Role of Points of Inflection in the Kinaesthetic Perception of Euclidean Distance and the Detour Effect

Henry Faineteau[1], Edouard Gentaz[2] & Paolo Viviani[1]

[1]FAPSE, Université de Genève, Suisse;
[2]CNRS, Laboratoire Cognition & Développement, Université Paris V, France;
Henry.Faineteau@pse.unige.ch

1 Introduction

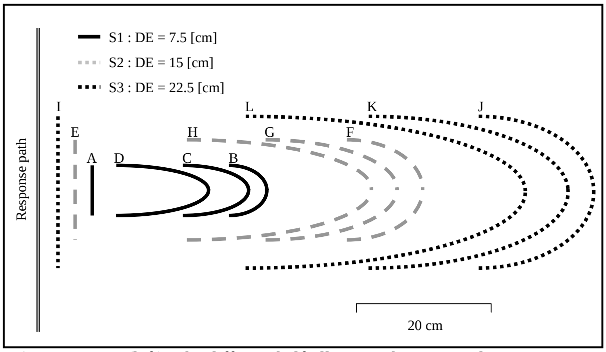
This study investigated the effect of the curved path followed by the hand on the estimation of the euclidean distance (straight-line) between the start- and end-points of the movement. This question has initially been raised in haptics by Lederman, Klatzky and Barber (1), who reported that the euclidean distance (ED) is increasingly overestimated when the length of the path exceeds twice the ED. More precisely, errors begin to increase only for paths covering relatively large portions of the working space, in the horizontal plane. Faineteau, Gentaz and Viviani (2) examined this question when the estimation is only based on the kinaesthetic cues. We investigated the effect that tracing a curved path with a stylus had on the judgment of the ED between the two endpoints of the path. The results showed that small paths yielded an overestimation of the ED, the errors increasing with the length of curvilinear paths. By contrast, the results for large paths showed that ED was consistently underestimated independently of the detour. We hypothesized that as the points of inflexion get closer in space and time for the small-scale paths, it became increasingly difficult to separate the sagittal (relevant) from the orthogonal (irrelevant) component of the displacement vector. To test this hypothesis, we investigated the estimation of the ED of half-elliptic paths (no points of inflection). If the presence of points of inflection increases the difficulty in estimating the ED, the detour effect should be reduced with these half-elliptic paths.

2 Method

Participant seated in front of a table placed horizontally. On the table was placed a Plexiglas board in which there were grooved several paths (Figure 1A). 12 paths divided into 3 sets (S1: {A, B, C, D}; S2: {E, F, G, H}; S3: {I, J, K, L}) were tested. Each set included one straight, and three curved paths. The straight paths (A, E and I) were 7.5, 15 and 22.5 cm long for S1, S2 and S3, respectively. For the half-elliptic paths, the ED between the endpoints was equal to the length of the straight paths (i.e. 7.5, 15, and 22.5 cm, respectively), and their length was either equal to 2, 3, or 4 times the ED tested. Blindfolded participant tracked with a stylus one of the 12 paths, and its endpoints were always aligned on her/his mid-sagittal axis. At the end of the tracking movement, the experimenter raised vertically the participant's hand, and placed the response path under the stylus by moving the board to the right. The participant was asked to estimate the ED by displacing the hand along the response path through a distance that she/he estimated to be subjectively equal to the ED between the endpoints of the path tracked in the encoding phase. Movements were recorded with the help of a digitizing table.

3 Results

The accuracy of the distance estimation was measured by the signed relative errors, i.e. the difference between the estimated and actual ED divided by the actual ED. Figure 1B summarizes the effects of scale and path length by pooling the data over directions, trials, and subjects. An ANOVA (3 [scale] × 4 [path length: 1×ED; 2×ED; 3×ED; 4×ED] × 2 [direction: disto-proximal; proximo-distal]) revealed significant effects of the scale factor ($F(2,20) = 11.8$; P=.003), and path length ($F(3,30) = 11.85$; P=.003). Most importantly, the scale × path length interaction was not significant ($F(6,60)=1.62$; P>.15). All other effects were not significant.



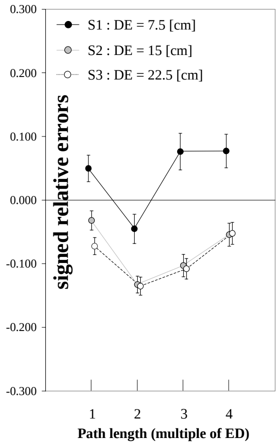


Fig 1A et B. A (left): The different half-elliptic paths presented.
B (right): Mean (±SD) of signed relative errors in Euclidean estimations as a function of scale and path length.

4 Discussion

The principal result was that the detour path effect, which was very conspicuous in the presence of points of inflection, no longer existed. The judgments of EDs for all paths were independent of the length of the detour. The tested paths included all the lengths already considered in a previous report (2), however, their trajectories were segments of ellipses shape, which have no points of inflection. Consequently, we argued that the detour effect arises because, at the points of inflection, it is difficult to isolate in the encoding movement the component that is parallel to the response movement (at points of inflection the balance between components changes). Whereas a veridical ED would require integrating only the parallel component over time, the (spurious) contribution of the orthogonal component inflates the estimated distance. The fact that the detour effect was much larger for small-scale paths, suggested that filtering out the orthogonal component becomes increasingly difficult as the points of inflection get closer in time and space. The absence of the detour effect when there are no points of inflection is fully in keeping with this hypothesis.

5 References

(1) Lederman, S.J., Klatzky, R.L., Barber, P.O.: Spatial and movement-based heuristics for encoding pattern information through touch, vol. 114. Journal of Experimental Psychology: General (1985) 33-49
(2) Faineteau, H., Gentaz, E., Viviani, P.: The kinesthetic perception of Euclidean distance: A study of the detour effect, vol 152. Experimental Brain Research (2003) 166-172