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Short Communication

Taking someone else's spatial perspective: Natural stance or effortful decentring?

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ABSTRACT

When perceiving stimuli, self-centred and decentred perspectives can be adopted. In the present study, we investigate whether perceivers have a natural perspective that constrains their spatial perception, with some people perceiving better with self-centred than decentred perspectives and vice versa for other people. We used a recognition task of tactile ambiguous letters (b, d, p, and q) presented on the stomach, for which three perspectives can be adopted (trunk-centred, head-centred, and decentred). At first, the participants were free to adopt any perspective they wanted. Then, either the same or a different perspective was imposed on them. Without constraints, 80% of the participants adopted a self-centred perspective (50% trunk-centred, 30% head-centred) and 20% a decentred one. The perspective adopted freely appears to be natural as recognition performance decreases with a different perspective and returns to its previous high level with the same perspective. Thus, to perceive space, some perceivers adopt naturally a perspective centred on themselves whereas others take naturally others' perspective.

1. Introduction

Perceivers can adopt different spatial perspectives that are either centred on their own location (i.e., self-centred) or else on a different location (i.e., decentred). On the one hand, self-centred perspectives underlie self-consciousness by binding together the multisensory experiences and the physical body (Ferrè, Lopez, & Haggard, 2014; Vogeley & Fink, 2003). Consequently, self-centred perspectives are often seen as having some sort of primacy in terms of spatial cognition (e.g., Epley, Morewedge, & Keysar, 2004). On the other hand, the ability to adopt the perspective of others is crucial when it comes to communicating and interacting with them (Schober, 1993). Decentred perspectives can be spontaneously adopted in collaborative situations (Duran, Dale, & Kreuz, 2011) and even in situations where communication is not required (Thirioux, Jorland, Bret, Tramus, & Berthoz, 2009; Tversky & Hard, 2009). In addition, as a consequence of certain personality traits – for instance, being dominated or dominant (see Galinsky, Magee, Inesi, & Gruenfeld, 2006) – some people adopt the perspective of others whereas other people adopt their own perspective. One important question is whether people have a natural stance to adopt either self-centred or decentred perspectives. In the present study, we target this question using the tactile ambiguous symbol recognition task.

Tactile perception is interesting for the investigation of spatial perspectives because self-centred (e.g., perception from our body) and decentred perspectives (e.g., perception from outside the body) conflict with each other. Moreover, more than one self-centred perspective exists: the perspective can be centred either on the stimulated surface or on a central body part (e.g., the head; Harrar & Harris, 2010; Ho & Spence, 2007). In this sense, the recognition of ambiguous tactile symbols displayed on the body surface such as the letters b, d, p, and q (Ferrè et al., 2014; Natsoulas & Dubanovski, 1964; Parsons & Shimojo, 1987; Sekiyama, 1991; for a review, see Arnold, Spence, & Auvray, submitted for publication) provides an excellent paradigm with which to investigate the perspectives that are naturally adopted by perceivers. The same perceived stimulation can be interpreted as corresponding to different symbols, as a function of the perspective that is taken when interpreting the stimulation. For example, when the letter b is drawn on a participant's stomach (from the viewpoint of the experimenter located in front of them), three different perspectives can be adopted (see Fig. 1): a decentred perspective oriented toward the participant's stomach (response b); a trunk-centred perspective oriented forward the participant (response d); a

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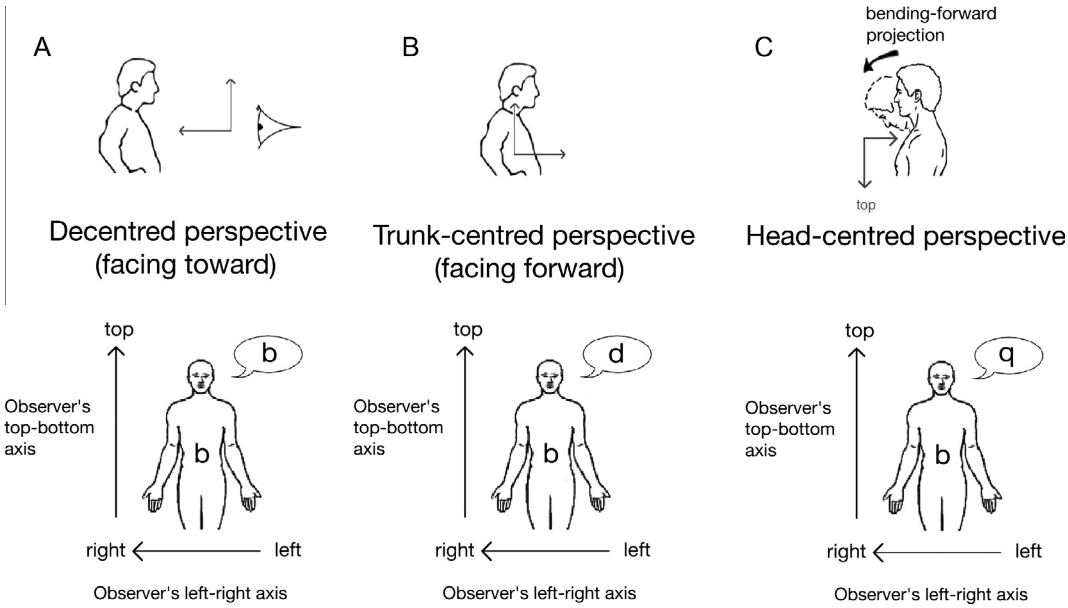

Fig. 1. Illustration of the three possible perspectives that participants can adopt when interpreting ambiguous symbols displayed on the body surface. In this figure, the lowercase letter "b" is drawn on the participant's stomach from the experimenter's perspective. Top row: the spatial perspective that can be inferred from the participant's responses. Bottom row: the different responses reported by participants. (A) Perception of the letter "b", resulting from the adoption of a decentred perspective whose origin is located in front of the participant. (B) Perception of the mirror-reversed letter "d", resulting from a trunk-centred perspective. The horizontal and vertical axes of the letter are assigned congruently to the participant's trunk. (C) Perception of the 180°-rotated letter "q", resulting from a bending-forward head-centred perspective.

head-centred perspective, as if the head was bending forward to "see" the tactile stimulation (response q).

Important inter-individual differences have been observed in the recognition of ambiguous tactile symbols with preferences to adopt one of the three possible perspectives (Sekiyama, 1991). However, one important question that has not been directly addressed is whether perceivers have a natural perspective that constrains their spatial perception. Do some perceivers perceive better from a self-centred perspective whereas other perceivers perceive better from a decentred perspective? The aim of the present study was therefore to investigate whether individual preferences for self-centred vs. decentred perspectives reflect the natural perspectives that people adopt. Tactile symbols were presented on the stomach, for which three different perspectives can be adopted (see Fig. 1). In order not to risk biasing the participants toward the experimenter's perspective, symbols were not drawn manually by the experimenter (which was the case in all previous studies) but by means of a matrix of vibrators.

To test the *natural perspective* hypothesis, the instructions given to the participants were varied in terms of the perspective that was to be adopted. First, the participants were free to adopt any perspective that they wanted, thus allowing us to evaluate their baseline preferences. Second, different perspectives were imposed on the participants. These corresponded either to the same or to a different perspective than the one that they had adopted freely. These imposed perspectives allowed for the evaluation of any cost associated with adopting an unnatural perspective. If the perspective that is adopted freely is natural, then imposing a different perspective should produce a cost in terms of recognition performance. Some perceivers should perform better with self-centred than decentred perspectives and vice versa for other perceivers. On the other hand, if participants are not constrained by a natural perspective, one possibility is that imposing a different perspective should not induce a cost. However, as decentred perspectives are more demanding than self-centred perspectives (Epley et al., 2004; Natsoulas, 1966), another possibility is that all of the perceivers would perform better with a self-centred than with a decentred perspective, independently of the perspective adopted freely. Finally, in order to evaluate whether the cost of adopting an unnatural perspective is simply explained by changes in perspectival instructions or by the difficulty that is associated with disengaging from a perspectival choice, we evaluated whether performance would improve when the participants returned to the natural perspective after adopting an unnatural one. If the cost of adopting a different perspective is explained simply by changes in instruction or the difficulty that is associated with disengaging from a perspectival choice, returning to the natural perspective adopted freely should not increase performance.

In addition, we evaluated whether the ability to adopt an unnatural perspective would be influenced by visuo-spatial abilities and by the natural perspective. We thus compared the cost of adopting an unnatural perspective in those participants who adopted the trunk-centred, head-centred, and decentred perspective. However, only the two perspectives for which the vertical axis is not reversed (i.e., the trunk-centred and decentred) were imposed. The decentred perspective was imposed on participants who freely adopted the trunk-centred perspective and vice versa for the decentred participants. For the head-centred participants, the trunk-centred perspective was imposed for one half and the decentred for the other half. The head-centred perspective was not imposed because the top–bottom axis is less prone to confusion than the left–right axis. Left–right confusion occurs when a self-centred or a decentred perspective is imposed on participants (Natsoulas, 1966). However, vertical confusion is less frequent because the vertical assignment is influenced, on the one hand, by both the external environment (i.e., gravity) and the orientation of the egocentric top–bottom axis (i.e., the head–foot axis; Oldfield & Phillips, 1983), and, on the other, by the orientation of the head with a head-centred perspective (Sekiyama, 1991). Moreover, when the vertical axis is reversed, consequently to the adoption of a head-centred perspective, there is only one possible left–right assignment.

2. Methods

2.1. Participants

Eighty participants completed the experiment (44 females; mean age = 26.6 years, range = 19–47), including participants who adopted freely the trunk-centred ($N = 20$), the decentred ($N = 20$), and the head-centred ($N = 40$) perspectives. The head-centred participants were divided into two groups ($N = 20$), one adopting the trunk-centred perspective and the other the decentred perspective. In addition to the 80 participants who performed the present experiment, a further 170 participants performed the first session and were then included in other studies (see Participants in the Supplementary Materials for details concerning the classification of the participants in the different groups). The participants provided informed consent and received payment for taking part in the study. The experiment was performed in accordance with the ethical standards laid down in the Declaration of Helsinki (1991).

2.2. Apparatus

The tactile stimuli were presented by means of 9 rectangular vibrators (Haptuator Mark II, Tactile Labs, Montreal, Canada) arranged in a 3-by-3 array with a centre-to-centre spacing of 5 cm (see Fig. 2a). A nine-channel amplifier drove each vibrator independently at a frequency of 250-Hz. The vibrator array was placed on the participant's stomach symmetrically to their body mid-sagittal line. Only one layer of clothing was allowed between the skin and the vibrators and the participants individually selected the intensity of each vibrator by means of a method of adjustment. The participants wore noise-reducing headphones with a noise reduction rating of 30 dB, in order to mask any sounds made by the vibrators.

2.3. Stimuli

The lower-case letters b, d, p, and q were presented. The tracing of these letters consisted of a sequence of 8 vibrotactile stimuli mapping the trajectory of vibrations as if the letters were traced beginning from the stem (see Fig. 2b). The same order of strokes was used for each letter, instead of respecting the conventions of normal manual writing, because the order in which the various strokes are made in normal manual drawing can itself provide a cue to letter recognition (Parkinson & Khurana, 2007). Note that it could be argued that tracing the letters from the stem end could have biased the participants' responses toward the letter "b", given that only this letter is written in this way. However, each letter was reported equally often by participants (24.8% of trials for the b, 24.9% for the d, 25.5% for the p, and 24.8% for the q; $F(3, 237) < 1$, *ns*). The duration of each vibration was 250 ms with no interval between consecutive vibrations, resulting in a total duration of 2-s for the presentation of each letter.

2.4. Procedure

The experiment was composed of three sessions of the letter recognition task, followed by the completion of the Mental Rotation Test (MRT; Vandenberg & Kuse, 1978) and the Object Perspective Taking Test (OPTT; Hegarty & Waller, 2004). In Session 1, the participants were free to adopt any perspective that they wanted to recognize letters. In Sessions 2 and 3, they were instructed to adopt a specific perspective. In one of these two sessions, the imposed perspective was the same as in Session 1. In the other session, the imposed perspective was different. Half of participants performed Session 2 with the same perspective as in Session 1 and performed Session 3 with the different one. The other half did the opposite.

Participants gave their responses by pressing the corresponding key on the computer keyboard with the index finger of their preferred hand. The participants were instructed to keep their head oriented upright during the letter tracing, so that they do not see their stomach. The participants were able to give their responses at any time from the onset of the first vibration and up to 3000 ms after the end of the last vibration. At the end of each trial, there was an interval of 3000 ms before the start of the next trial.

Each of the three sessions was composed of 3 blocks of 16 trials (4 presentations of each of the 4 letters). At the beginning of Session 1, the participants performed a practice block with one presentation of each letter. At the beginning of Sessions 2 and 3, the practice block was composed of 3 presentations of each letter. During the practice blocks, feedback was presented indicating that the participant has given a response that was either correct or incorrect. Feedback was not presented during the test blocks but the participants were informed of their percentages of correct responses and mean response times at the end of each block.

3. Results

3.1. Proportions of each perspective adopted freely and consistency in the perspective adopted

Across all participants ($N = 250$; 150 females; mean age = 25.2 years, range = 18–47) who completed the task under free instructions, 49.6% adopted the trunk-centred, 29.2% the head-centred, and 21.2% the decentred perspectives. Around 4 out of 5 participants thus adopted a self-centred perspective (centred either on

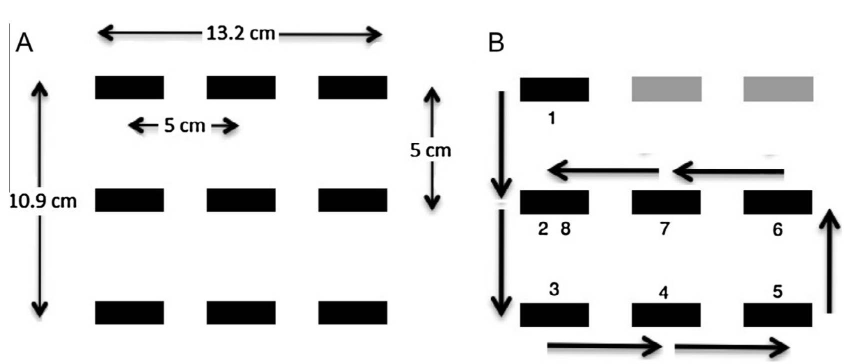

Fig. 2. (A) Schematic figure illustrating the 3 × 3 array of rectangular vibrators. (B) The sequence of 8 vibrations for drawing the letter b. The duration of each vibration was 250 ms, without intervals between each vibration.

their head or on their trunk), whereas only 1 out of 5 adopted a decentred perspective.

For the 80 participants who performed the entire experiment, the consistency in the perspective adopted was high: 82% in Block 1, 92% in Block 2, and 96% in Block 3 (see the Supplementary Materials for more details on consistency). The consistency was not significantly different for those participants adopting the trunk-centred (88.4%), the head-centred (93.3%), and the decentred (88.8%) perspectives ($F(2,77) = 1.00$; $p > .250$). There was no significant difference between the 3 groups with respect to response times (RTs) during Session 1 ($F(2,77 < 1$; *ns*). The three perspectives were thus not more or less demanding when participants were free to adopt their natural perspective.

3.2. Cost of perspective change

In order to evaluate the cost of adopting an unnatural perspective, ANOVAs were conducted on accuracy and RTs with Block (1-1, 1-2, 1-3, 2-1, 2-2, 2-3, 3-1, 3-2, 3-3; the first number indicates the Session and the second the Block) as a within-participant factors and the Order of imposed perspectives (same-different, different-same) as a between-participants factor. With accuracy, there was a significant main effect of Block ($F(8,624) = 9.45$; $p < .001$; $\eta^2 = .108$) and a significant interaction between Block and Order of imposed perspectives ($F(8,624) = 7.77$; $p < .001$; $\eta^2 = .091$). The cost of perspective change was evaluated by comparing recognition performance in blocks 1-3 and 2-1 for those participants who adopted the different perspective in Session 2 (different-same order), and in blocks 2-3 and 3-1 for those participants adopting the different perspective in Session 3 (same-different order). There was a significant cost associated with participants adopting the different perspective in Session 2 (a decrease of 9.3 percentage points in accuracy; $F(1,78) = 25.44$; $p < .001$; $\eta^2 = .246$) and for participants adopting the different perspective in Session 3 (a decrease of 7.2 percentage points; $F(1,78) = 11.65$; $p = .001$; $\eta^2 = .130$) (see Fig. 3a).

There were also training effects within sessions, with the participants making fewer errors after consecutive blocks with the same perspective (significant for both groups in Session 1, all *ps* < .001; approaching significance for the different perspective in Session 2, $p = .054$, and the different perspective in Session 3, $p = .080$). In order to make sure that the cost of adopting a different perspective was not merely explained by a lack of training, we compared recognition performance in Blocks 1-1 and 2-1, in Blocks 1-2 and 2-2, and in Blocks 1-3 and 2-3, for those participants who adopted the different perspective in Session 2. There was a significant cost in Block 2-2 (a decrease of 5.9 percentage points in accuracy; $F(1,78) = 6.80$; $p < .05$; $\eta^2 = .075$) and 2-3 (a decrease of 5.6 percentage points; $F(1,78) = 10.65$; $p < .01$; $\eta^2 = .130$), but not in Block 1 2-1 (an increase of 3.4 percentage points; $F(1,78) < 1$; *ns*). However, performance in Block 1-1 was low, probably because the participants were not yet familiar with the task. Except for the first block, performance was thus better for the natural than for the unnatural perspective, even when the participants received the same amount of training in each perspective. Note that we did not make these comparisons for those participants adopting the different perspective in Session 3 because they kept their natural perspective in Session 2 and received thus more training with the natural than the unnatural perspective. However, the cost was not significantly different for participants adopting the unnatural perspective in Session 2 (decrease of 9.4 percentage points in accuracy) and in Session 3 (decrease of 7.2 percentage points; $t(78) < 1$; ns).

Importantly, a significant improvement in accuracy was also observed for participants returning to their perspective in Session 3 (an increase of 5.3 percentage points in accuracy; $F(1,78) = 6.36$; $p = .014$; $\eta^2 = .075$). This improvement indicates that the decrease in recognition performance with the different perspective was neither produced by a change in perspectival instructions, nor by the difficulty associated with disengaging from a perspectival choice, but by the difficulty that the participants experienced when trying to adapt to an unnatural perspective.

With respect to the RT data, there was a significant main effect of Block ($F(8,624) = 46.89$; $p < .001$; $\eta^2 = .375$) and a significant interaction between Block and Order of imposed perspectives ($F(8,624) = 43.78$; $p < .001$; $\eta^2 = .359$) (Fig. 3b). A significant cost of adopting an unnatural perspective was observed in Session 2 (an increase of 436 ms in RT; $F(1,78) = 45.64$; $p < .001$; $\eta^2 = .369$) and in Session 3 (an increase of 768 ms; $F(1,78) = 70.48$; $p < .001$; $\eta^2 = .475$). RTs were also significantly shorter for participants returning to their natural perspective in Session 3 (a decrease of 441 ms; $F(1,78) = 23.22$; $p < .001$; $\eta^2 = .229$).

3.3. Cost as a function of the natural perspective

We evaluated whether the cost of adopting an unnatural perspective varied with the natural perspective of the participant (see Fig. 4). With respect to the accuracy data, the cost was significantly different from zero for the trunk-centred participants when adopting the decentred perspective (a decrease of 10.6 percentage points in accuracy; $Z = 5.23$; $p < .001$), the head-centred participants when adopting the trunk-centred perspective (a decrease of 7.2 percentage points; $Z = 2.33$; $p = .010$), and the head-centred participants when adopting the decentred perspective (a decrease of 12.8 percentage points; $Z = 3.15$; $p = .001$). For the decentred participants adopting the trunk-centred perspective, the difference approached significance (a decrease of 2.5 percentage points; $Z = 1.41$; $p = .080$). A one-way ANOVA revealed that the cost was significantly smaller for the decentred than for the self-centred participants ($F(1,76) = 5.34$; $p = .024$; $\eta^2 = .066$), without there being any significant differences between the 3 groups of self-centred participants (all *ps* > .172).

With respect to the RT data, the cost was significantly different from zero for all groups of participants (all *ps* < .001). A one-way ANOVA showed that the cost was significantly smaller for the decentred than for the self-centred participants ($F(1,76) = 6.75$; $p = .011$; $\eta^2 = .082$), without there being significant differences between self-centred participants (all *ps* > .116).

3.4. Influence of visuospatial abilities

With respect to mental rotation, there was a significant negative correlation ($r = -.34$; $t(78) = 3.10$; $p = .01$) between the score in the MRT and the cost of perspective change in accuracy: The greater the mental-rotation abilities, the smaller the cost. In addition, the trunk-centred (mean score = 26.7, SD = 7.9) and decentred participants (mean score = 28.5, SD = 7.3) showed greater mental-rotation abilities than the head-centred participants (mean score = 22.8, SD = 9.3; $F(2,77) = 3.38$; $p < .05$). With respect to visuo-spatial perspective taking, there was neither a significant correlation between the mean error in the OPTT and the cost of perspective change ($r = -.07$; $t(78) < 1$; *ns*) nor any significant differences between the groups ($F(2,77) < 1$; *ns*).

4. Discussion

The study reported here was designed to evaluate whether perceivers have a natural perspective that constraints their perception of stimuli presented on their body surface. When perceivers are free to adopt any perspective that they want, 80% consistently adopt a self-centred perspective (50% trunk-centred, 30% head-centred) while 20% adopt a decentred one. The fact that

A	Session 1 free	Session 2 imposed	Session 3 imposed
same-different	free	same	different
different-same	free	different	same

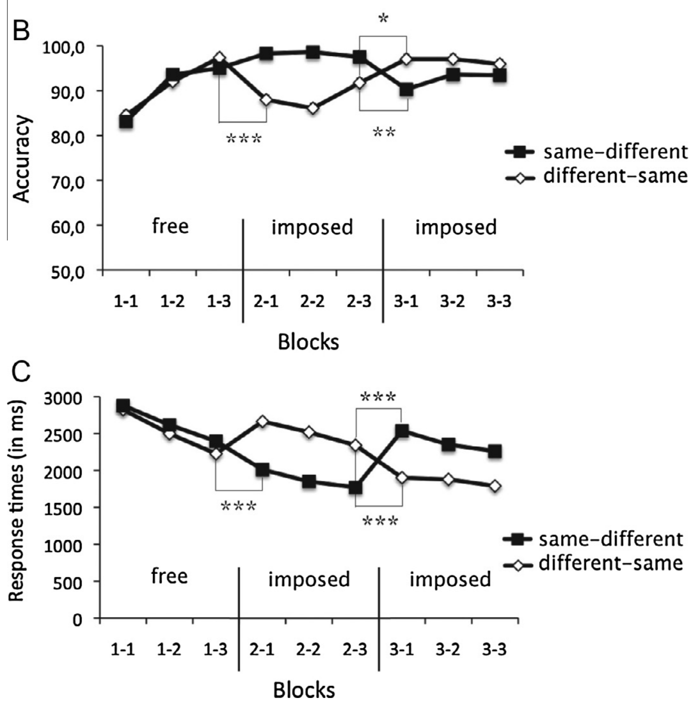

Fig. 3. (A) Illustration of the perspective imposed in each session for the two groups of participants. "Same-different" means that the imposed perspective was the same as in Session 1 for Session 2 and was different for Session 3. "Different-same" means that the imposed perspective was different for Session 2 and the same as in Session 1 for Session 3. Participants' (A) accuracy (percentage correct) and (B) response times as a function of Block and Order of imposed perspectives (same-different, different-same). For both accuracy and response times, the performance decreased significantly when imposing a different perspective and increased significantly when returning to the same perspective as in Session 1. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

recognition performance decreases with an unnatural perspective and returns to its previous high level with a natural one supports the view that the perspective adopted is natural. In addition, when a different perspective was imposed, the participants made more errors corresponding to the adoption of their natural perspective than other errors (see Quality of responses in the Supplementary Materials). Some of the observers perceive spatial relations better from a self-centred perspective whereas others perceive better from a decentred perspective. However, the greater cost for self-centred than decentred participants shows that decentred perceivers adopt more easily an unnatural perspective than self-centred perceivers.

The fact that the cost of adopting an unnatural perspective was correlated with mental rotation but not with visuo-spatial perspective taking also supports the existence of a natural perspective. When an unnatural perspective was imposed, the participants may have kept their natural perspective and then have mentally rotated the perceived letter rather than to really adopt the unnatural perspective (see Surtees, Apperly, & Samson, 2013, for the role of mental rotation in perspective taking), possibly explaining the slowing of RTs. The possible involvement of mental rotation when an unnatural perspective is imposed raises the question of what adopting a spatial perspective really means. It could just involve specifying the spatial coordinates that result from the perspective that is being taken (i.e., the left–right orientation of someone else's body space) without imagining the self being located at the decentred location.

In the present study, only 20% of the participants adopted a decentred perspective, which is less than reported in previous studies presenting ambiguous symbols on the stomach (50% in Sekiyama, 1991; 71% in Parsons & Shimojo, 1987). This difference can be explained by the fact that the symbols were presented by means of a matrix of tactile vibrators, thus avoiding the major bias that may have been present in previous studies toward adopting the experimenter's perspective (since they drew the stimuli on the participant's skin). Nonetheless, even though the experimenter was not present in our experimental setup, some people appear to prefer adopting a decentred perspective, thus suggesting that this perspective may be their default perspective. In future work, it would be interesting to quantify such natural decentring by directly comparing the probability of decentring for tactile devices and for experimenter-drawn stimuli.

Self-centred perspectives can be centred on the stimulated surface (the trunk) or on a central body part (the head). Sekiyama (1991) has demonstrated that this head-centred perspective is adopted only when the corresponding bending-forward movement of the head toward the stimulated surface is possible. This head-centred perspective may thus involve a kind of visual strategy. The fact that some perceivers naturally adopt such a visual perspective may be explained by their lower spatial abilities. It would also be interesting to evaluate whether blind individuals adopt this head-centred perspective less frequently than do sighted individuals. Similar proportions of self-centred and decentred perspectives have been reported in blind and sighted people (Shimojo, Sasaki,

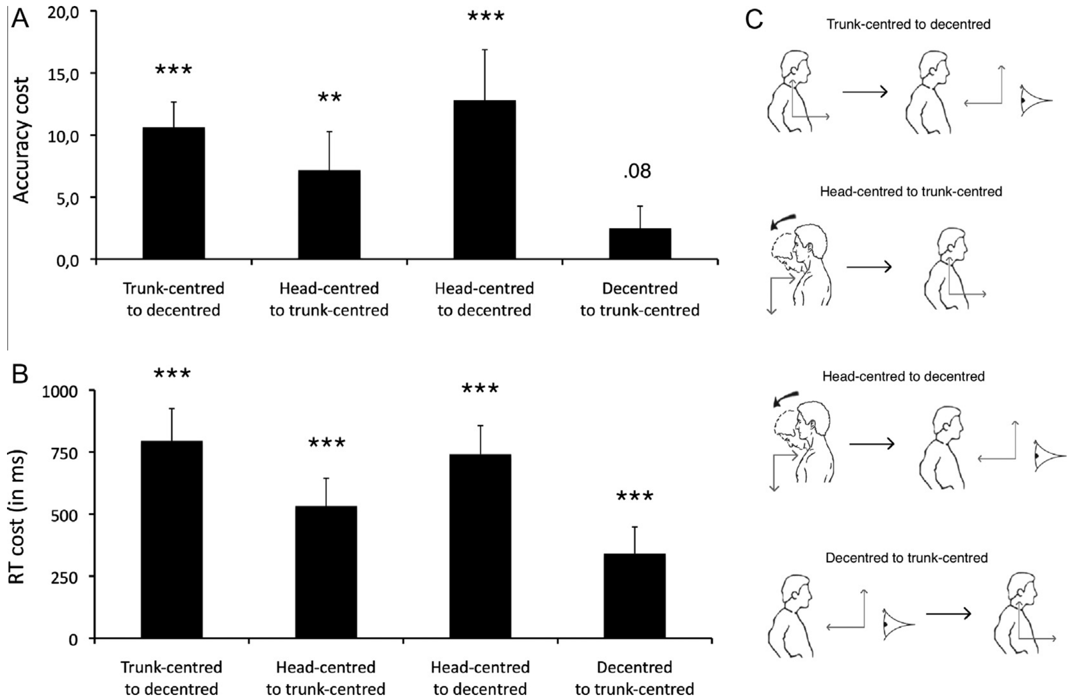

Fig. 4. Cost in (A) accuracy (percentage correct) and (B) response times when the different perspective was imposed on participants, as a function of the natural and the imposed perspectives. For example, 'trunk-centred to decentred' means that the cost was computed for the natural trunk-centred participants when adopting the decentred perspective. Error bars represent the standard errors of the means. The presence of asterisks indicates that the cost was significantly different from zero. $^{**}p < .01$, $^{***}p < .001$. (C) Schematic illustration of the natural and the imposed perspectives for the 4 different groups.

Parsons, & Torii, 1989) but the vertical inversion corresponding to the adoption of a head-centred perspective was not taken into account. Finally, the fact that vertical inversion was observed only when the head-centred perspective was adopted (see Quality of responses in the Supplementary Materials) reinforces previous observations that the top–bottom axis is less prone to confusion that the left–right axis (Oldfield & Phillips, 1983; Parsons & Shimojo, 1987; see also Farrell, 1979; Takano, 1998; Uehara, 2013). The vertical axis may thus be assigned before the horizontal axis when interpreting tactile symbols.

To conclude, the present study reveals that perceivers do not adopt the same perspective when interpreting ambiguous spatial information. Some perceivers prefer to perceive space from their own centred point of view whereas others prefer the point of view of another person. Even though decentred perspectives were adopted less frequently than self-centred ones, the natural adoption of a perspective decentred from the location of the body was observed (in 20% of the cases) in our study. Such spatial decentring also characterizes out-of-body experiences, where the self and the body are temporarily disconnected (Blanke, Landis, Spinelli, & Seeck, 2004; Ehrsson, 2007). Interestingly, a reinforcement of the processes anchoring the self to the body by galvanic stimulation of the vestibular system has recently been reported to bias participants toward self-centred perspectives in the ambiguous tactile symbol recognition task (Ferrè et al., 2014). The results of the present study, however, reveal that the adoption of a decentred perspective can reflect other processes than a sole distortion in the relation between the self and the body. Not only does it occur quite frequently, but it can also be considered as a stance crucial to know that other persons perceive the world in a differently way than we do and to understand how they perceive it.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2015.12.006.

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