CENTER FOR RESEARCH IN HUMAN MOVEMENT VARIABILITY

Utilizing Functional Near-Infrared Spectroscopy to Examine Hemodynamic Cortical Activity During Locomotion

Douglas A Rowen[a], Joao R Vaz[a,b], Luis Silva[a], and Nicholas Stergiou[a,c]

[a]Dept. of Biomechanics, University of Nebraska at Omaha, Omaha, NE

[b]Universidade Europeia, Lisbon, Portugal

[c]Dept. of Environmental Agricultural and Occupational Health, University of Nebraska Medical Center, Omaha, NE

INTRODUCTION

- Metronomes are used as a rehabilitation approach to improve gait in pathologic populations [1].
- These metronomes, however, may not be optimal as they operate on a fixed tempo and healthy walking demonstrates stride to stride fluctuations that have a pink noise type of distribution [2,3].
- Studies show increased brain activation in the prefrontal cortex during high attentional demanding tasks [4].
- It is unknown how walking with a metronome impacts brain activity and if any differences in brain activity occur between different types of metronomes.
- We investigated the response of the brain during walking with 3 different temporally structured metronomes.

HYPOTHESES

- Walking with a metronome would result in increased activity in the prefrontal cortex, which has been previously shown during arm movements with a metronome [5].
- However, walking with a metronome that is constructed temporally using pink noise would show less activation since it is more similar to natural walking.

METHODS

Figure 1: This figure shows the fNIRS probe used for the study and the schematic of the visual metronome used for the study.

- 13 healthy young adults (25.54 ±3.79 yrs).
- Footswitches (Noraxon) were worn to determine gait events and were used to determine the synchronization between heel strikes and the metronome.
- Two minutes of treadmill walking with: 1) fixed/non-variable, 2) random/white-noise, and 3) natural/pink-noise visual metronomes (Figure 1).
- 2 minute walking trials were recorded directly before and directly after the metronome trials to determine the baseline blood flow levels.
- Metronome was a continuous visual display attached to glasses (Figure 1).
- Blood flow was measured using a 4x4 functional near infrared spectroscopy (fNIRS) probe (Figure 1).
- Mean oxygenated blood flow was measured in the prefrontal cortex (PFC), supplementary motor area (SMA), and the motor cortex (MC).

RESULTS & DISCUSSION

- The stride times showed no significant differences ($p>0.05$).
- Significantly higher correlation between stride times and metronome times when walking to the pink-noise metronome (Figure 2).
- All metronomes showed increased brain activity in the PFC when compared to walking without a metronome (Figure 3).
- The increases in the PFC were potentially caused by the dual task nature of walking with a visual metronome [6].
- The pink-noise visual metronome resulted in the largest increase in the PFC, possibly indicating increased attentional demands (Figure 3).
- White-noise metronome showed the highest amounts of activation in both the SMA and MC, suggesting that there is a more active role in motor control when people walk randomly.

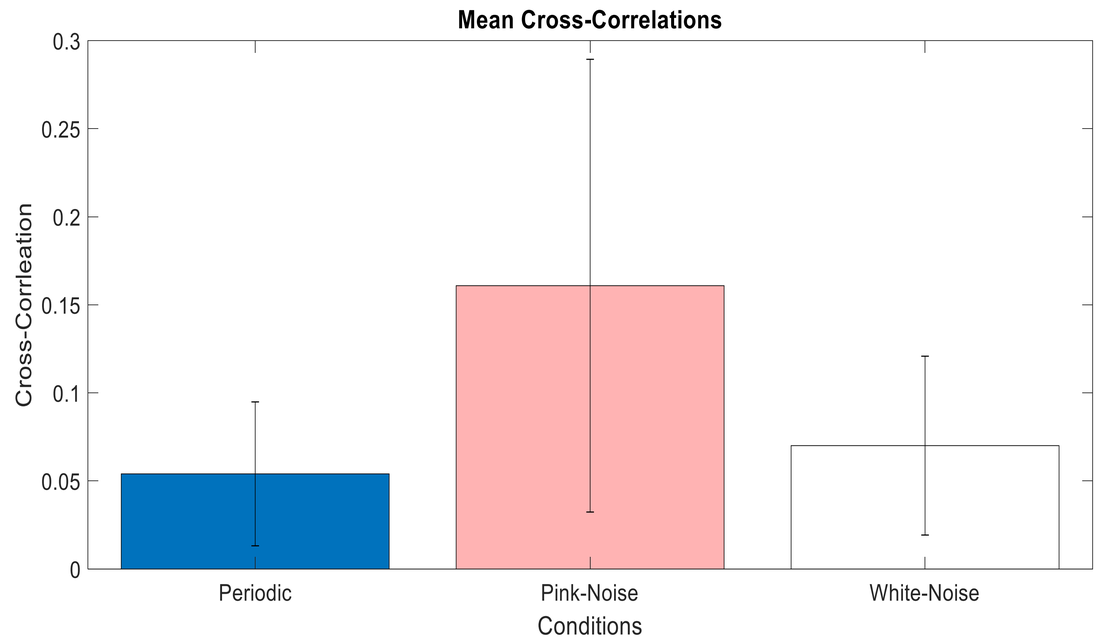

Figure 2: This figure shows the cross correlation between the stride interval and metronome beat intervals for all three metronome conditions. A value of 1 indicates perfect synchronization while a value of 0 indicates no synchronization.

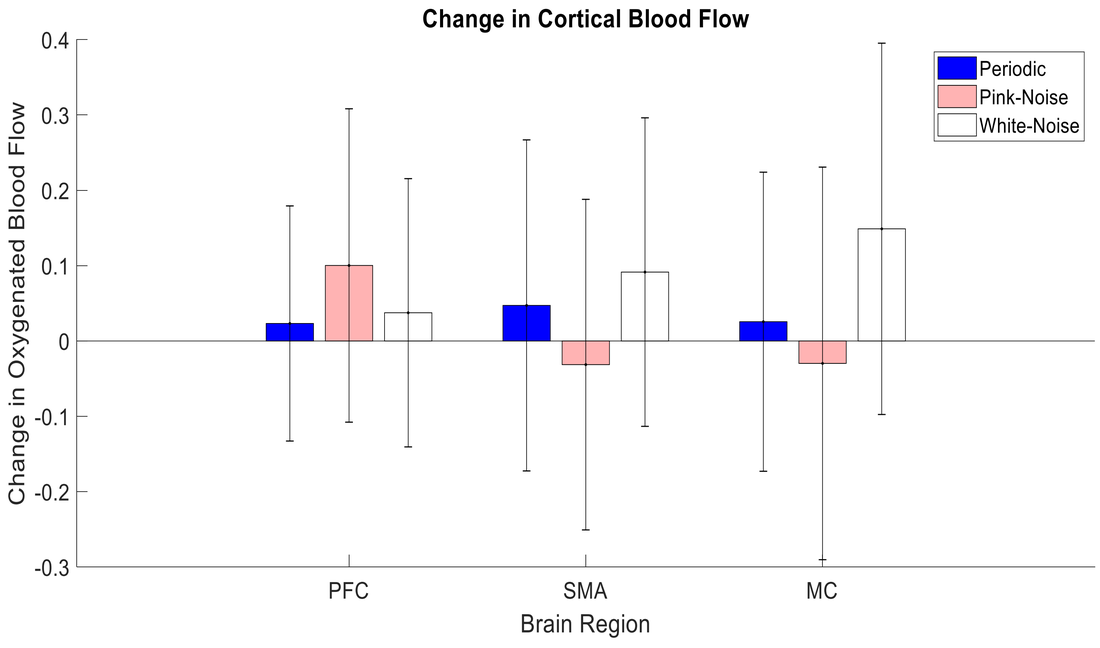

Figure 3: This figure shows the change in oxygenated blood flow from no metronome to metronome walking for each of the three visual metronome conditions. This was measured in the prefrontal cortex (PFC), the supplementary motor area (SMA), the motor cortex (MC).

CONCLUSIONS

- The higher cross correlation for the pink noise metronome may have resulted in a higher PFC activation.
- The temporal structure of each metronome may result in different attentional demands to achieve and maintain synchronization which are seen primarily in the prefrontal cortex.
- Further research is needed to determine if a pink noise metronome provides a different brain response than a non-variable metronome.

REFERENCES

1. Whittwer JE. et al. Disabili Rehabil 35, 164-176, 2013
2. Kaipust JP, et al. Ann Biomed Eng 224, 507-518, 2012.
3. Hunt N. et al. Scientific Reports 4, 5879, 2014.
4. Holtzer et al. J. Gerontol. A. Biol. Med. Sci. 66, 879-887, 2011.
5. Shimoda et al. Neural Plasticity 269120, 2014.
6. Herold F. et al. Neurophotonics 4, 041403, 2017

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UNIVERSITY OF Nebraska Omaha