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My true face: Unmasking one's own face representation

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ABSTRACT

Face recognition has been the focus of multiple studies, but little is still known on how we represent the structure of one's own face. Most of the studies have focused on the topic of visual and haptic face recognition, but the metric representation of different features of one's own face is relatively unknown. We investigated the metric representation of the face in young adults by developing a proprioceptive pointing task to locate face landmarks in the first-person perspective. Our data revealed a large overestimation of width for all face features which resembles, in part, the size in somatosensory cortical representation. In contrast, face length was compartmentalised in two different regions: upper (underestimated) and bottom (overestimated); indicating size differences possibly due to functionality. We also identified shifts of the location judgments, with all face areas perceived closer to the body than they really were, due to a potential influence of the self-frame of reference. More importantly, the representation of the face appeared asymmetrical, with an overrepresentation of right side of the face, due to the influence of lateralization biases for strong right-handers. We suggest that these effects may be due to functionality influences and experience that affect the construction of face structural representation, going beyond the parallel of the somatosensory homunculus.

1. Introduction

The face represents one of the most social parts of our body, it is our presentation to the world and how others remember us. The face defines us more than any other body part, and is involved in important and complex functions, such as eye-hand coordination, eating or speaking. The face is instrumental to create a sense of self, and to construct our identity (Tsakiris, 2008). Threats to face integrity cause severe loss of the sense of identity, such as after face disfigurement (Callahan, 2005). Despite this, self-face representation is not static and is susceptible to representational plasticity and multisensory influences. This plasticity is an adaptive quality to maintain a coherent sense of self despite the subtle physical changes that faces experience with the passage of time (Felisberti & Musholt, 2014; Walton & Hills, 2012). Representational plasticity is also a shared characteristic with other body areas. For instance, the hands are susceptible to modulation of sensory information as the effects of extensive practice (e.g., Cocchini, Galligan, Mora, & Kuhn, 2018; Cavina-Pratesi, Kuhn, Ietswaart, & da Milner, 2011), which may reflect functional-anatomical modifications of underlying regions of the brain (e.g., Burton, Sinclair, & McLaren, 2004; Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995). Self-face representation is also linked to attractiveness criteria, with a preference for having larger eyes and small nose, and self-esteem (Felisberti & Musholt, 2014).

The representation of the body and in particular, of the hands, has been widely studied, highlighting the importance of the different multisensory influences to construct a coherent representation. In contrast, face research has been predominantly focused on face recognition across sensory modalities (Casey & Newell, 2005), whilst few attempts have been made to study the underlying body model as per other body parts. In previous studies, there is a predominant use of depictive tasks that rely on visual information, for example, pointing to different locations for size estimation on a computer screen (Fuentes, Runa, Blanco, Orvalho, & Haggard, 2013), drawing the head's outline (Bianchi, Savardi, & Bertamini, 2008) or using visual estimation tasks (D'Amour & Harris, 2017; Felisberti & Musholt, 2014; Linkenauger et al., 2015). In general, the representation of the face is distorted, showing a tendency to overestimate width and underestimate length (D'Amour & Harris, 2017; Fuentes et al., 2013; Linkenauger et al., 2015). However, it is not clear that these techniques capture the representation of one's own face specifically, and not another's face. Studies using tactile information have also shown a pattern of distortions on the forehead similar to the hand when using the two-point discrimination task, as both skin areas have similar acuity (Miller,

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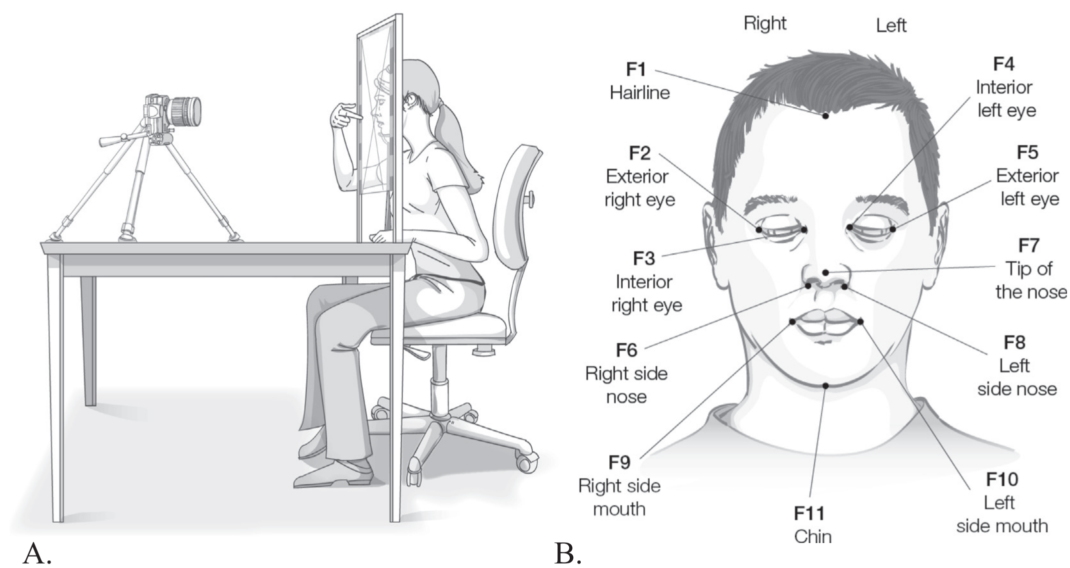

Fig. 1. Face apparatus (A) and face landmarks (B).

Longo, & Saygin, 2016). Another study, using participants' face pictures, in a forced-choice paradigm, showed a tendency to perceive the nose size less accurately than the size of the mouth or of the eyes (Felisberti & Musholt, 2014). Whilst these do capture how one's own body is represented, they do not capture a pure structural representation (Longo & Haggard, 2010, 2012) within personal space. Thus, there remains an important gap in understanding how one's own face is represented.

With this in mind, we designed an experiment to assess the influence of proprioception in the metric representation of the face by pointing in first-person perspective: that is, pointing *towards* one's own face. We aimed to examine size judgements for different face features by developing a novel version of the localisation task, which enables us to discern the metric representation of the face within personal space.

Previous studies on structural representation have suggested an influence of somatosensory representation on size perception (e.g. Longo, Azañón, & Haggard, 2010), and it has been proposed that the somatosensory homunculus may provide the base system from which an implicit body model is based. Facial features occupy differently-sized areas in the somatosensory homunculus, with the mouth and tongue area overrepresented (McCormack, 2014). If it is true that homuncular size representation influences perceived size of the body part, highly represented features will be perceived as bigger. Thus, we hypothesized a distorted representation of face features, with an overestimation of areas such as the mouth, compared to the nose. Additionally, different face portions have different mobility, which may affect body size perception. Previous studies have shown overestimation of highly movable body parts, such as the ankle (Stone, Keizer, & Dijkerman, 2018) and wrists (Longo, 2017), and a compartmentalised representation of upper and lower face regions (Fuentes et al., 2013). Thus, we sought to study size differences between the representation of top (eyes) and bottom (mouth) face areas anticipating overestimation for areas whose movement tends to change shape and size to a much greater extent (bottom). Lastly, we analysed the possible spatial shift that underlies the aforementioned distortions of face representation. Studies have shown a tendency to overestimate the right side of the body for right handers (Hach & Schütz-Bosbach, 2010), and this may be a characteristic also shared by the face. For this, we calculated the horizontal and vertical shifts in pointing judgements, to consider the symmetry of these judgements.

2. Methods and procedure

2.1. Participants

An a priori power analysis for one sample *t*-test with an effect size of 0.8, α of 0.05, and power of 0.8 was carried out to set the sample size in G* Power (Faul, Erdfelder, Buchner, & Lang, 2009). Previous studies on body representation have used one sample *t*-test for the localisation task, reporting average effect sizes of 0.8 for finger lengths (i.e., Ganea & Longo, 2017). The power analysis indicated the adequate sample size would be of 15.

Seventeen participants (10 females and 7 males) between 19 and 39 years of age (M = 24.67; SD = 5.39) were recruited. On average, participants had 16.5 years of formal education (SD = 1.2).

Handedness was assessed with the Oldfield Questionnaire (Oldfield, 1971), on which scores range is from −1 to 1. Scores below −0.5 indicate left-handedness; scores over +0.5 indicate right-handedness and scores between −0.5 and +0.5 indicate ambidextrosity. All participants but one (score = 0.36) were considered right-handed (M = 0.90; SD = 0.11; range −1 to +1).

The study was approved by the Goldsmiths Research Committee and it was carried out in accordance with the Declaration of Helsinki (BMJ 1991; 302: 1194). All participants gave written consent.

2.2. Face apparatus and procedure

Participants were comfortably sat in front of a table. A vertical acrylic sheet (30 × 30 cm) resting on two metal posts (20 cm of height) was placed in front of them. A chin rest was positioned on the edge of the table, between the participant and the acrylic sheet. To take into consideration the curved shape of the face introducing some lateral distortion, the face was positioned very close to the acrylic setting (1 cm from the tip of the nose).

A Nikon D3200 camera (single-lens reflex digital camera, 24.2 megapixels, 18–55 mm VR lens, 1.5× FOV crop, 23.2 × 15.4 mm DX-format CMOS APS sensor) was positioned on a tripod in front of the sheet at 90 cm from it. The camera focus was exactly on the centre of it, and camera lens was set at 18 mm. Attached to the sheet there were two measuring tapes, one along the left edge and another along the top edge, to facilitate conversion of pixels into centimetres for later analyses (see Fig. 1A).

A small black dot (1–2 mm of diameter) was drawn on participants' right index fingernail as reference for later analysis of pointing