**Relationships between finger tapping and gait timing in musicians and non-musicians**

## Project Description

### A. Background/ Description of Project

The ability to produce motor tasks with precise timing is crucial for many human activities. Motor timing is often measured as the variations in time between consecutive motor outputs. For example, people with Parkinson's disease (PD) typically suffer from dysrhythmia, characterized by higher motor timing variability in different effectors. Studies have shown that finger tapping, gait and speech variability are correlated in people with PD[1] . In addition, after training of walking with music or metronomes, people with PD showed improvements not only in gait, but also in basic motor timing and timing perception. People with PD with musical background also synchronized their step more accurately when walking with metronomes[2], suggesting a tight link between musical expertise and gait timing. Another study found that a positive response to 'walk with music' training was predicted by the synchronization performance in hand tapping[3] .

These findings lead to the general hypothesis that motor timing is correlated across effectors. If this general hypothesis was confirmed, it may lead to a breakthrough in rehabilitation techniques for people with PD. For example, it may be possible to improve gait rhythmicity and timing through upper limb training. To test this general hypothesis, I am going to take a different, unique approach to the previously mentioned studies. It is well established in the literature that musicians present better motor timing in finger tapping tasks compared to non-musicians[4] . Therefore, I will test the specific hypothesis that musicians, who present better 'basic' motor timing (finger tapping), will also present better gait timing (i.e., time intervals between consecutive gait cycles).

The following research questions will be addressed:

1. How does gait timing of musicians compare to that of non-musicians?
2. How does musical expertise affect gait timing?
3. What is the relationship between finger tapping and gait timing in musicians and non-musicians?

### B. Activities/ Methodology

**Participants.** I will recruit 45 people ranging in age from 19-50 years old. They will be recruited based on their musical training and be placed in one of three categories accordingly. Each category will roughly contain the same number of participants and I will try to match the demographics in each group (note that this may be difficult since people with greater musical expertise may be older). The three categories will be defined as: 1) no musical background (less than 5 years of training or experience, have not practiced/ no formal training in last 5 years, not currently playing instrument); 2) beginner musical background (more than 5 years but less than 10 years, formal musical training within last 5 years); 3) expert musical background (at least 10 years of training, currently playing). Participants will be recruited from fliers and posters on the UNO campus, music stores/ music schools across the Omaha-metro area, music newsletters, as well as electronic fliers on social media platforms.

**Procedure.** All data collections will be conducted in the University of Nebraska Omaha Biomechanics Research Building (UNO BRB), and on the walking track in the Health and Kinesiology building. Participants will attend a single, two hour- long data collection. After providing written informed consent, they will answer a questionnaire regarding their medical history, their musical background, and the Beat Alignment Test, which measures timing perception by asking participants to decide if the beeps are 'on' or 'off' the beat of different music (without lyrics).

Participants will then perform four finger tapping and four walking trials. For both the finger tapping and the walking trials, the four trials will be: 1) self-paced (tap or walk around the track at a comfortable pace

without metronomes); 2) synchronization-continuation (SC) at preferred frequency (tap or walk in time with a metronome set at their preferred frequency, which was found in the self-paced task, and continue to tap or walk at this speed when the metronome stops); 3) SC at a faster frequency (30% faster than preferred tapping or walking rhythm); and 4) SC at a slower frequency (30% slower than preferred tapping or walking rhythm). The finger tapping synchronization-continuation tests will be used to confirm that musicians in our study have better basic motor timing than non-musicians. Each trial will be two minutes long and be repeated three times. Participants will perform the walking tasks while wearing instrumented insoles (Noraxon USA Inc.; 300Hz) to record gait. Finger tapping data will be collected with a midi pad. Previous studies show that tapping along with music can be difficult due to lack of a strong beat in some music[5]. Due to this difficulty this study will use metronomes for beat synchronization, rather than a more complex rhythmic auditory stimulus, such as music.

**Analysis.** The data collected will be analyzed to see how much their gait synchronized with the metronome. This will be done by analyzing the footswitches data to find the coefficient of variation (CV). Coefficient of variation evaluates the magnitude of the deviations of the stride time with respect to each subject's mean stride value[6]. In this study participants with less musical background should have a greater CV than those who have more musical background. The data will also be analyzed for timing "accuracy", defined as the difference between the tap or stride interval and the target interval from the metronome. Accuracy will be used in the tapping and walking data to determine if they synchronized with the metronome in both series of trials. The CV of accuracy is to determine how much variation a participant had while synchronizing with the metronome. This measure is important because some participants may not be accurate (i.e., out of sync with the metronome) but might have been consistent (low timing variability). Results will be compared in the individual groups as well as compared to each other to show if in fact musicians do have a more rhythmic gait than non-musicians.

I will perform 3-way ANOVAs (musical training vs. synchronization/continuation phases vs. tempo) for each outcome in the finger tapping and in the walking trials (Research Questions 1 &2). I will also calculate the coefficient of correlation between similar outcomes from finger tapping and walking trials (e.g., correlation between tap-to-tap CV and stride-to-stride CV) to answer the Research Question 3. Tukey's HSD post hoc analysis will be conducted on significant differences from the ANOVAs. Significance level will be set at $p<0.05$.

## C. Project Timeline

| Semester | Tasks |
|---|---|
| **Fall 2020** | Complete IRB application and the Movement Analysis Core Project Initiation form |
| **Spring 2021** | Recruit participants, order materials, collect data |
| **Summer 2021** | Continue to collect data, start data analysis |
| **Fall 2021** | Continue data analysis, work on student poster presentation for UNO research fair |
| **Spring 2022** | Present at UNO research fair, apply to present at other conferences, prepare manuscript for publication |

## D. Student/ Faculty Mentor Roles

I will complete the IRB application, recruit participants, collect and analyze data with Dr. Marmelat's supervision. Dr. Marmelat will provide any advice and insight that might be needed during this process, as well as checking the reliability of my procedures and analysis. We will discuss the progress of this project during our bi-weekly individual meetings.

## E. Previous Internal Funding

I have not received any previous internal funding via FUSE or UCRCA.

**Budget and Budget Justification**

| | |
|---|---|
| Movement Analysis Core Fees | $143 |
| Participation stipends ($5/participant x 45 potential participants) | **$**450 |
| Student Stipend | $1,907 |
| **Total** | $2,500 |

I am asking for $143 for the Movement Analysis Core Fees, because I have to pay this fee in order to use the equipment I need. The Biomechanics Research Building already has the footswitches and software needed to run them, as well as an aux cord splitter and one aux cord to connect the equipment, however the fee is needed for me to use these.

To compensate the participants for their time, they will be given a $10 check from the College of Health and Human Sciences. Participants do not need to complete the entire study to receive compensation for their time. I am planning to recruit 45 participants.

I am asking for $2,000 for a student stiped which is $10/ hour for an estimated 200 hours that it will take to complete this project. This stiped will help cover the cost of living while I work on this project.

**References**


1. Puyjarinet, F., Bégel, V., Gény, C., Driss, V., Cuartero, M., Kotz, S. A., . . . Dalla Bella, S. (2019). Heightened orofacial, manual, and gait variability in Parkinson's disease results from a general rhythmic impairment. *Nature Partner Journals, 19*, parkinson's disease, 1-7.

2. Cochen De Cock, V., Dotov, D. G., Ihalainen, P., Bégel, V., Galtier, F., Lebrun, C., . . . Dalla Bella, S. (2018). Rhythmic abilities and musical training in Parkinson's disease: Do they help? *Nature Partner Journals, 8*, parkinson's disease, 1-8.

3. Dalla Bella, S., Benoit, C., Farrugia, N., Keller, P. E., Obrig, H., Mainka, S., & Kotz, S. A. (2017). Gait improvement via rhythmic stimulation in Parkinson's disease is linked to rhythmic skills. *Scientific Reports, 7*(42005), 1-11. doi:https://doi.org/10.1038/srep42005

4. Repp, B. H. (2010). Sensorimotor synchronization and perception of timing: Effects of music training and task experience. *Human Movement Science, 29*(2), 200-213.

5. Large, E. (2000). On Synchronizing Movements to Music. *Human Movement Science, 19*, 527-566.

6. Hausdorff, J. M., Balash, J., & Giladi, N. (2003). Effects of Cognitive Challenge on Gait Variability in Patients with Parkinson's Disease. *Journal of Geriatric Psychiatry and Neurology, 16*(1), 53-58. doi:10.1177/0891988702250580

CENTER FOR RESEARCH IN HUMAN MOVEMENT VARIABILITY

University of Nebraska Omaha

December 18, 2020

Dear FUSE Grant Reviewers,

It is with great enthusiasm that I support Meghan Prusia for her FUSE grant, entitled *Relationships between finger tapping and gait timing in musicians and non-musicians*. Meghan joined my research team in September 2019, and since then has been a **dedicated student and a hard-worker**.

Meghan started as a volunteer, helping my team around 10 hours/week. Based on the quality of her performances, after only two months (instead of a usual full semester of "trial"), I offered her a student worker position in my team. Meghan has been involved in data collection and data processing for different projects, collaborating with graduate and undergraduate students in my research team. With a background as a musician, Meghan showed great interest in my research projects focusing on using auditory rhythms such as metronome or music to improve gait in people with Parkinson's disease. After some discussions, I encouraged her in Spring 2020 to read some literature in the field of sensorimotor synchronization to identify knowledge gaps. We met several times (online) in Summer 2020 to discuss about her ideas and refine her plan for an individual study. After many iterations, I think Meghan's project is now **extremely rigorous and scientifically sound**.

Meghan's project aims to compare gait and finger tapping timing in musicians and non-musicians. While a lot of literature exists on "basic" motor timing in musicians, surprisingly Meghan could not (and neither did I) find anything about motor timing from other parts of the body, such as lower limbs during gait. Her experimental design is both simple and elegant to address a fundamental scientific question that may have a big impact in the field of sensorimotor neurosciences, and may lead to breakthrough in rehabilitation for people suffering from timing disorders. Meghan has been trained to use the equipment she proposes to use, and she has the expertise to process her data. Meghan's project perfectly fits with my research interests but is **completely independent** from what I've done so far. In particular, my research typically involves patients with Parkinson's disease, but I never conducted any study focusing on musicians.

In light of Meghan's aspiration to pursue a MS and a PhD, this project will give her a unique opportunity to develop and run an entire study. I am very confident that the quality of the data Meghan will be collecting will allow her to write a paper as first author.

In summary, Meghan is a **very promising undergraduate student,** and I am very confident she will be able to lead this project with the support from the research environment in the Department of Biomechanics at UNO and from myself. I strongly support her application and believe she would be an excellent recipient who would truly fulfill every expectation.

Sincerely,

Vivien MARMELAT, PhD
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