Decoupling the Biomechanics of Locomotion and the Direction of Spatial Updating During Blind-walking Tasks

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Introduction

- Does the direction of locomotion affect spatial updating?
- Do the biomechanics of locomotion influence the accuracy of spatial updating during open-loop walking?
- Spatial updating, or the process of keeping track of locations of objects relative to one’s spatial position while moving, is critical to a variety of navigation tasks.
- Although updating is likely to occur automatically during sighted walking, walking without vision (open-loop walking) requires imagined updating of the spatial relationships that change concurrently with movement.
- Dynamic spatial updating likely underlies accurate performance when blind-walking to previously seen targets, a task commonly-used to assess the spatial relationships that change concurrently with movement.
- Forward blind-walking, (Kunz, et al., 2009).
- Blind-walking to previously seen targets, a task commonly-used to assess the spatial relationships that change concurrently with movement.
- Backward walking without vision (open-loop walking) requires imagined updating of navigation tasks.

General Method

- View a target, create a mental image of the target in the surrounding environment, and walk forward or backward without vision to the target
- Forward and backward blind-walking to targets on floor
  - 9 trials to 3, 4.5 & 6 meters for each walking direction
- Experiment 1: Walking direction consistent with direction of spatial updating
- Experiment 2: Removing spatial updating component from backward walking
- Experiment 3: Decoupling walking direction and direction of spatial updating during backward walking

Experiment 1

- Forward walking with forward spatial updating
- Backward walking with forward spatial updating
- No effect of walking direction
  \[ F(1, 16) = 4.03, p = .062 \]
- A significant difference in meters walked between target distances
  \[ F(2, 32) = 470.58, p < .0001 \]
- Distance walked increased with target distance
  \[ p < .0001 \]
- Accurate walking to target distances in both walking directions
  \[ p > .05 \] for all target distances

Experiment 2

- Forward walking with spatial updating
- Backward walking without spatial updating; distance matching
- No effect of walking direction
  \[ F(1, 19) = 2.71, p = .116 \]
- A significant difference in meters walked between target distances
  \[ F(2, 38) = 228.85, p < .0001 \]
- Significant interaction between walking direction and distance walked
  \[ F(2, 38) = 3.40, p = .044 \]
- Distance walked increased with target distance
  \[ p < .0001 \]
- Significantly undershot 3m (p = .007) and 4.5m (p = .023)

Experiment 3

- Forward walking with spatial updating
- Backward walking with imaged forward walking and consistent forward spatial updating
- No effect of walking direction
  \[ F(1, 16) = 3.5, p = .061 \]
- A significant difference in meters walked between target distances
  \[ F(2, 32) = 884.18, p < .0001 \]
- Distance walked increased with target distance
  \[ p < .0001 \]
- Significantly undershot all target distances
  \[ p < .0001 \] for all target distances

Results

Backward Walking Comparison
- No significant main effect of Experiment on distance walked in the backward walking conditions
  \[ F(2, 51) = 1.93, p = .156 \]
- Compared to Experiment 1, distance walked in Experiment 3 was significantly less to the 3 m target (p < .002) and to the 4.5 m target (p = .025)
- No significant differences between Experiments 1 and 2 or Experiments 2 and 3

Forward Walking Comparison
- No significant main effect of Experiment on distance walked in the forward walking conditions
  \[ F(2, 51) = .97, p = .387 \]

Conclusion and Discussion

- Across all three experiments, there was no significant difference in distance walked between forward and backward blind walking.
- For backward blind walking, walking distance was the most accurate in Experiment 1 (consistent direction of locomotion and spatial updating) and the least accurate in Experiment 3 (inconsistent direction of locomotion and spatial updating), suggesting that the biomechanical information from walking direction influences the accuracy of spatial updating.
- The task directions for the backward walking conditions may have affected the participants’ abilities to accurately spatially update position while walking during the forward walking conditions.
  - Participants reported greater difficulty during all backward walking conditions compared to forward walking.
  - Individual differences in spatial updating / spatial imagery, motor imagery abilities may account for differences in backward walking performance, particularly when the walking direction and direction of spatial updating are decoupled.
- Follow-up to this series of experiments include blocking and counterbalancing walking direction and condition and increasing target distances. Differences between forward and backward walking may be apparent at longer target distances.

References


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