End-of-award summary report for project:
"Real-time measurement of the meditative effectiveness of Argentine Tango"

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The goal of our project was to investigate if electroencephalography (EEG) could be measured during Argentine Tango dancing in a manner unobtrusive to the dancer using a portable, wireless headset. The ultimate goal would be to analyze the EEG signals to search for correlates of meditative effectiveness of the dance. While previous studies have shown *behaviourally* the meditative capacity of Argentine tango, neurological correlates of such capacity have yet to be found. This Agile seed funding application was aimed at taking a first step to fill this gap: see if EEG could indeed be reliably collected while dancing.

The CIRMMT Agile seed funding of $1500 was used for two purposes: purchase a portable openBCI EEG headset (~US$500), and the remainder was used to pay an RA to collect some pilot data. Data collection happened at INRS in a large classroom and project participants Ilona Posner and Bruno Afonso, who are experienced Argentine tango dancers, served as subjects. Three different tango songs were chosen with varying characteristics believed to affect the perception of dance flow and dancer connection: melody, rhythm, and their combined effects. Figure 1 shows the experimental setup at INRS for data collection. Each dancer used an OpenBCI headset, a BioHarness 3 heart and breathing rate monitor, as well as an Empatica E4 smartwatch which measured heart rate, temperature, and galvanic skin response. As an exploratory aim, we were also interested in seeing if certain physiological measures synchronized once the dancers entered a flow state and if such synchrony related to the dancers' meditative states.

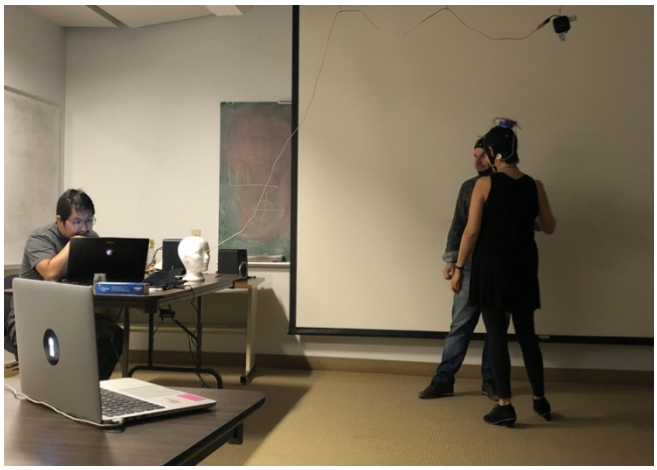

Figure 1: Experiment setup to monitor dancer neurophysiological signals

Data was successfully collected during the experiment and no significant challenges were found. We were able to accurately remove the signal artefacts from the EEG signal using tools that we had developed for other ambulatory subjects (e.g., first responders running on a treadmill). Figure 2 depicts a sample of the collected EEG signals before (grey) and after (black) signal enhancement. At the end of the experiment, we had the dancers fill out questionnaires and several EEG features were extracted from the enhanced signals.

After signal analysis, we found that EEG features in the alpha and beta bands presented positive correlation with the self-reported aspects of (personal) connection and flow for the lead dancer. The highest correlation was of 0.76 between the connection rating the and the high-alpha band power (see Fig 3a). For the follow dancer, in turn, positive correlations for alpha and beta bands were found for flow (see Fig 3b). Lastly, by analyzing the data of both dancers together, we found that the highest correlations were obtained between flow and alpha (specifically high alpha) and beta bands (see Fig 3c). These results point towards the

relevance of the alpha band in the detection of flow during dancing. These results were inspiring, as increases in alpha band power have been associated with meditation and relaxation. As a next step, we will investigate the physiological synchrony between dancers under the different experimental conditions and explore those effects on their perception of connectivity. We plan to also investigate changes and synchrony using other signal modalities, such as heart/breathing rates and galvanic skin responses, and explore the effects they have on dancer perception and meditative potential.

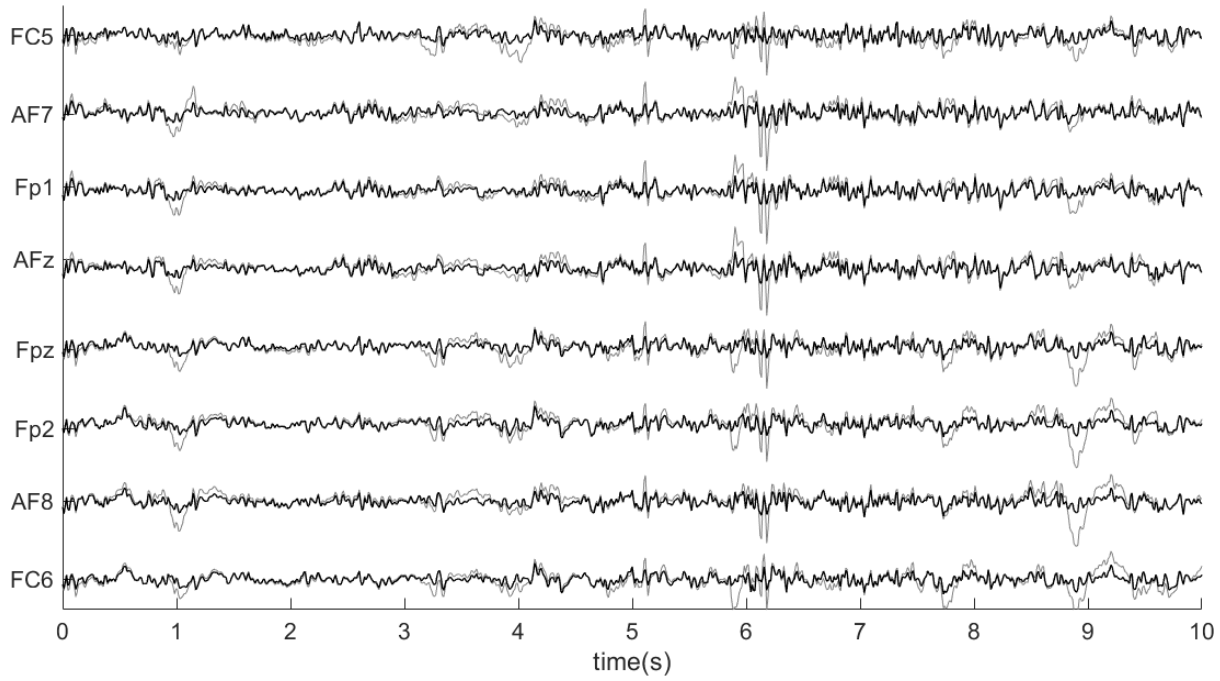

Figure 2. EEG signals before (grey) and after (black) artefact removal.

We are currently in the process of preparing a conference paper describing these findings, to be submitted to the IEEE SMC Brain-Machine Interface Workshop by mid-May 2020. These experiments also gave us the confidence to partner with another Professor at INRS on an FRQSC *Appel à projets collaboratifs Colombie-Québec 2019-2020* on a project titled "Création de vêtements intelligents pour l'analyse de spectacles de danse : quand l'art et la technologie se rencontrent." The project aims at building a smart dress that monitors dancer movements and correlates movements with the dancer's perception of how successful the show went. Our role in the project is to incorporate EEG and search for neural correlates of dancer perception. The pilot experiments conducted with this CIRMMT Agile Seed Funding were paramount for the success of this FRQSC proposal.

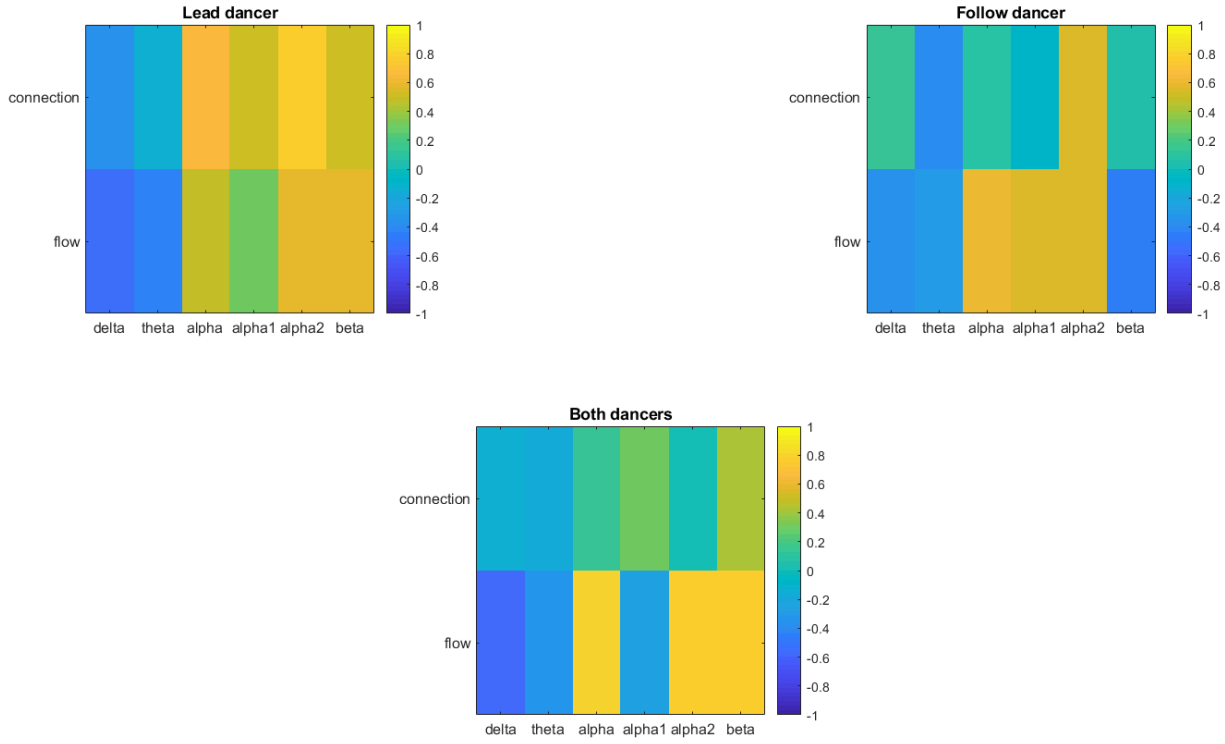

Figure 3. Correlations between EEG spectral features and connection and flow ratings for: (a) lead dancer, (b) follow dancer, and (c) both dancers.