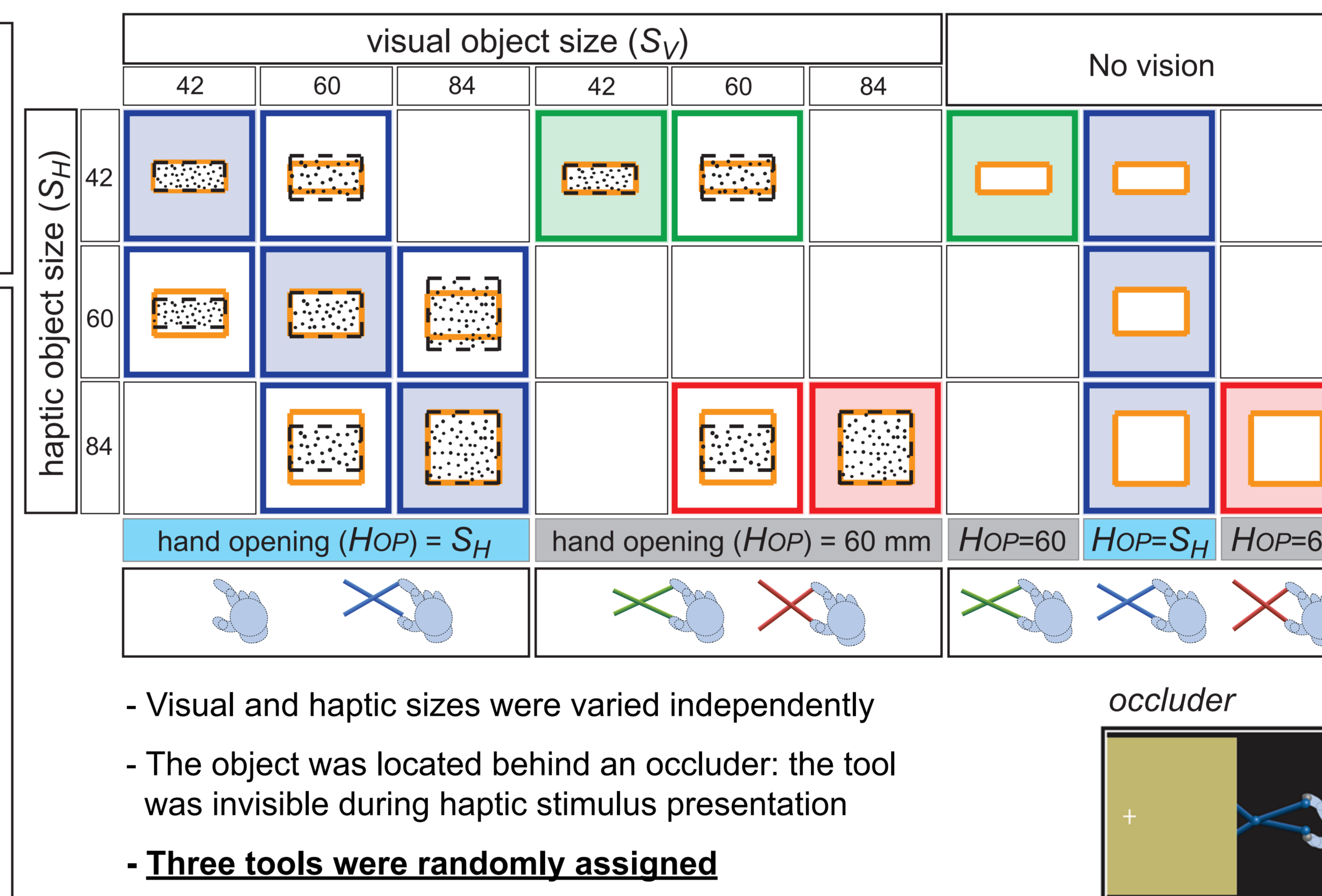
### PHANTOM device



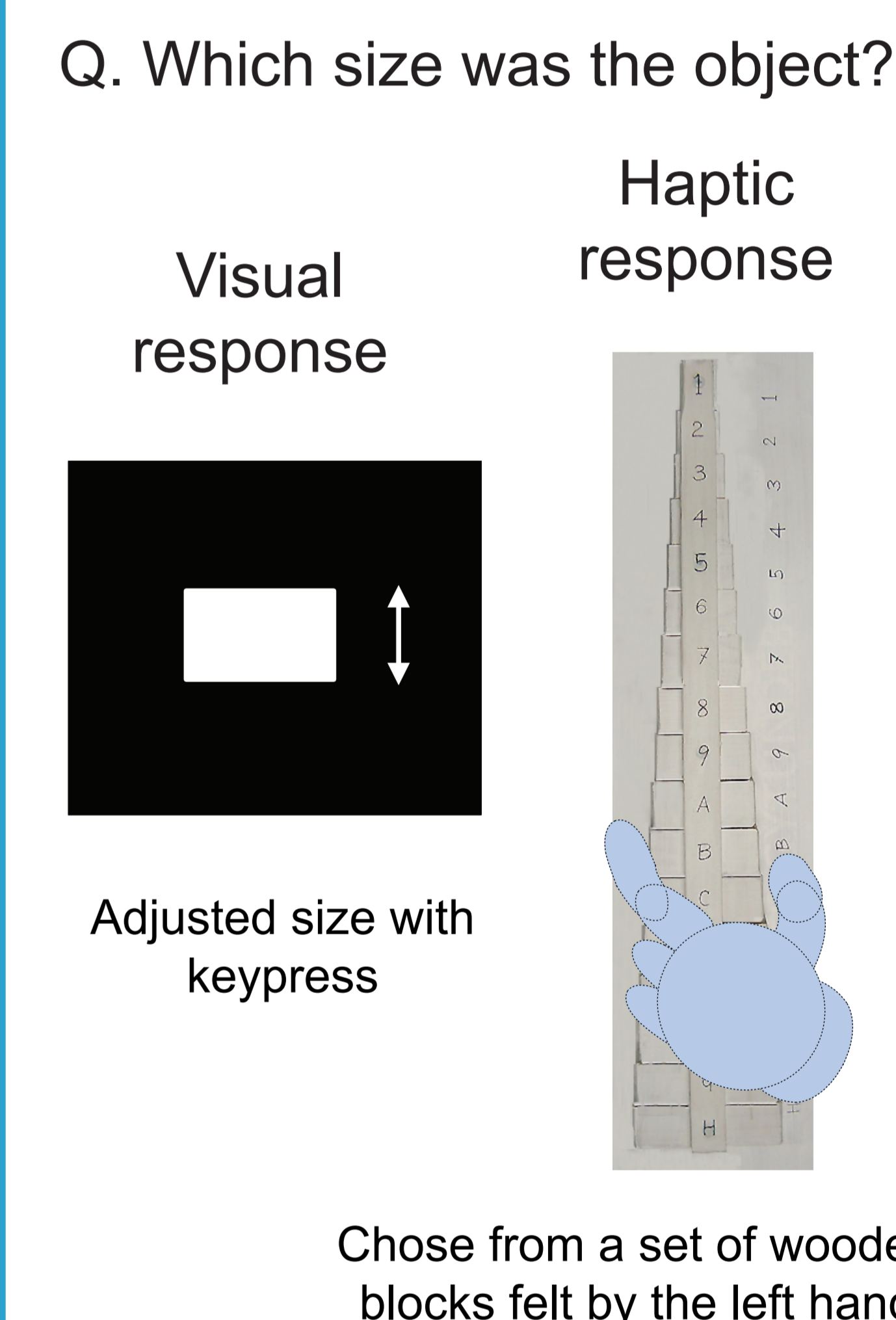
### Perceive an object size



### Explore period

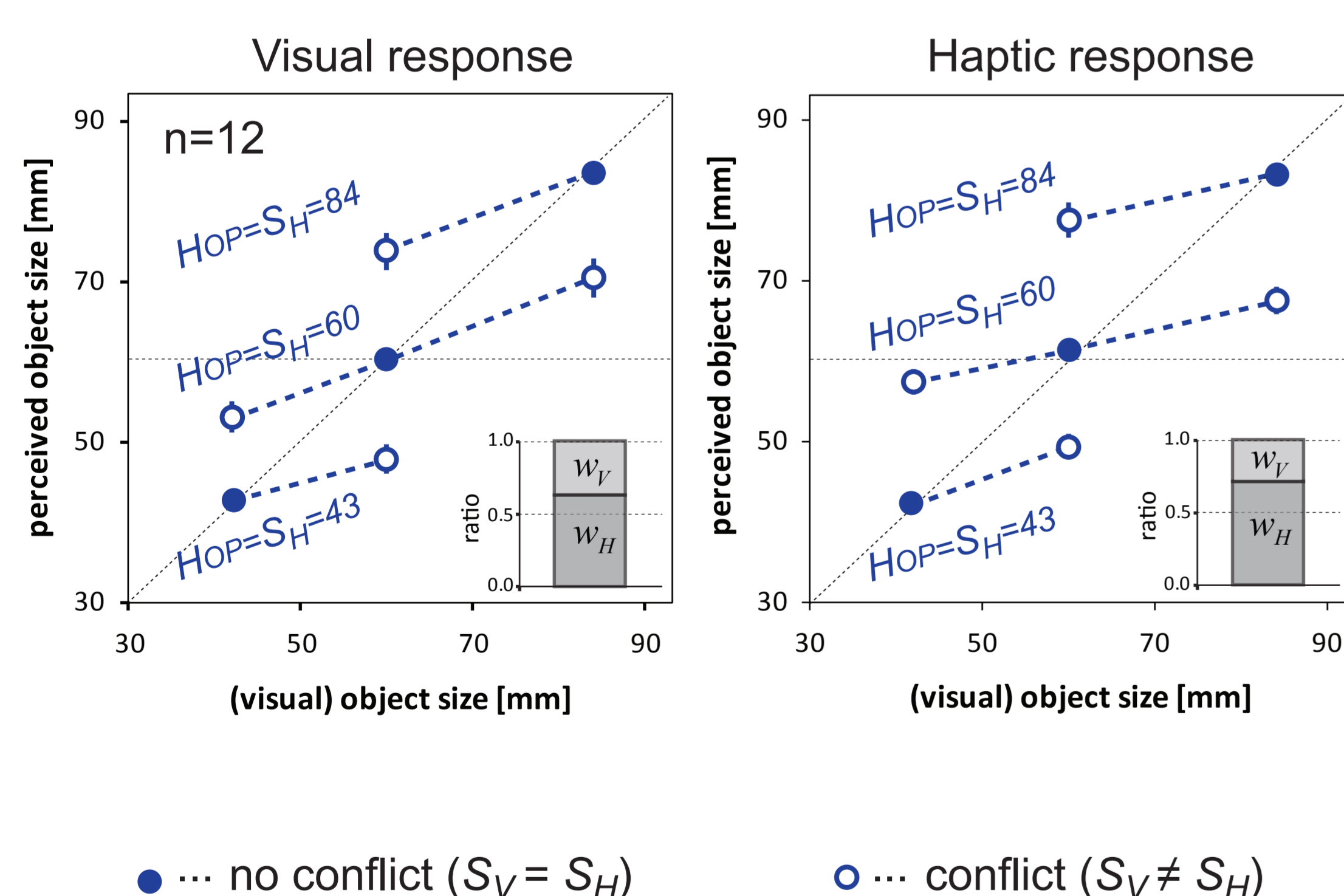


### Response period



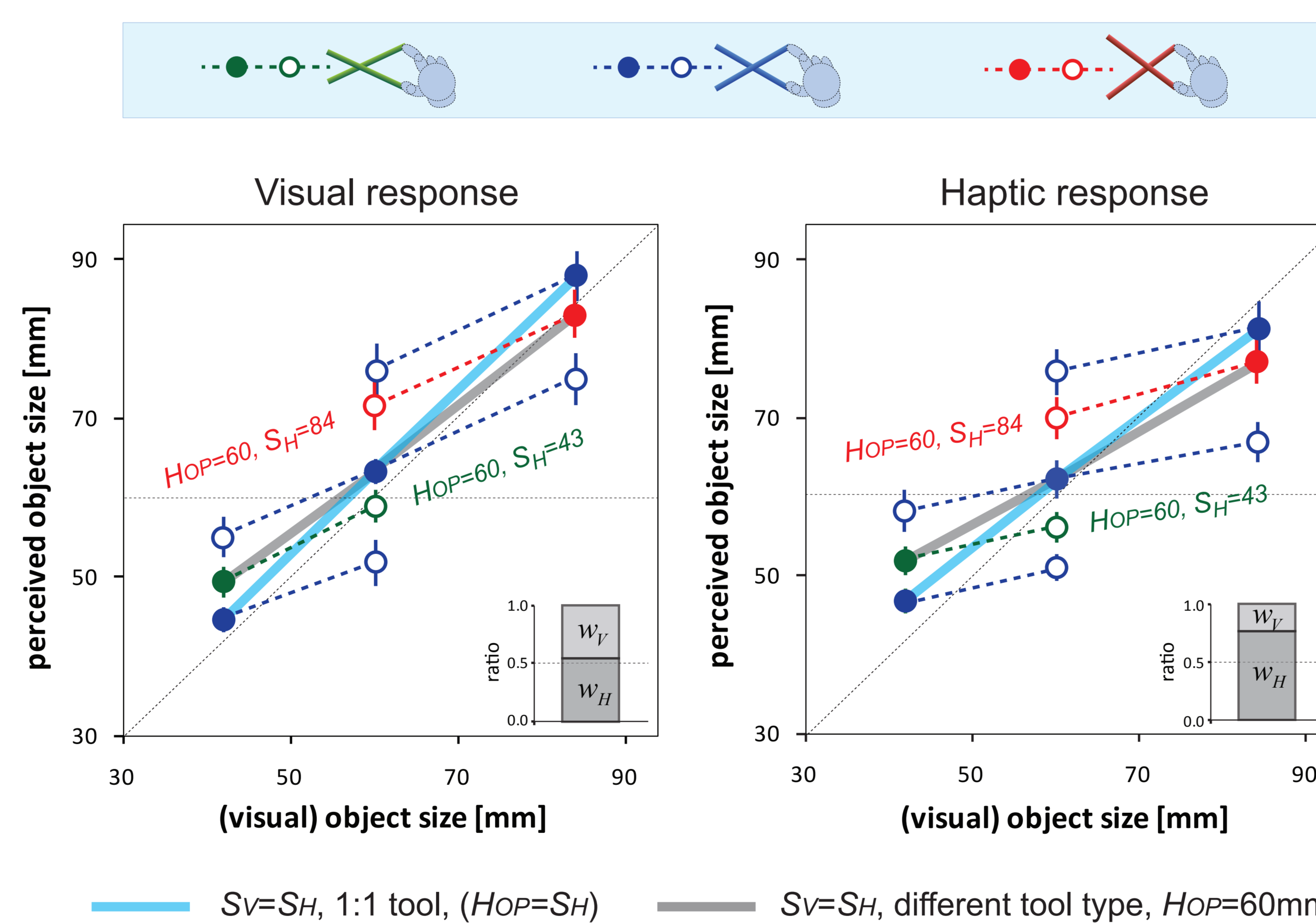
## Results

### No tool: Vision + Haptics

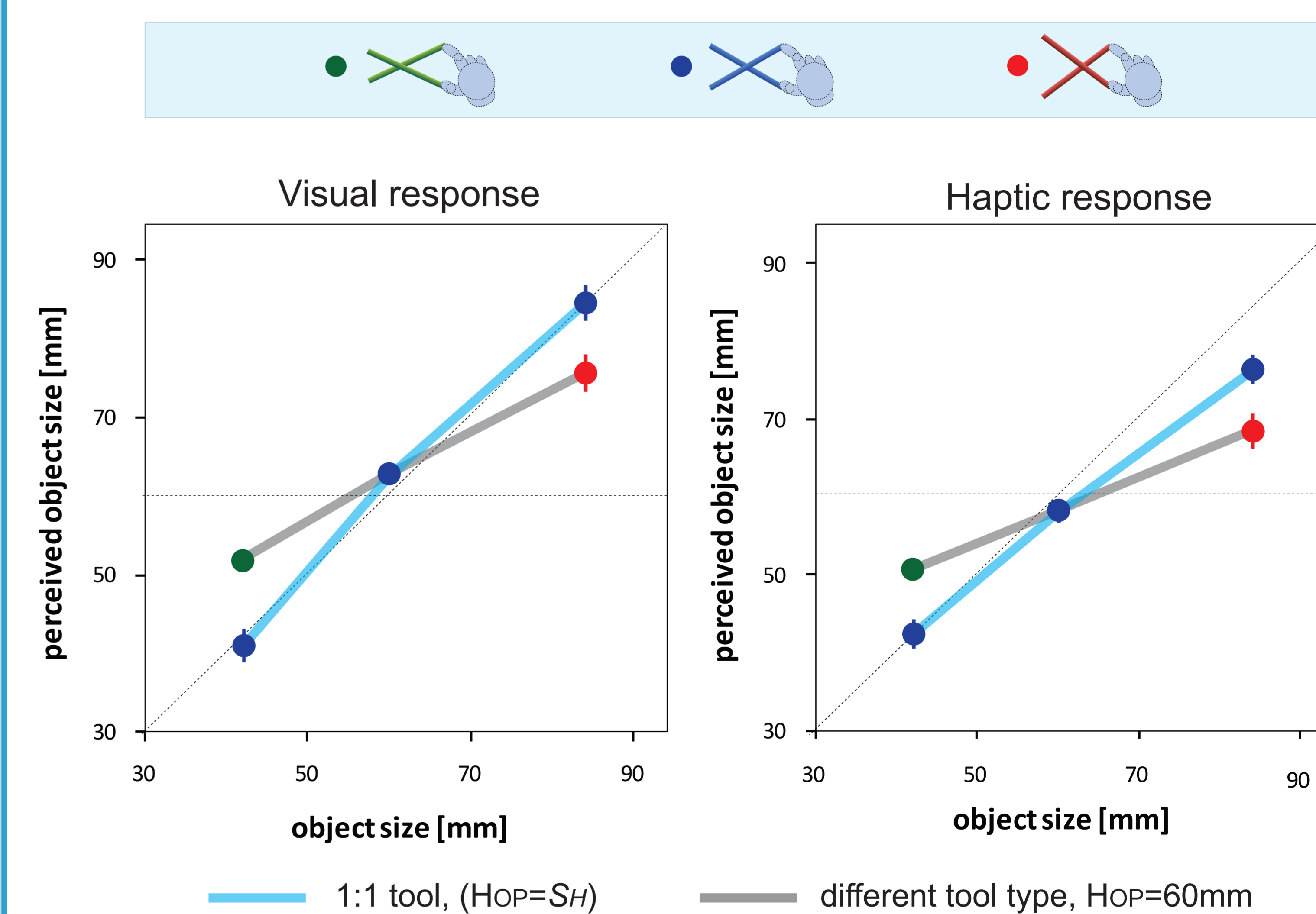


- $S_V$  and  $S_H$  contributed to perceive object size

### Vision + Haptics



### Haptics alone

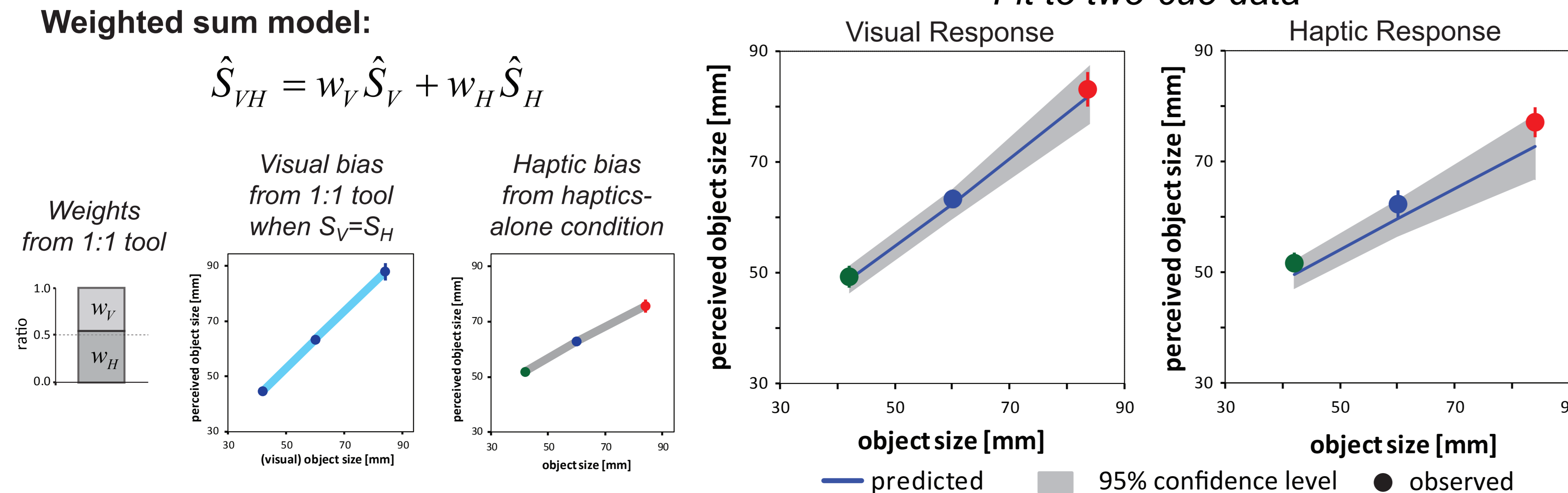


Is the rescaling of haptic estimates consistent, independent of which cues are available (vision + haptics vs. haptics alone)?

### Weighted sum model:

$$\hat{S}_{VH} = w_V \hat{S}_V + w_H \hat{S}_H$$

### Fit to two-cue data



## Conclusions

- The brain dynamically rescales haptic estimates, taking account of the geometry of tools. This rescaling is incomplete, however.
- Thus, the visual-haptic correspondence problem could be solved NOT on ‘raw’ haptic signals, but on rescaled haptic estimates, in ‘object coordinates’.
- We found similar rescaling of haptic estimates with tool use in (i) haptics alone, and (ii) vision-plus-haptics conditions, as well as across response modalities.
- These results are consistent with obligatory, dynamic rescaling of haptic estimates (at the ‘likelihood level’), to account for different relationships between hand opening and object size specified by haptics.