

INFLUENCING HUMAN GAIT DYNAMICS WITH AN ADAPTIVE SPLIT-BELT TREADMILL

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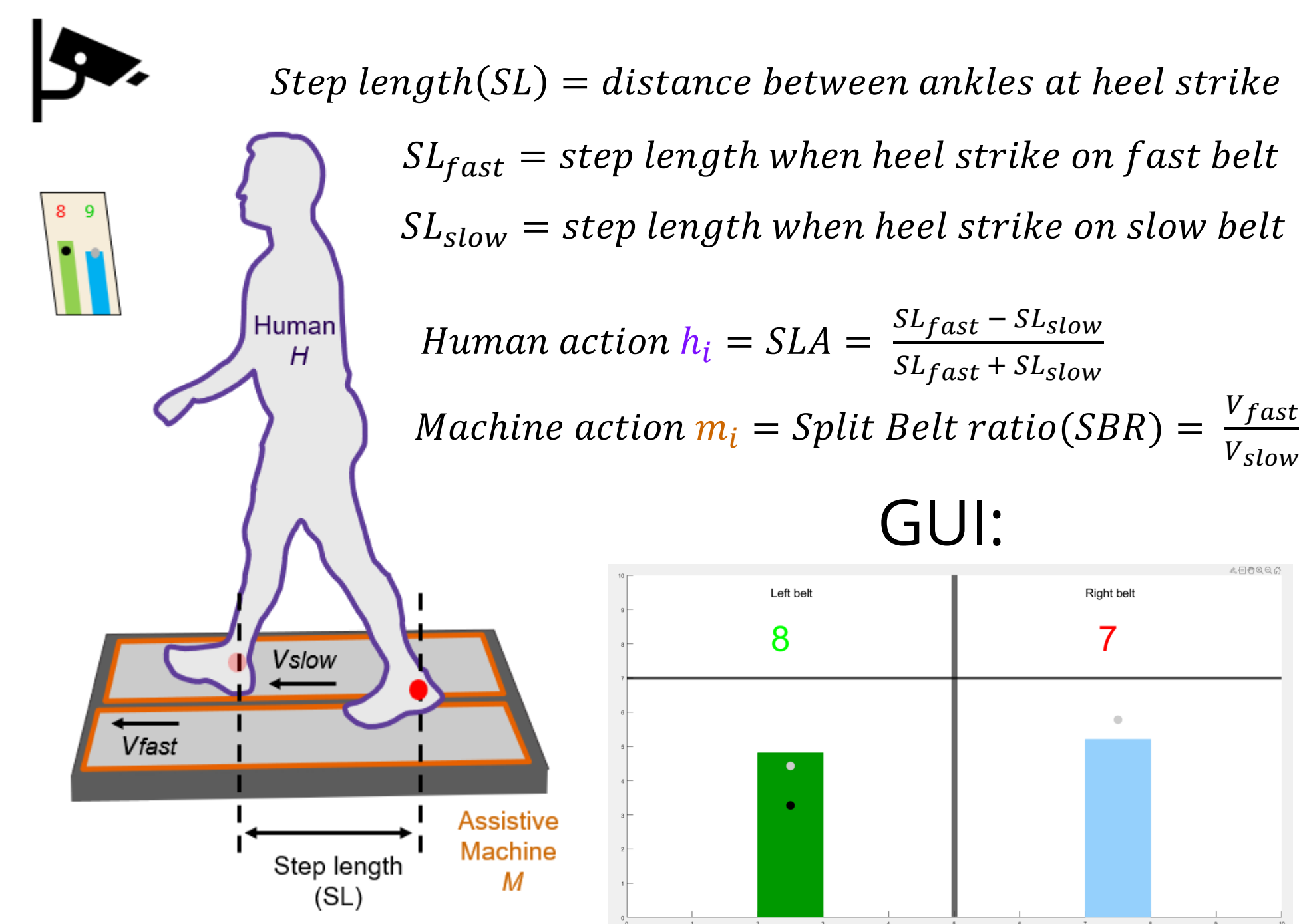
Introduction

- Walking on a split-belt treadmill can reduce the energy cost of walking [1,2].
- The treadmill can produce net positive work to a human if they adopt a positive *step length asymmetry* (SLA).
- Naïve users require guidance and/or long exposure times (> 30 minutes) to learn the strategy, while experienced users might spontaneously adopt it.
- It is unclear how this strategy translates to different walking scenarios on a split-belt treadmill with different *split-belt ratios* (SBR)

Objective: Understand how humans adapt to walking on a split-belt treadmill with varying split-belt ratio

Methods

Experiment 1: Training naïve participants' SLA with visual feedback and observing self-selected SLA with a different split-belt ratio (n = 15)

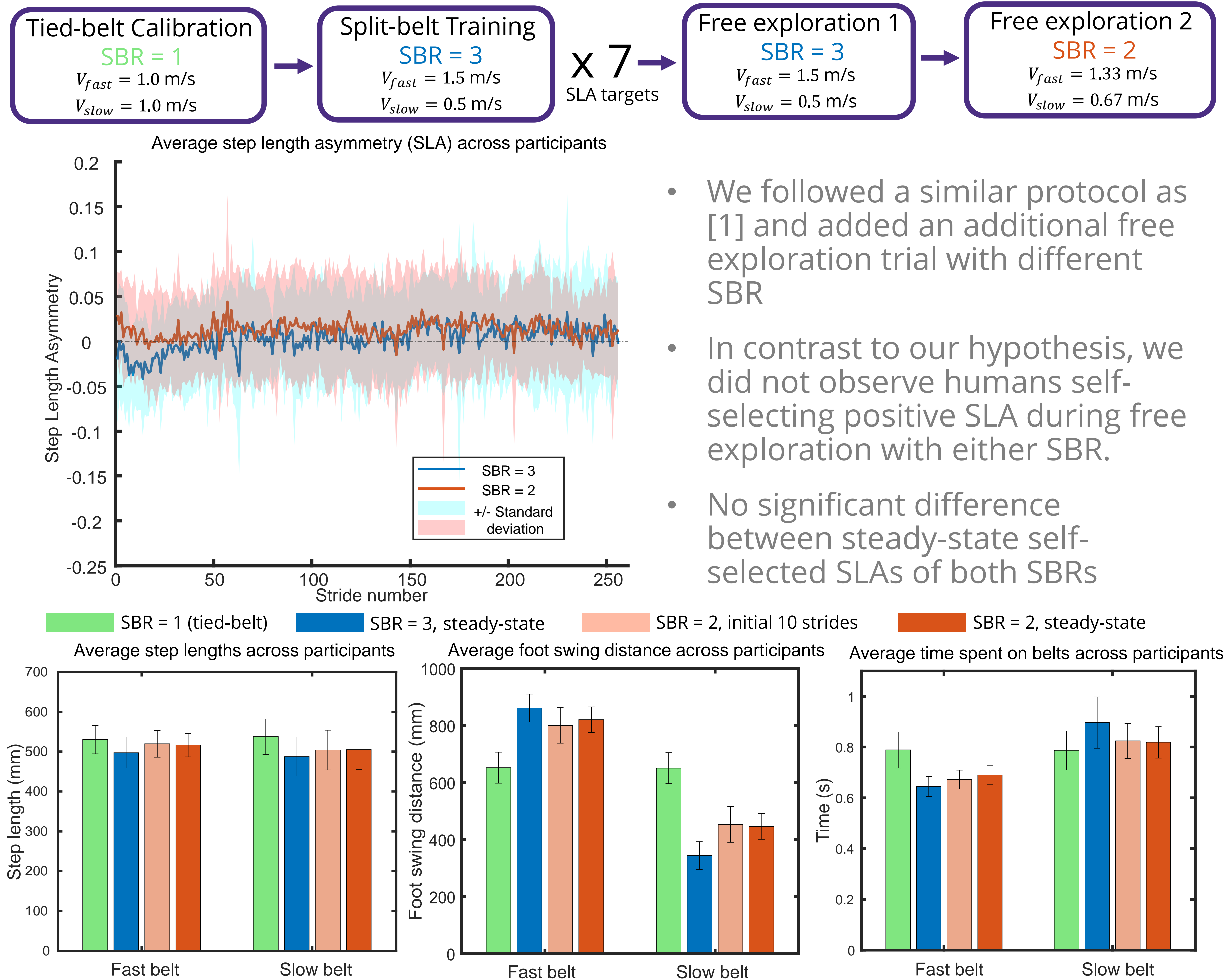


Experiment 2: Observing how experienced participants self-select SLA with an adaptive algorithm that dynamically adjusts SBR as a function of SLA (n = 3)

$$m_{i+1} = m_{i-1} - a * (m_i - h_i - 2)$$

Learning rate a is a parameter we adjust

Experiment 1 - Varying Split-belt ratio after training



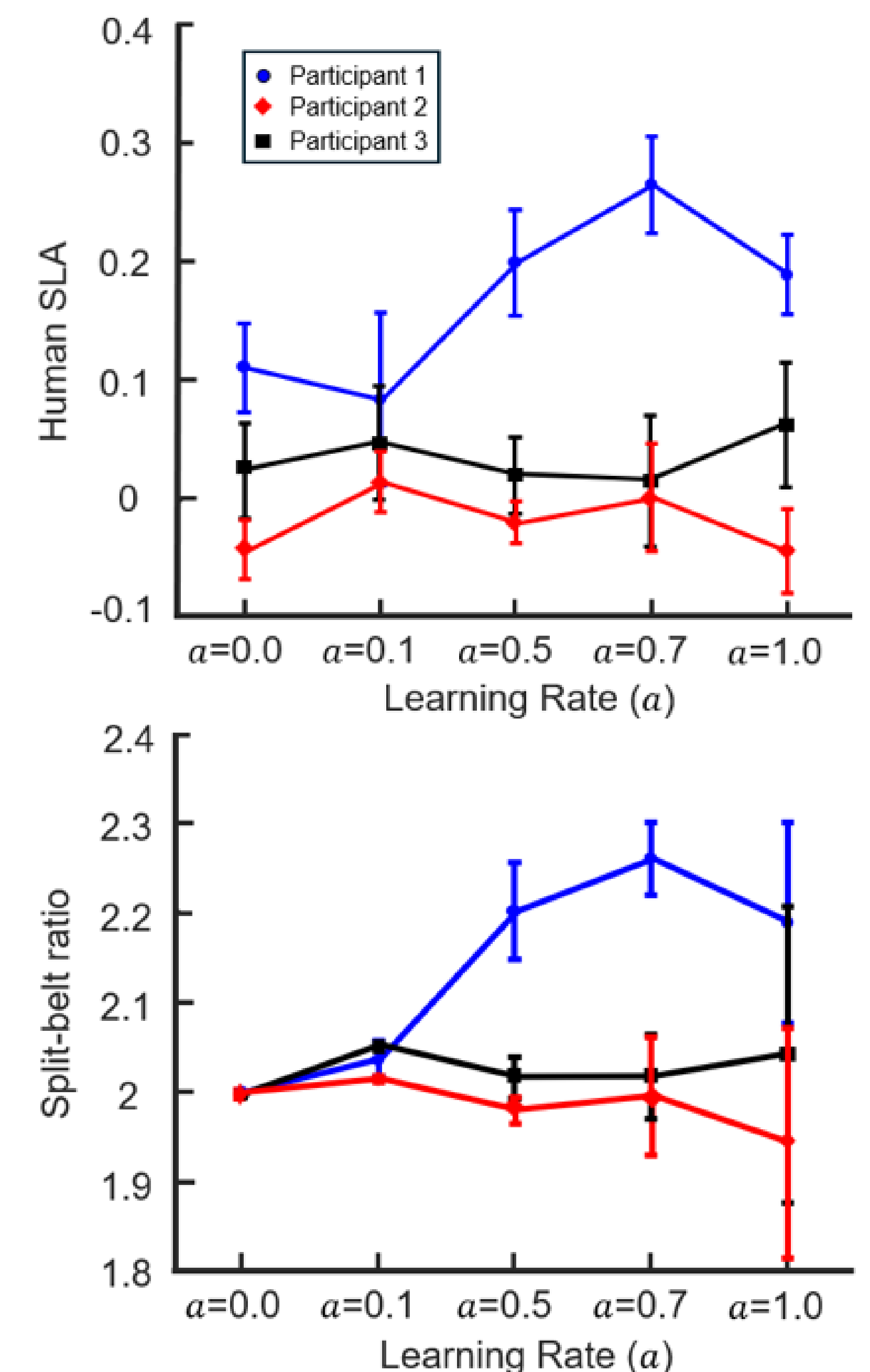
Comparing free exploration trials at $SBR = 2$ to $SBR = 3$, participants:

- Maintained similar step lengths on both fast belt and slow belt
- Maintained similar leg swing distance on the fast belt while increased leg swing distance on slow belt
- Maintained similar time spent on fast belt while decreased time spent on slow belt

Conclusions and next steps

- Contrary to our hypothesis, the naïve users did not consistently self-select positive SLA after guided exploration with either split-belt ratio.
- The naïve users maintained similar step lengths between two split-belt ratios by changing mainly their slow leg gait pattern when moving from higher SBR to lower SBR.
- Adaptive algorithm showed potential of steering human SLA choices with experienced users.

Experiment 2 - Adaptive Algorithm



- Experienced users responded differently to time-varying split-belt ratios at different learning rates, a .
- All experienced participants (n = 3) were able to adopt a positive SLA at some learning rates.

Acknowledgements

We thank the participants for their time and effort in these experiments.

References

- [1] Sánchez N, Simha SN, Donelan JM, Finley JM. Taking advantage of external mechanical work to reduce metabolic cost: the mechanics and energetics of split-belt treadmill walking. J Physiol. 2019 Aug;597(15):4053-4068. doi: 10.1113/JP277725.
- [2] Sánchez N, Simha SN, Donelan JM, Finley JM. Using asymmetry to your advantage: learning to acquire and accept external assistance during prolonged split-belt walking. J Neurophysiol. 2021 Feb 1;125(2):344-357. doi: 10.1152/jn.00416.2020.