Cognition 131 (2014) 254–262

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Brief article

Categorical perception of tactile distance

Frances Le Cornu Knight [a,*], Matthew R. Longo [b], Andrew J. Bremner [a]

[a] Sensorimotor Development Research Unit, Department of Psychology, Goldsmiths, University of London, United Kingdom
[b] Department of Psychological Sciences, Birkbeck, University of London, United Kingdom

ARTICLE INFO

Article history:
Received 1 June 2012
Revised 23 January 2014
Accepted 25 January 2014

Keywords:
Self perception
Body representation
Tactile perception
Categorical perception
Tactile acuity

ABSTRACT

The tactile surface forms a continuous sheet covering the body. And yet, the perceived distance between two touches varies across stimulation sites. Perceived tactile distance is larger when stimuli cross over the wrist, compared to when both fall on either the hand or the forearm. This effect could reflect a categorical distortion of tactile space across body-part boundaries (in which stimuli crossing the wrist boundary are perceptually elongated) or may simply reflect a localised increased in acuity surrounding anatomical landmarks (in which stimuli near the wrist are perceptually elongated). We tested these two interpretations across two experiments, by comparing a well-documented bias to perceive mediolateral tactile distances across the forearm/hand as larger than proximodistal ones along the forearm/hand at three different sites (hand, wrist, and forearm). According to the 'categorical' interpretation, tactile distances should be elongated selectively in the proximodistal axis thus reducing the anisotropy. According to the 'localised acuity' interpretation, distances will be perceptually elongated in the vicinity of the wrist regardless of orientation, leading to increased overall size without affecting anisotropy. Consistent with the categorical account, we found a reduction in the magnitude of anisotropy at the wrist, with no evidence of a corresponding localised increase in precision. These findings demonstrate that we reference touch to a representation of the body that is categorically segmented into discrete parts, which consequently influences the perception of tactile distance.

1. Introduction

The spatial representation of tactile information is no mean feat. We must resolve numerous cutaneous and neural variations (Cholewiak, 1999; Hagert, Forsgren, & Ljung, 2005; Ochoa, 2010; Penfield & Boldrey, 1937), and also perceptual distortions (Cody, Gaarside, Lloyd, & Poliakoff, 2008; Green, 1982; Longo & Haggard, 2011; Weber, 1834/1996). There is certainly no straightforward one-to-one spatial correspondence between skin surface and neural region (Longo, Azañón, & Haggard, 2010). One potential solution to these challenges is to represent touch, not in terms of metric extent, but rather according to salient body parts and anatomical landmarks. Here, we investigated how the representation of distinct body parts affects the spatial perception of touch.

The body is not one continuous sheet: it has a clear landscape with well-defined contours and observable segments. Investigating the structuring effect of body-part boundaries on tactile distance perception, de Vignemont, Majid, Jola, and Haggard (2009) reported an intriguing perceptual warping of distance over the wrist. Tactile distances presented proximodistally along the length of the limb were perceived to be larger when they crossed

* Corresponding author. Address: Goldsmiths, University of London, Lewisham Way, New Cross, London SE14 6NW, United Kingdom. Tel.: +44 0207 078 5127/0776 652 5374.

E-mail address: f.knight@gold.ac.uk (F.L.C. Knight).

http://dx.doi.org/10.1016/j.cognition.2014.01.005
0010-0277/

over the joint in comparison to the same distances presented entirely within the bounds of either the hand or the forearm. Does the presence of distinct body parts drive this perceptual distortion of tactile distance?

These results could be explained by either of two contrasting accounts. Firstly, de Vignemont et al. (2009) interpret this perceptual warping as reflecting a perceptual segmentation of the body, with the joints forming the boundaries of body-part categories. This kind of categorical segmentation is comparable with the way in which colour terms influence hue discrimination (e.g., Kay & Kempton, 1984). Alternatively, these results may be based on differential acuity across the body: The distance distortion may reflect an increase in acuity in the vicinity of anatomical landmarks such as the wrist (Cholewiak & Collins, 2003; Cody et al., 2008; Weber, 1834/1996). Given that perceived tactile distance is known to relate systematically to acuity (i.e., *Weber's illusion*, Taylor-Clarke, Jacobsen, & Haggard, 2004; Weber, 1834/1996), increased acuity in the vicinity of the wrist could cause a general increase in perceived tactile distance. Existing data do not differentiate between these two interpretations.

We developed a novel method to test whether perceptually increased tactile distance traversing the wrist reflects categorical perception of tactile distance over body-part boundaries (the categorical account) or overall increases in perceived distance in the *vicinity* of the wrist (the localised acuity account). Our method was based on the following prediction: If the categorical account is true then tactile distances should be increased whenever they cross over the wrist boundary (i.e., in the proximodistal orientation), but not when they run parallel to the wrist boundary (i.e., in the mediolateral orientation). Alternatively, if the acuity account is correct, then increases in tactile distance should be seen at the wrist, regardless of orientation. Tactile distance perception is known to exhibit anisotropies on both the forearm (Green, 1982) and the hand (Longo & Haggard, 2011), with stimuli running mediolaterally, across the limb being perceived as larger than stimuli running proximodistally, along the limb.

Therefore, the categorical account makes the critical prediction that the magnitude of anisotropy should be reduced for stimuli crossing the wrist, compared to those presented entirely on the hand or forearm. Conversely, according to the localised acuity account the anisotropy will remain constant. Therefore, a reduction in the anisotropy at the wrist is predicted by the categorical – but not the localised acuity – account. No change in the anisotropy at the wrist would suggest that the perceptual elongation of distance over the wrist as found by de Vignemont et al. (2009) may in fact be driven by a localised increase in acuity around anatomical landmarks. Fig. 1 provides a visual depiction of how tactile perception would be distorted on the wrist according to the differing accounts.

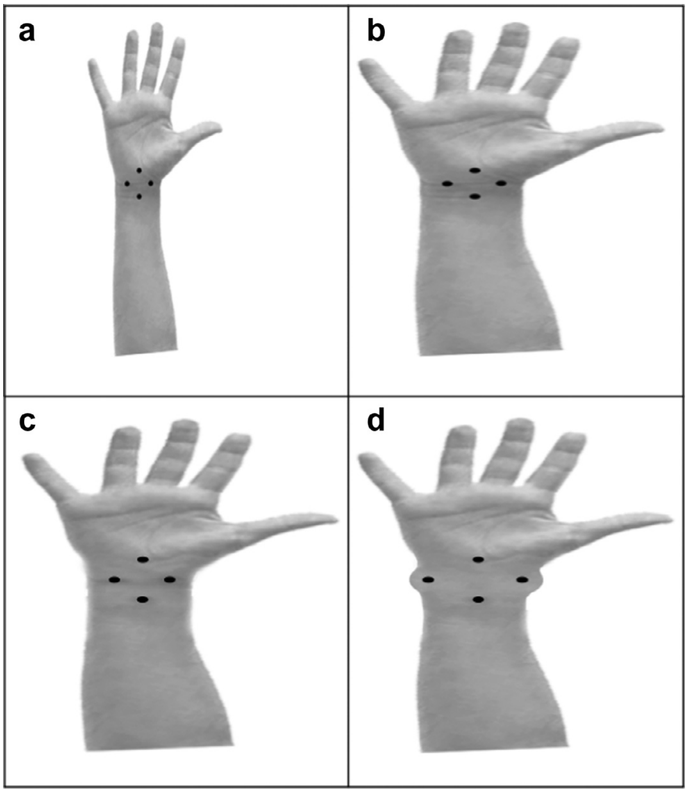

Fig. 1. An image depicting example points of stimulation across and along the ventral wrist (a and b) indicates how these would be perceived according to the known mediolateral bias. We also illustrate perceptual distortions at the wrist according to the two accounts being investigated in this paper (over and above the mediolateral bias): the categorical account (c) shows a selective proximodistal elongation, whereas the localised acuity account (d) assumes a perceived increase in distance in both axes at the wrist.