Is the accuracy of linear path integration sex-related?

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Introduction

Sexual dimorphism has been observed in spatial orientation, but the exact nature of this difference remains unclear. This could be due to the scarcity of data on basic abilities involved in spatial behavior, like the computation of linear traveling distances. This work is an attempt to assess the limits of path integration mechanisms according to questions concerning distance, sex, passive or active transportation and environmental conditions.

Material and method - Experiment 1 - Indoors

Participants

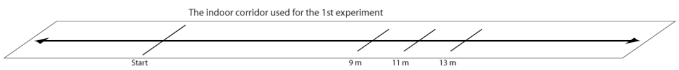
Sixty adult women (23.1 ± 5.1) and sixty adult men (28.1 ± 5.1) participated in the first experiment.

Apparatus

On the floor, in the middle of the section of a large indoor corridor, a graduated 25 m line ran parallel to the walls. A second line of 50 cm, perpendicular to the first one, marked the starting point. On the left side of the corridor three vertical white marks, numbered 1 to 3 and placed at 9, 11 and 13 m, served as visual cues for the experimenters. A wheelchair was used for passive transfer.

Testing procedure

At the beginning of testing, a traveling distance was randomly chosen. Both the guide and the subject ignored the chosen distance. Blindfolded subjects were guided on foot three times to one of the three marks (9, 11 or 13 m), which remained the same throughout testing. They were then turned around and led back towards the starting point. Subjects were asked to stop walking when they thought they had reached the starting point. The distance to the starting point was measured (negative values ⇒ underestimation; positive values ⇒ overestimation). Testing was repeated with subjects transported in a wheelchair. This time they had to say "stop" when they thought they had reached the starting point.



Material and method - Experiment 2 - Outdoors

Participants

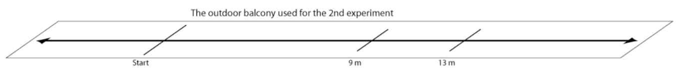
Forty-two adult women (20.2 ± 1.5) and forty-two adult men (24.1 ± 4.4) participated in the second experiment.

Apparatus

On the floor, in the middle of the section of a large fourth-floor balcony, a graduated 25 m line ran parallel to the wall. A second line of 50 cm, perpendicular to the first one, marked the starting point. On the left side of the balcony two vertical white marks, numbered 1 and 2 and placed at 9 m and 13 m, served as visual cues. Noise coming from a road passing near the building and from passersby on the other side of the balcony was relatively constant.

Testing procedure

At the beginning of testing, a traveling distance was randomly chosen. Both the guide and the subject ignored the chosen distance. Blindfolded subjects were guided on foot to one of the two marks (9 or 13 m). They were then turned around and led back towards the starting point. Subjects were asked to stop walking when they thought they had reached the starting point. The distance to the starting point was measured (negative values ⇒ underestimation; positive values ⇒ overestimation). Testing was repeated, but with subjects having a 2 seconds glance (a colored flag was placed next to the mark) before departing and another 2 seconds glance (a second colored flag was placed next to the starting point) before returning.



Results

Is there a specific distance up to which linear path integration is still possible? Are individual variations around this distance sex-related?

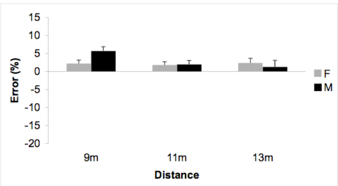


Figure 1: Indoor walking without vision; men's (M) and women's (F) mean error.

No significant sex differences were observed (F [1, 118] = 0.702; ns).

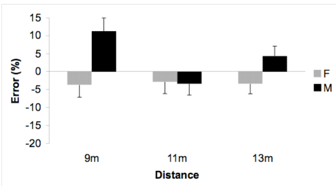


Figure 2: Indoor passive transport without vision; men's (M) and women's (F) mean error.

Men's mean error was larger (F [1, 118] = 7.870; p = 0.006).

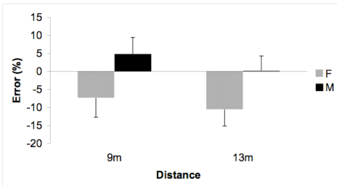


Figure 3: Outdoor walking without vision; men's (M) and women's (F) error.

Women's error was larger than men's (F [1, 82] = 5.868; p = 0.018).

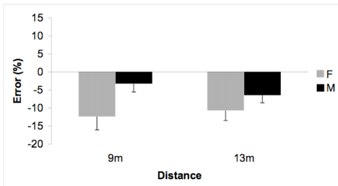


Figure 4: Outdoor walking with initial visual input; men's (M) and women's (F) error.

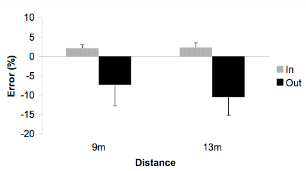
Women's error was again larger than men's (F [1, 82] = 5.683; p = 0.020).

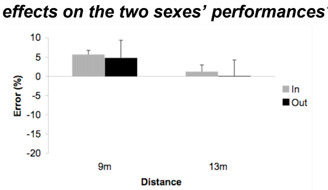
No significant effect of distance was observed, but in the absence of any visual input, a 9 m distance induces men's higher error, whereas error seems to decrease with distance, particularly when the displacement is active. Women's error is either stable, either slightly increasing with distance.

Do the observed sex differences in linear path integration persist in passive transportation?

In passive transport sex differences persist (fig. 2). In absolute terms, women are more accurate than men. They tend to underestimate distances, while men overestimate them.

Do the environmental conditions have similar effects on the two sexes' performances?



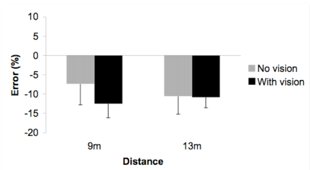


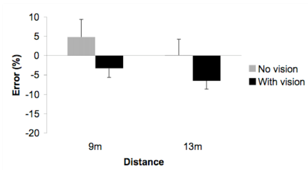
Figures 5 and 6: Comparison of women's (left) and men's (right) indoor and outdoor performances

A comparison of the results for 9 and 13 m distances shows that the environment has a significant effect on women's performance (F [1, 82] = 9.387; p = 0.003), but no effect for men's (F [1, 82] = 0.086; ns).

The environmental conditions seem to greatly affect women. The presence of a multitude of stimuli in the outdoor experiment had a clear negative effect on their performance.

How does initial visual input interfere with the accuracy of linear path integration when a target is presented before the displacement starts?





Figures 7 and 8: Comparison of women's (left) and men's (right) performances with and without initial visual input

Availability of initial visual information has a significant negative effect on men's performance (F [1, 82] = 4.412; p = 0.039). The observed effect on women's performance is not significant (F [1, 82] = 0.384; ns).

It was quite surprising to find that an initial visual input has such a negative effect on men's performance. It would seem that they rely on this visual information, even if the absence of update makes it unreliable.

Comments

In the light of these results, it seems that sex differences in spatial abilities could be rooted in basic mechanisms involved in spatial navigation. These findings support the hypothesis that women and men differ in information selection according to their strategy choice. Moreover, our results suggest that linear path integration accuracy might be related to a threshold that varies between men and women. Further studies are needed in order to test these hypotheses. Experimental procedures adapted to one sex's strategies at a time, could serve this purpose.

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