Vibrotactile spatial acuity on different regions of the back

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I. Introduction

An important factor in the design of vibrotactile displays is the spatial distribution of the tactors (i.e. vibration motors). It may be desirable to have a higher tactor density in areas with higher spatial acuity. Spatial acuity is known to vary over body regions [1]. Here we determined vibrotactile spatial acuity in four areas on the back in two orientations: horizontal and vertical.

II. Method

Thirteen participants performed the experiment (age range 18-31 years, one left-handed, 7 female). The experiment was approved by the local ethics committee. Participants wore a T-shirt. The vibrotactile display consisted of 9 tactors (Elitac wearables development kit, ERM motors type 312-101, Precision Microdrives, set to the highest frequency 158.3 $\pm$ 2.4 Hz of vibration) positioned as shown in Figure 1. The vibrotactile display was fastened with an elastic band wrapped around the torso. Using the centre point of the centre tactor as a reference at 8 cm left or right of the spine the four back areas were defined as follows: Upper/Middle/Lower left areas: at the height of the armpit/halfway between armpit and navel/navel; Middle right area: halfway between armpit and navel.

Participants sat in front of a computer on a stool. During a trial two tactors sequentially switched on for 500 ms with a break of 500 ms in between. Distance between the two tactors was 2, 4, 6 or 8 cm. Participants were notified about the orientation (horizontal or vertical) and indicated the perceived direction (left – right or up – down). Each of the 16 distance and direction (left, right, up, down) combinations was repeated 16 times (256 trials per back area). For each combination spatial acuity was determined by fitting a psychometric function (a cumulative Gaussian using a GLM with Probit link function) to determine the Just Noticeable Difference (JND).

III. Results

Figure 1 shows the JNDs for each back area and it can be seen that JNDs for the vertical orientation were larger than for the horizontal orientation for all back areas. A 3 x 2 (left back area x orientation) repeated measures ANOVA on the left back areas showed an effect of orientation only ($F(1,9) = 26.2, p = 0.0012$). Also, comparing the left and right side with a 2x2 (side of spine x orientation) repeated measures ANOVA showed an effect of orientation ($F(1,9) = 29.8, p = 0.008$) only. The JND averaged over all back areas was 2.8 ± 0.2 cm (Mean $\pm$ SE) for the horizontal orientation and 6.1 ± 0.7 cm for the vertical orientation.

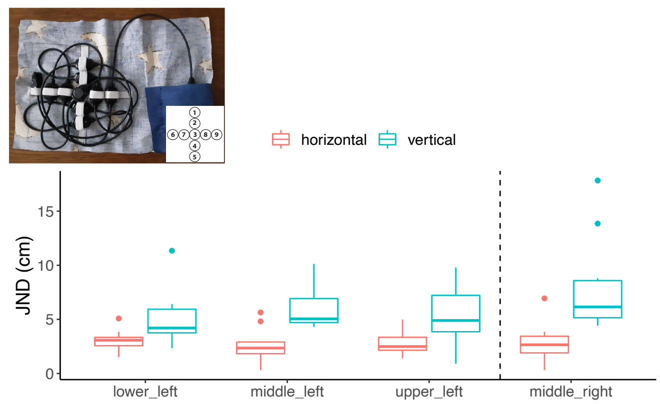

Fig. 1. Boxplot of the JNDs for the four different back areas and the two orientations. The thick horizontal line indicates the median, the box indicates the 25% to 75% interval and the whiskers indicate the total range without outliers. Dots indicate outliers. The inset shows the configuration of the tactors.

IV. Discussion

We found an effect of orientation, but not of back area. The JNDs were larger in the vertical orientation than in the horizontal orientation by roughly a factor two. This confirms earlier results by Hoffmann and colleagues [2]. It is also consistent with Weber's findings that tactile spatial acuity is higher across the body width than along the body length using pressure [3]. The absence of an interaction effect between back area and orientation in our results indicates that this anisotropy of acuity is constant across the back areas that we tested. The considerable difference between the horizontal and vertical acuity should be taken into consideration when deciding on tactor spacing.

References

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