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Haptic Discrimination of Curved Strips

Sylvia C. Pont, Astrid M. L. Kappers, and Jan J. Koenderink

Helmholtz Institute, University of Utrecht, The Netherlands

The pychophysics of touch is still in its infancy. The aim of the present research is to investigate the discrimination and categorization of two- and three-dimensional shapes in a quantitative way. With mathematically well-defined forms, we systematically vary the available structure during the haptic process to get insight into the most important factors, such as joint position and pressure. In haptics, both kinesthetic and cutaneous stimulation play a role.

Until now discrimination of curved strips by touch has not been investigated systematically for different positions of the stimulus relative to the hand. We have to do so if we wish to identify the roles played by the different parts of the hand in the natural exploration of three-dimensional objects. Davidson (1972) investigated the haptic judgments made by blind and sighted participants regarding actively touched curved strips and concluded that it is the scanning technique that determines the veridicality and repeatability of the judgments. Goodwin, John, and Marceglia (1991) investigated the discrimination of curvature with the test surface being passively touched with the fingerpad of the index finger. They found absolute thresholds of +4.9 /m and -5.4/m for convex and concave surfaces, respectively. The maximum curvature of the stimuli we used in the present investigation was +1.0/m and -1.0/m, and thus could not be distinguished from a flat surface by using only cutaneous information from a single fingerpad.

Method

Here we report on the discrimination of a straight strip from curved strips. The curved strips had a curvature in the range -1.0/m (concave) to +1.0/m (convex). The participant had to judge by using static touch which of two successively presented stimuli was the more positively curved. All combinations were presented 5 (participant RB) or 4 (participant SP) times in one order and 5 or 4 times in the other order in a random way. Psychometric curves were determined from the percentages of correct judgments. The basic dependent variable was the 84%-correct discrimination threshold.

This experiment was done for several different positions on the hand (see Figure 1). Because of the heterogeneous structure of the hand, we expected the results to vary with position. Also two separate conditions were investigated for all tested positions: In one condition the participant had to put the palmar side of the right hand on the stimulus which rested on the table, in the other the participant had to put the dorsal side of the

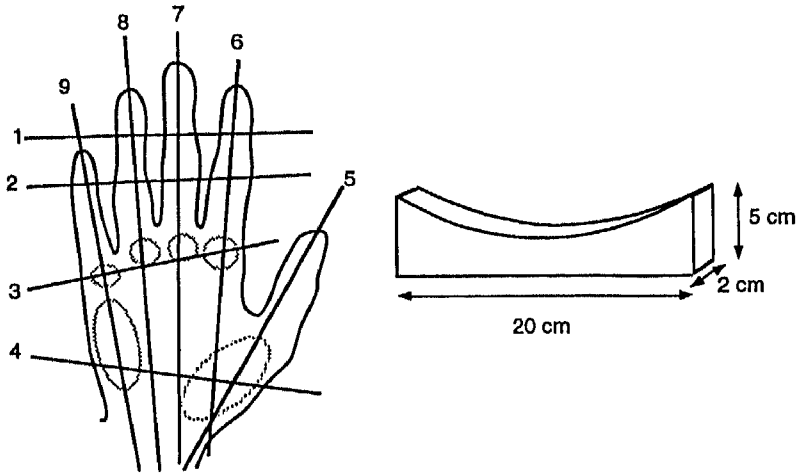

Figure 1. The nine different positions, and a concave curved strip.

hand on the stimulus fixed upside-down to a stable frame above the hand. Two control conditions were tested for participant SP. For Positions 4 and 7 the position of the stimulus was reversed for the dorsal and palmar condition (so that the hand had to be turned palm-upwards). Two hundred trials were run in about 40 minutes. The palmar and dorsal conditions were measured separately because of practical limitations. So far, two participants have been tested in this task.

Results and Discussion

Figure 2 show the discrimination thresholds for Participants SP and RB. It is very clear that discrimination was always poorer for the dorsal than palmar condition. This effect seems to be larger for positions 1 to 5 than for positions 6, 7, and 8. The hand was turned palm-upwards in the control experiments but the discrimination was again poorer for the dorsal condition than for the palmar condition. So this effect cannot have been caused by the experimental set-up.

The results show that discrimination of curved strips is poorer with the dorsal than palmar side of the hand. A possible explanation is that the density of cutaneous receptors is lower on the dorsal side. Discrimination of curved strips was best in both conditions when the strips were placed along the second to fourth fingers. We will extend this investigation by determining the thresholds for the discrimination of convex, straight, and concave strips for all 9 different positions in the palmar and dorsal condition for several participants.

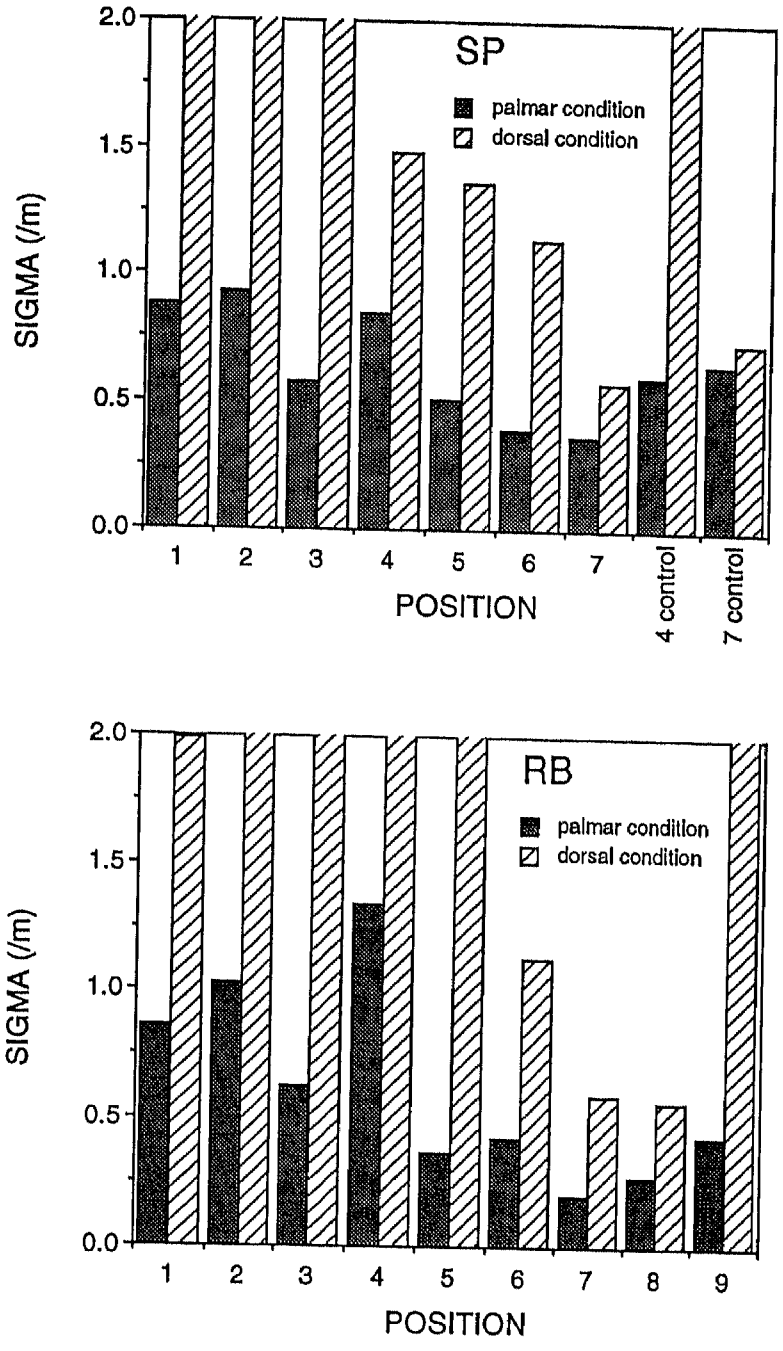

Figure 2. Resulting sigmas for Participants SP (top) and RB (bottom).

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