Responses to locomotion commotion caused by translation perturbations

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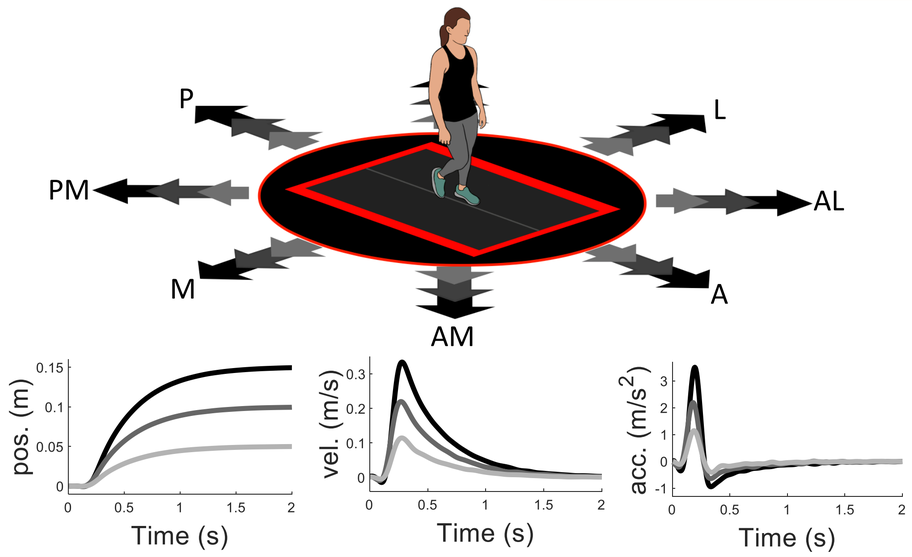
Motivation

How do humans navigate non-steady-state environments?

An understanding of stability could aid in
- Assessing and assisting impaired populations [1]
- Creating assistive and augmentative devices [2]
- Controlling legged robots in diverse environments

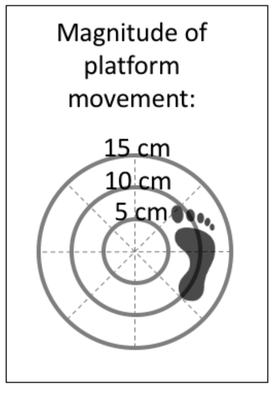
Perturbation recovery strategy is indicated by:
- Step length (SL)
- Step width (SW)
- Step time (ST)

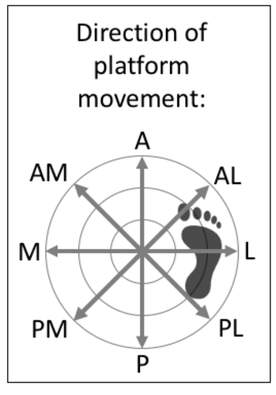
Methods



- N = 1
- Walking speed: 1.25 m/s
- Perturb subject by translating walking platform (24 conditions)
  - Magnitudes: 5, 10, 15 cm
  - Directions: 45° increments
  - (24 conditions) x (12 repetitions) = 288 perturbations
- Collected kinematics
- Identified gait events using kinematic coordinate method [3]
- Calculated step length (SL), step width (SW), and step time (ST) for the perturbed step (S_0) and subsequent steps (S_1-S_5)

Results

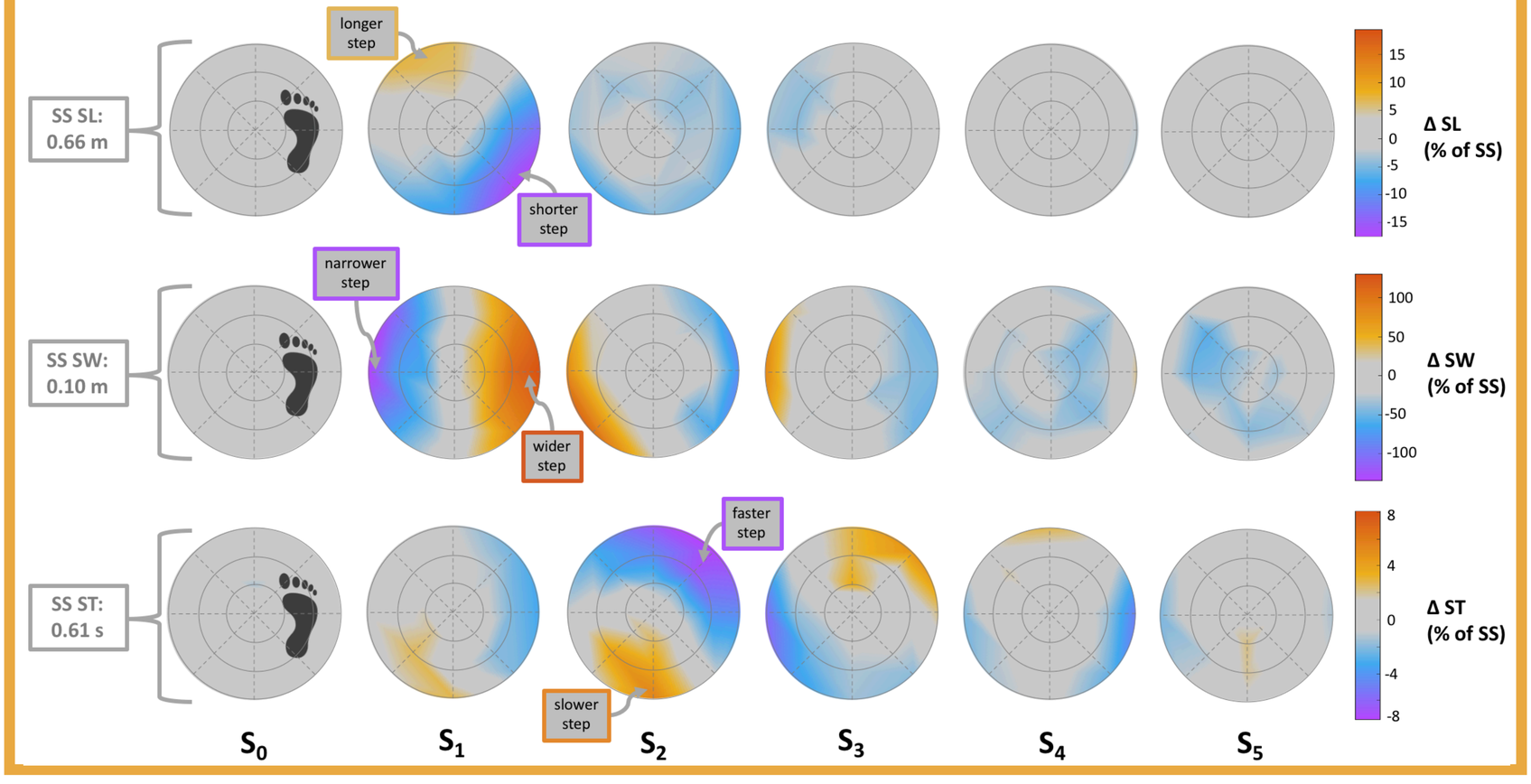




- **Radial axis:** magnitude of platform movement
- **Angular axis:** direction of platform movement relative to stance foot, all data displayed as right foot perturbed

- **Columns:** perturbed step (S_0) and subsequent steps (S_1-S_5)
- **Rows:** change in SL, SW, and ST as a percent of steady-state (SS)

- In general, platform movement in one direction will cause center of mass (CoM) movement in the opposite direction
  Ex: lateral (L) perturbation causes CoM movement to the medial side of the perturbed stance foot



Discussion

Step length:
- Most affected on the S1 step, trends last 1-2 steps
- Shorter steps with PL perturbations (up to -18%), longer steps with AM perturbations (up to +7%)

Step width:
- Most affected on the S1 step, trends last 2-3 steps
- Narrower steps with M perturbations (up to -135%), wider steps with L perturbations (up to +129%)

Step time:
- Most affected on the S2 step, trends last 3-4 steps
- Faster steps with AL perturbations (up to -7%), slower steps with P perturbations (up to 6%)

Humans modulate SL, SW, and ST in response to perturbations

Largest changes to SL, SW, and ST are not elicited by the same perturbation conditions

References

[1] S. M. Bruijn, et al., *J. R. Soc. Interface* 10, (2013)
[2] D. Tokur, et al., *Hum. Movement Sci.* 69, (2020)
[3] J. A. Zeni, et al., *Gait Posture* 27, (2008)

Acknowledgements

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