Bimanual Size Estimation: No Automatic Integration of Information across the Hands

C. Lange[1], R. L. Klatzky[2], and M. O. Ernst[1]

[1] Max-Planck-Institut für biologische Kybernetik, Postfach 2169, D-72012 Tübingen,
christoph.lange@tuebingen.mpg.de
[2] Carnegie Mellon University, Department of Psychology – Baker Hall 342c,
Pittsburgh, Pennsylvania 1521

Abstract. Sensory input is often integrated to gain a single estimate of the underlying physical property. Here we investigate if size estimates from the left and right hand are automatically integrated. Six subjects participated in a bimanual matching task. Subjects were presented (virtual) objects to be felt with either hand or with both hands. Their task was to reproduce the sizes after presentation. The bimanual stimuli either had the same size for each hand or there was a size conflict between the hands. We showed that there is no automatic integration and subjects retained access to both hands' size estimates.

1 Introduction

It has recently been shown that when seeing and feeling an object's size, these two perceptual estimates are automatically integrated into one single size percept of the object [2]. Bimanual tasks have been addressed in many studies, howewer, most of them deal with hand movement and manipulation of objects (e.g. [3]; see [4] for a review).

Here we ask whether the size estimate between both hands is also automatically integrated, or whether we retain access to the two individual estimates of the object sizes derived from the two hands. Subjects' task was to feel an object with both hands.

2 Material and Methods

To explore bimanual size integration we used a matching paradigm. The stimuli were rendered using PHANToM haptic devices. Subjects felt the size of an object either with only the left or the right hand (uni-manual conditions) or with both hands simultaneously (bimanual conditions) for 1.5 seconds. In our setup, the thumbs were fixed in a gimble, and the index fingers operated two PHANToMs, such that subjects could perform a precision grip in either hand. All conditions were randomly intermixed. After exploration subjects indicated the perceived size with the same hand by opening their finger and thumb to the appropriate aperture. In the bimanual matching condition subjects indicated the

perceived size in each hand sequentially. There were two bimanual conditions, one in which the left and right hand felt exactly the same sized object and one in which there was a size conflict of 1 cm between the left and right hand. We chose a conflict of 1 cm because this is a size difference that is big enough for investigating the desired effect, but small enough to not be reliably detected by the subjects [1]. These conflict conditions were used for detecting any possible crosstalk between the two hands' size estimates. Six right-handed subjects participated in the experiments.

Fig. 1. Four-Finger PHANToM setup: The subjects' index fingers are put into one PHANToM force feedback roboter each, their thumbs are fixed in a gimbal on the bar in the front.

2.1 Statistics

To explore differences in size estimation between right and left hand, we used the Welch modification of Student's t-Test [5] to check for differences between slope and intercept of a linear regression line through the subjects' means of the reported sizes as shown in Fig. 2. A simple pairwise t-Test directly on the data was not possible due to the stimulus size offset we introduced by having a base size difference of 2 cm, but a conflict of only 1 cm. To have no significant difference between left and right hand means, that neither slope nor intercept differ signifficantly between hands.

3 Results

For the unimanual conditions we found good scaling (Fig. 2), although small sizes are overestimated and big sizes are underestimated. There is no difference between left and right hand responses.

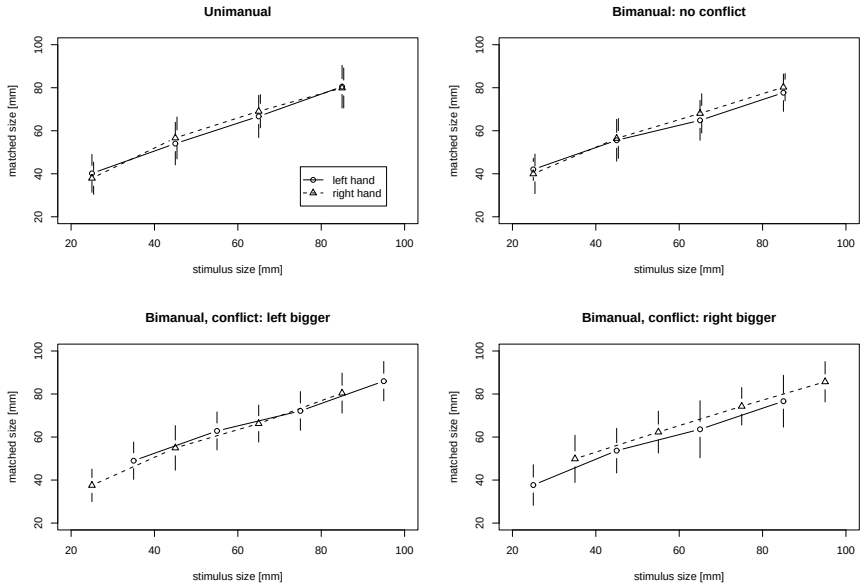

Fig. 2. Matched sizes plotted against presented sizes in the four different conditions. Shown are the means over subjects of the means of each subject's ten repetitions of every condition.

For the bimanual conditions we only analysed the first responses, because second responses were contaminated by a clear memory effect (i.e. increased variance, regression to the mean).

The size matches of the bimanual no-conflict condition are not different from the uni-manual responses. However, the variance in these responses increased. This may be due to the fact that subjects now had to remember two instead of only one size estimate. The increased variance is clearly inconsistent with integration.

In the bimanual conflict conditions, there seems to be a small effect between the left and right hand responses. However, this difference is non significant. Furthermore, if this effect should result from a crosstalk between the two hands estimates, this bias effect should be in the opposite direction—a bigger stimulus size in the one hand should result in a bigger estimate in the other hand and vice

versa. In conclusion, there seems to be no automatic integration of information between the two hands' estimates.

4 Discussion

We found no automatic integration of size across the hands. The fact that we can access both estimates independently seems reasonable, because we usually do not feel the same object with both hands, and if so it will mostly not be at the same position on the object, so that the size estimates between the hands usually differ and could even be used as a shape cue. We will now further investigate whether the human perceptual system is able to integrate these signals optimally when forced to.

References

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