NEST 2025

New England Sequencing & Timing

The 33rd Annual Meeting

April 5, 2025
University of Connecticut
Weston A. Bousfield Psychology Building
Room A106

Please use this **Live Stream link** for virtual conference attendance:
http://www.kaltura.com/tiny/lg2d6

Gala reception with cocktails, dinner, and jam will occur at Ed Large's home after the event.

Music Dynamics Lab
UCONN

https://musicdynamicslab.uconn.edu/

Registration & Breakfast: 9:00-9:20		
9:20	**Edward Large** University of Connecticut	Welcome
Session 1: 9:30-10:30		
9:30	**Arun Asthagiri** Northeastern University	Entrainment of Neural Oscillations to Naturalistic Rhythms in Music Impacts Cognition
9:50	**Franchino Porciuncula** Boston University	Amplifying Walking Activity in Parkinson's Disease Through Autonomous Music-Based Rhythmic Auditory Stimulation
10:10	**Spencer Ferris** University of Connecticut	Perceptual Practice Facilitates Learning a Multifrequency Bimanual Coordination Pattern
10 Min BREAK		
Session 2: 10:40-11:20		
10:40	**Benjamin De Bari** DeSales University	Keeping Time: Motor Abundance Increases Multiscale Interactivity and Supports Rhythmic Production
11:00	**Poster Presenters**	Poster Datablitz
15 Min BREAK		
Session 3: 11:35-12:15		
11:35	**Aleksei Krotov** Northeastern University	Embodiment and Control of a Complex Object: Rhythmically Hitting a Target with a Whip
11:55	**Hélène Serré** Northeastern University	Stability in Emergent vs Enforced Motor Patterns and its Effect on Time Perception
LUNCH & POSTERS: 12:15-1:30		
Session 4: 1:30-2:30		
1:30	**Wenbo Yi** McGill University	Causal Relations Between Behavioral and Physiological Dynamics in Interpersonal Coordination
1:50	**Bavo Van Kerrebroeck** McGill University	Disentangling Human- and Model-Specific Features in Virtual Partner Interaction Paradigms
2:10	**Andrii Smykovskyi** McGill University	How Emotions Drive Interpersonal Synchronization: Insights for Modeling
10 Min BREAK		

Session 5: 2:40-3:40		
2:40	**Connor Spiech** Concordia University	4/4 and Even More: Pupillary Entrainment in Complex Meters
3:00	**Silvia Buscaglione** Northeastern University	Maintaining Balance by Holding Hands in Ballet Dancers and Untrained Individuals
3:20	**Laura A. Stambaugh** Rhode Island College	A Longitudinal Analysis of Beat Perception and Beat Production by College Musicians
15 Min BREAK		
Session 6: 3:55-5:00		
3:55	**Anna Palumbo** New York University	Music Improvisation Enhances Reward and Motor Response Post-Stroke: an fMRI study
4:15	**Florence Ewomazino Nweke** University of Lagos	(Dis)Ableness and Inclusive Cities: Negotiating Practice-led Action Research in Music and Arts with Disabled People in Lagos, Nigeria
POSTERS: All Day		
	P. Adrian Frazier University of Connecticut	Looking For Support: Does Optic Flow Influence Bean Pole Nutation?
	Mina Golmohammadi University of Connecticut	The Missing Pulse Revisited: Comparing Dynamic Models With Expert Listeners
	Steven A. Masi University of Connecticut	1:2 Frequency Task Guidance and Training with Pendulums: The Helpful and the Harmful
	Donna Syed North Arrow Consulting	The Seven-Layer Symphony: How Multisensory Engagement and Music Enhance and Optimize Neural Networks
	Susan Tilbury University of Connecticut	Neural Resonance and the Embodied Dynamics of Musical Groove
	W. Ryan Waite Brown University	Is Perceptual Timing Shared with Emergent Motor Timing?
Gala reception with cocktails, dinner, and jam will occur at Ed Large's home after the event.		

Abstracts

Session 1

9:30 **Entrainment of Neural Oscillations to Naturalistic Rhythms in Music Impacts Cognition**
Arun Asthagiri (Northeastern University)

During music listening, neural activity entrains (aligns in phase and time) to musical rhythm. Although naturalistic music unfolds over many different rhythms, theoretical tools for quantifying phase alignment are traditionally developed for stable, metronomic rhythms. Here, we aim to quantify nonlinear interactions between naturalistic music and brain activity using phase-based and cross-frequency analyses to reveal how musical rhythms influence neural processes associated with attention and memory.
Two projects used commercial music recordings to (1) entrain theta oscillations to support focus and (2) increase theta-gamma coupling to mitigate effects of Alzheimer's Disease (AD). Study 1 (n=21) tested the effects of theta amplitude modulation added to popular ballads on phase-locking between the music and neural oscillations. Phase-locking was calculated as the phase-angle alignment between the cochlear-filtered acoustic signal and EEG data. Results suggest that amplitude modulation added to naturalistic music can drive phase-locking specifically at the modulated frequency associated with the tempo of the music. Furthermore, the strength of phase-locking predicts performance on a sustained attention task, which indicates attentional effects of targeted neural entrainment. Study 2 involves a music-based intervention (n=22) that uses naturalistic music with light stimulation to restore healthy brain activity in older adults with mild cognitive impairment or mild AD. Phase-amplitude coupling—an index of neural coordination across timescales—was computed from the distribution of gamma amplitude over theta phase within the EEG signal. Rhythmic frequencies in naturalistic music increased phase-locking and delta-theta power in the gamma music-based intervention. Furthermore, theta-gamma coupling distributed across frontal-central regions increased over the intervention for participants in the treatment but not the control group. Together, phase-based methods for uncovering dynamic stimulus-brain relationships reveal the effects of naturalistic music on attentional and cognitive processes.

9:50 **Amplifying Walking Activity in Parkinson's Disease Through Autonomous Music-Based Rhythmic Auditory Stimulation**
Franchino Porciuncula, Jim Cavanaugh, Jenna Zajac, Nicholas Wendel, Teresa C. Baker, Dheepak Arumukhom Revi, Nicole Eklund, Mary Beth Holmes, Louis N. Awad, and Terry D. Ellis (Boston University)

Habitual moderate intensity walking has disease-modifying benefits in Parkinson's disease (PD). However, the lack of sustainable gait interventions that collectively promote volume, intensity, and quality of walking marks a critical gap in PD rehabilitation. We conducted two early clinical trials that examined the potential of autonomous, closed-loop, music-based rhythmic auditory stimulation (RAS) in improving real-world walking activity in PD. In Study 1, a single-arm initial pilot study (clinicaltrials.gov#: NCT04891107), we demonstrated the feasibility and proof-of-concept associated with delivering an autonomous digital walking intervention

based on RAS principles to persons with PD in a community setting. Participants with PD (N=23) demonstrated high adherence to the digital walking intervention (4 weeks) of unsupervised, overground walking with music-based cues. Gait speed, stride length, and cadence increased within sessions, and gait variability decreased during cued walking compared to uncued walking ($p < 0.05$). Compared to baseline, participants demonstrated increased daily moderate intensity walking and steps ($p < 0.05$). In Study 2, a randomized controlled trial (clinicaltrials.gov#: NCT05421624), we demonstrated the effectiveness of a real-world walking intervention (8 weeks) delivered using an autonomous music-based digital rhythmic auditory stimulation (RAS) system. In comparison to an active-control arm (N=20) of moderately intense brisk walking, the autonomous RAS system used in the experimental arm (N=21) amplified moderate-to-vigorous walking intensities, increased daily steps, and improved (reduced) gait variability. Together, findings from these studies supported the use of a personalized, autonomous RAS gait intervention that is effective, habit-forming and translatable to real-world walking in individuals with PD.

10:10 **Perceptual Practice Facilitates Learning a Multifrequency Bimanual Coordination Pattern**
Spencer Ferris (University of Connecticut)

Mental practice (i.e., using motor imagery to mentally rehearse an action) has been shown to be an effective way to learn, or relearn, motor skills. Limited previous research has identified a parallel method of motor skill learning, perceptual practice. This research suggests that if participants learn to discriminate action-relevant variables in visual displays, their ability to perform a relevant motor task improves. This prior research utilized a multi-week training protocol, which significantly limits it's potential for real-world applications. We investigated the potential practicability and of extension of perceptual practice by testing two hypotheses. First, we expect improvements in the ability to differentiate an action-associated perceptual variable within a single session of perceptual practice training. Second, we expect those improvements to immediately result in improvements in the ability to learn a novel motor task (i.e., 1:2 bimanual circling). We found support for both hypotheses. We discuss the challenges of developing and applying perceptual training to motor skill learning, including the potentially relevant distinction between action-related and action-relevant (specifying) variables.

Session 2

10:40 **Keeping Time: Motor Abundance Increases Multiscale Interactivity and Supports Rhythmic Production**
Benjamin De Bari (DeSales University)

Stemming from the insights of Nicolai Bernstein, scholars have advocated that brain and body capitalize on motor abundance – a high degree of redundancy in the degrees of freedom (DOF; joints, muscles, motor neurons, etc.,) – to compose flexible and adaptive perceptual-motor processes. Recent work proposes that multifractal interactivity in the motor system may support the soft-assembly of DOF in dexterous action. Looking to a specific form of dexterous activity, music, it is increasingly understood that skilled performance is embodied, dependent on contributions from across the perception-action system rather than merely the brain and relevant

effectors. We explored if rhythmic tapping in a synchronization-continuation task was affected by the amount of physiological DOF by manipulating the amount of external stabilizing constraints on the finger, hand, and arm. Motor variability increased with decreasing external constraints, but inter-tap variability remained low across conditions. Multifractal interactivity also increased with the removal of support, suggesting that fluctuations across scales of the body promoted task resilience despite greater motor variability. This work paves the way for exploring the embodied and multi-scaled coordination underlying rhythmic behaviors including music.

11:00 **Poster Datablitz Session**
See below for the poster abstracts

Session 3

11:35 **Embodiment and Control of a Complex Object: Rhythmically Hitting a Target with a Whip**
Aleksei Krotov (Northeastern University)

When rhythmically hammering a nail into a wall, the hand can move along multiple trajectories even if the hammer always hits the nail. For such movements, without a tool or with a rigid one, high task accuracy is generally associated with low variability in both in the hand and the tool. Manipulation of complex objects or 'tools', such as clothes or ribbons, have received less attention, despite their abundance in daily life. Our research explores interaction with an extreme example of complex tools, a bullwhip.
Subjects used a 1.6-m whip to repeatedly hit a target at 2.2-m distance, with 30 trials per block. 16 and 16 novices practiced the task either in 5 or 35 blocks, respectively, and an expert practiced the task in 5 blocks. Arm and whip kinematics were recorded via 3D motion capture. Variability throughout the throw interval was quantified by each marker's cross-sectional areas of its repeated trajectories within each block.
Expectedly, experts hit the target in 90% of the trials, and novices scored 5-60%. In addition, the results suggested an emerging spatiotemporal structure of variability:

- Variability was lower in the expert, than in novices, and reduced with practice in novices.
- In all subjects, the tip of the whip reached minimum variability when it extended backwards before each throw and when it was closest to the target.
- In all subjects, the hand reached minimum variability at the time of its maximum velocity, and low variability propagated from the hand to the tip of the whip during the throw.

In agreement with task requirements and our previous findings, variability was reduced at the times and locations most relevant for the task: preparing the whip and then transferring energy from the hand through the whip to the tip. Assuming low variability reflects a focus of control, this control point appeared to shift from the hand towards the tip of the whip, suggesting embodiment of even such a complex tool as a whip.

11:55 **Stability in Emergent vs Enforced Motor Patterns and its Effect on Time Perception**
Hélène Serré[1], Tri Nguyen[2], Joo-Hyun Song[2], Dagmar Sternad[1] ([1]Northeastern University, [2]Brown University)

The human capacity to perceive and process time is likely to have been acquired through movement. When exposed to an auditory rhythm, it is the coupling between motor and auditory processes that enable time prediction. This coupling is manifested in the beta-band (~20Hz) activity of the sensory-motor cortex, bursting at each beat expectation, even when distracted by another task. This auditory-motor coupling is strengthened by practice, such as playing a musical instrument. As a result, such practice improves time prediction. The link between auditory and motor timing has mainly been studied in the context of music production. Does the interaction between perceptual and motor timing also occur in activities that do not require specifically timed actions? For example in bouncing a ball rhythmically, motor timing arises from complex neural subsystems, modulated by biomechanical properties as well as idiosyncratic preferences. Over time, these subsystems generate stable spatiotemporal patterns, or 'dynamic primitives'. Does time sensitivity increase as stability emerges? To answer this question, we carried out an experiment with five sessions over five days in which participants were asked to use a paddle to bounce a virtual ball shown on a screen. One group of participants bounced the ball at their own pace to allow emergence of a spontaneous stable pattern. A second group of participants were instructed to reach a given target that turned green if the ball's maximum height was close enough to the target. This second task enforced a 600ms bouncing period and, due to the success feedback, an error-correction strategy, intended to slow down the emergence of motor stability. In each practice session, participants performed six blocks of 5 trials (30s). Following this motor practice, participants are tested in a psychometric task, where they had to listen to a rhythmic tone sequence and identify whether one of the intervals were shorter or longer than the others. This task tested three standard intervals, one corresponding to the bouncing period of the participant, the other two higher and lower than the motor-derived period. Our findings suggest that: 1) Bouncing at one's own pace led to a more stable pattern than bouncing to reach a specified target. 2) When bouncing at their own pace, participants became more time-sensitive around their bouncing period, shown as lower Weber fractions than for the other intervals. These findings shed light on the fundamental role of dynamic stability and motor primitives for processing auditory rhythms. The results also suggest opportunities to improve time sensitivity beyond music practice, as may be relevant for some neurological disorders.

Session 4

1:30 **Causal Relations Between Behavioral and Physiological Dynamics in Interpersonal Coordination**

Wenbo Yi, Caroline Palmer (McGill University)

Interpersonal coordination in joint tasks can involve behavioral and/or physiological synchronization, yet their causal relationship is not understood. We tested directional relationships between partners' behavioral and physiological synchrony as 64 musically trained adults produced melodies together. Partners' respiratory and cardiac signals were compared across dyadic melody perception, melody synchronization, and resting (silent) baseline tasks. Synchronization trials introduced perturbations to partners' auditory feedback (disrupting their tone onset synchrony) or to partners' respiratory rhythms (disrupting their cardiac synchrony), in order to assess directional effects of perturbations at one level (behavioral or physiological) on the other level.

Respiratory perturbations most disrupted partners' auditory-motor synchrony. Partners who breathed more synchronously exhibited greater tone onset synchronization. Auditory perturbations also disrupted partners' auditory-motor synchrony and facilitated cardiac synchrony, despite the fact that partners' cardiac synchrony was greater during joint synchronization than during joint perception. Partner-specific differences also affected behavioral and physiological synchronization. Partners with similar intrinsic behavioral frequencies (measured by Spontaneous Production Rates) achieved better behavioral synchrony, and partners with more similar resting heart rates showed stronger cardiac coupling during synchronization. These findings indicate dynamic entrainment processes between behavioral and physiological levels, and highlight the importance of group-level differences in interpersonal coordination.

1:50 **Disentangling Human- and Model-Specific Features in Virtual Partner Interaction Paradigms**

Bavo Van Kerrebroeck[1], Caroline Palmer[1], Alexander P. Demos[2] ([1]McGill University, [2]University of Illinois Chicago)

The virtual partner paradigm, in which agents interact with humans in performing a task, has emerged as a powerful tool in study of group dynamics. This paradigm allows researchers to probe human responses to diverse models and specific parameter values. However, limitations exist in distinguishing human-specific traits (such as sensorimotor variability), model-specific features (such as coupling dynamics), and their interactions; instead, human groups are often used as baselines for comparison, or simple human-model comparisons are made without systematic cross-model comparisons. To address this problem, we propose a novel framework that systematically crosses models during (empirical) and after (simulation) human data collection, in order to isolate human- and model-specific contributions. We present a case study with one human-human dyad compared with two distinct human-model dyads that perform a tapping synchronization task. By applying model optimization criteria, we identify classes of potential outcomes and methods to distinguish among them: Individual main effects attributable to human-specific features or model-specific features; and human-model interactions. Finally, we extend this approach to larger groups in order to consider a robust methodology for analyzing social behavior. This framework may advance theory-driven foundations for understanding diverse human-agent settings and enable researchers to identify optimal human-agent interactions.

2:10 **How Emotions Drive Interpersonal Synchronization: Insights for Modeling**

Andrii Smykovskyi, Stefan Janaqi, Benoît G. Bardy, Bavo Van Kerrebroeck, Jonna K. Vuoskoski, Caroline Palmer (McGill University, University of Oslo)

Interpersonal synchronization is a fundamental process through which individuals align their actions and co-regulate their emotions. Traditional explanations of this phenomenon have often overlooked the essential role of emotions. To investigate the impact of naturalistic emotion induction on interpersonal synchronization, we conducted two experiments that examined both spontaneous and intentional synchronization in groups of three participants. Spontaneous synchronization was assessed in an unstructured improvisational dance session in the first study, and intentional synchronization was measured through a structured task in which participants synchronized their oscillatory finger movements in a second study. In both experiments, participants received individual performance feedback after each trial,

and its effect on subsequent synchronization was measured. Without their knowledge, all participants received the same pre-determined positive- or negative-valenced feedback. Both studies indicated that positive-valence feedback strengthened synchronization, whereas negative-valence feedback weakened it, albeit to varying degrees depending on the context. These findings suggest the need for the integration of the emotional response into mathematical models of interpersonal synchronization, such as Kuramoto and Delay-coupled models. As a first step in doing so, we describe a subsequent study that addresses whether emotional response to feedback influences interpersonal coupling between individuals in an auditory synchronization paradigm in which partners receive matched-valence or mismatched-valence feedback. We consider whether unidirectional or bidirectional coupling best captures the impact of emotional response to feedback on auditory synchronization.

Session 5

2:40 **4/4 and Even More: Pupillary Entrainment in Complex Meters**
Connor Spiech (Concordia University)

In music psychology, groove is defined as the pleasurable urge to move to music. Previous work has found that rhythmic complexity exhibits an inverted U-shaped relationship with this experience. Physiologically, sustained pupil dilations (a measure of noradrenergic attention allocation) have been found to exhibit a similar relationship while entrained pupillary activity (an index of attentional precision in time) has been shown to decrease with increasing rhythmic complexity (Spiech et al., 2024). Previous work (Spiech et al., in revision) has found that groove's relationship to rhythmic complexity is modulated by metric expectations: rhythmically simpler music samples elicited higher groove ratings when the music was in uncommon meters (e.g., 7/8) as opposed to common ones (i.e., 4/4). These results imply that the listener's metric model impacts rhythm processing in groove, but it is unclear whether attention is similarly affected by these metric models. Specifically, the deployment of metric models was hypothesized to demand greater attentional resources (as evidenced by greater sustained pupil dilations) and result in better rhythmic processing (as evidenced by pupillary entrainment). Thus, we recorded participants' pupil sizes while they listened to 26 musical clips in either 4/4 or an uncommon meter. Following each clip, participants rated how much the music made them want to move and how much they liked it. Behavioral findings replicate prior work, with ratings in common meters following the inverted U-shaped pattern whereas for uncommon meters, lower rhythmic complexity elicited the highest level of groove. Preliminary sustained pupil dilation results show no difference by meter, indicating comparable attention allocation. Similarly, the pupillary entrainment is stronger for rhythmically simple music regardless of the meter and as rhythmic complexity increases, attentional entrainment switches from the beat to the slower, more predictable bar level. These findings suggest that attentional processes in groove are not sensitive to metric expectations.

3:00 **Maintaining Balance by Holding Hands in Ballet Dancers and Untrained Individuals**
Silvia Buscaglione (Northeastern University)

Maintaining postural balance requires complex neuromuscular control, which must be highly developed to provide the foundation for the precise, smooth, and harmonious

movements demanded of professional ballet dancers. Understanding the neural control of postural balance can contribute to this development by informing highly focused training regimes. In ballet, partnered routines (pas de deux) are a basic element; here, physical contact between partners provides support but can also present additional challenges to balance. While previous studies established that even light touch of a stable surface reduced postural sway, the effect of ‘holding hands’, providing interactive but also unstable support, remain largely unexplored.
This study examined the effect of ‘holding hands’ on postural balance between two partners with different skill levels. To simulate the high level of postural control balance required in dance, participants were required to stand in a tandem stance on a narrow beam (width 3.65cm, height 7.62cm). We hypothesized that pairing with a same-skilled partner enhances balance, while an expert paired with a not-trained partner experiences performance degradation.
Experts (n=14, professional ballet dancers) executed the task coupled with a novice and an expert, while novices (undergraduates, n=10) were coupled with a novice partner. Both groups were also tested standing alone. During the coupled conditions, partners stood side by side on a narrow beam, placed on a force plate, both facing forward, holding the same handle of a compliant robot. Each coupling condition was performed in 10 consecutive trials (30s each). We recorded the kinematics of the focal participant’s body motion to calculate the center of mass (CoM), ground reaction forces to obtain the center of pressure (CoP), and the robotic handle force. Dependent measures were the velocity of the CoM and the CoP. As participants frequently stepped off from the beam, the step-offs were also a metric for evaluating the goodness of the performance.
In the single conditions, novices stepped off the beam more frequently than experts and exhibited greater CoM velocity and CoP fluctuations, as expected. Yet, when ‘holding hands’ with a novice partner, all dependent measures decreased, reaching expert values. Counter expectations, all experts’ metrics remained unaffected by physical coupling, indicating that experts were neither perturbed by a non-trained partner, nor stabilized by a skilled partner. The haptic forces exchanged between partners via the robotic handle are under investigation.
By showing that novices improved when coupled with another novice, our study highlights the ability of the CNS to exploit haptic information. The fact that experts maintained their performance, even when coupled with a less skilled subject, indicated that they were able to reject perturbations by focusing on their own stability. These findings underscore the important role of haptic sensation in postural balancing and highlights the need to further investigate the bi-directional haptic communication. Insights into partner support across different coupling scenario have the potential to inform novel balance-training protocols tailored to individuals' skill levels.

3:20 **A Longitudinal Analysis of Beat Perception and Beat Production by College Musicians**

Laura Stambaugh (Rhode Island College), Bryan Nichols (Pennsylvania State University)

In a previous study, we found college musicians’ ability to detect rhythm errors was not significantly correlated with their ability to perceive beat alignment (Harvard BFIT) or tempo change (Goldsmiths BAT). A regression model showed melodic error detection ability was the only significant predictor for rhythmic error detection ability. We wondered if beat production might be more related to rhythmic error detection than the beat perception tasks. Therefore, in the present study, we had first-semester music

majors (n = 66) complete the Harvard BFIT, a synchronization-continuation task, a rhythm error detection test, and Digit Span Forward for working memory as part of an error detection study. Thirty-four participants returned to do the tasks again at the beginning of their third year of studies. Preliminary analyses indicate working memory was stable from Year One (M = 5.71, SD = 1.00) to Year Three (M = 6.82, SD = 1.29) t(33) = -.642, p = .524. Students ability to perceive tempo change was also stable from Year One (M = 21.35, SD = 2.71) to Year Three (M = 21.87, SD = 1.89) t(30) = -.984, p = .333. Rhythm Error Detection scores improved marginally from Year One (M = 14.27, SD = 3.5) to Year Three (M = 14.87, SD = 2.76), although this was not significant t(29) = -1.273, p = .213. Beat production scores were not significantly correlated with tempo perception (BFIT) or the Rhythm Error Detection test (p > .05). During the NEST presentation, we will look at individual and group level data. Discussion will consider the limited relationships among timing tasks in relation to previous literature.

Session 6

3:55 **Music Improvisation Enhances Reward and Motor Response Post-Stroke: an fMRI study**

Anna Palumbo (New York University)

Background: Music interventions improve motor function, mood and activation of sensorimotor brain networks post-stroke. Reward during music playing is linked to greater motor recovery. Our previous work links music improvisation to increased reward and motor performance in healthy adults. Research is needed to identify the underlying neural mechanisms linking reward to motor performance and to investigate these effects in survivors of stroke.
Objective: This study investigates the effects of music improvisation and live accompaniment on motor, affective, and neural response during a drum playing task among survivors of stroke and neurological normal control (NNC) participants.
Methods: 16 survivors of stroke and 16 NNC participants completed a drum playing task while either (i) improvising or maintaining the beat and (ii) playing with live or pre-recorded piano accompaniment. Motor response was characterized by hand acceleration, as measured by accelerometry, and muscle activation, as measured by electromyography (EMG). Autonomic arousal was measured by tonic electrodermal activity (EDA). Pleasure, physical effort, and cognitive challenge were measured by 5-point Likert scale after each playing condition. Neural response was measured via functional magnetic resonance imaging (fMRI), including region of interest (ROI) analysis in motor and reward-related brain regions, and functional connectivity between these two regions. For all outcomes, linear mixed effects models included a triple interaction between group (stroke vs NNC), improvisation (improvise vs. maintain the beat), and accompaniment (live vs recorded). Control variables included song composition, musical reward sensitivity (Barcelona Music Reward Questionnaire), and musical training (Goldsmith Musical Sophistication Index). For tonic EDA, hand acceleration was also included as a control variable to account for the effects of physical movement on EDA levels.
Results: Improvisation increased hand acceleration, muscle activation, and tonic EDA levels compared to maintaining the beat. Improvisation and live accompaniment increased ratings of pleasure. The presence of stroke increased ratings of physical effort and cognitive challenge. The presence of stroke also interacted with the effect of improvisation on muscle activation; among survivors of stroke, muscle activation during

improvisation was still greater than during the maintain the beat condition, however this effect was attenuated compared to the NNC group. Finally, hand acceleration was positively associated with tonic EDA levels during improvisation, but there was no association between hand acceleration and tonic EDA during the maintain the beat condition. Initial findings from fMRI indicate greater activation in reward and motor related brain regions during improvisation and live accompaniment compared to other conditions, among individual participants.
Conclusions: Improvisation increases pleasure, motor response, and autonomic arousal during music playing among survivors of stroke and healthy adults. The association between hand acceleration and tonic EDA during improvisation suggests a reward mechanism for increasing motor response, which will be evaluated at the neural level using fMRI findings.

4:15 **(Dis)Ableness and Inclusive Cities: Negotiating Practice-led Action Research in Music and Arts with Disabled People in Lagos, Nigeria**
Florence Ewomazino Nweke (University of Lagos)

The discourse around equity and social inclusion in many African societies has come to the fore lately, especially with recent developments such as the 2021 UNESCO-led advocacy for inclusive education, economy, and cities in Nigeria. In the ever-busy city of Lagos, Nigeria, a significant issue emerges that affects everyone, regardless of where we live. It is the challenge of social and economic inclusion, particularly for individuals living with disabilities. This issue, often overlooked, is crucial as it directly impacts the quality of life for these individuals and the overall health of our society. Disability, a condition that many might view as a limitation, can instead be a source of untapped potential. The concept of an inclusive society is one where every individual, regardless of their physical or mental abilities, is considered an integral part of the community. This is not just about fairness; it's about enriching our society with diverse perspectives and talents. However, there is a gap in understanding and practice of this inclusion, especially in Lagos. The consequences of this exclusion are not just felt by those directly affected, but ripple out to impact us all, socially and economically. This study addresses this issue, focusing on using music and art as therapeutic tools for students in special homes at the Modupe Cole Child Treatment Centre. The fieldwork was carried out at the Modupe Cole home where disabled children were kept. Music was performed, and the excitement and individual and group performances of these children reveal that music enhances social inclusion. It creates an avenue for the children to express positive emotions. This study reveals the untapped potential of these individuals and reframes our view of Lagos as an 'able city'. The implications for music and brain health are profound: music not only fosters social inclusion but also stimulates cognitive and emotional development, providing a therapeutic and expressive outlet for children with disabilities.

Posters

Looking For Support: Does Optic Flow Influence Bean Pole Nutation?
P. Adrian Frazier (University of Connecticut)

The tendril-climbing vine, *Phaseolus vulgaris* or the common bean, seeks its host support in a manner almost reminiscent of spinning and throwing a lasso. In the early stages of development, the apical shoot revolves in circular nutations, growing longer

with each cycle until finally colliding with something it can wrap around and climb. A question can be asked about whether *P. vulgaris* is blind to the presence of a nearby support before making contact with it, or if like its ranch-dwelling human counterparts, *P. vulgaris* has access to information in the light about where to aim. In this talk, I will present the results of an experiment suggesting that, indeed, these plants do use optic flow to guide their movements. Bean plant seedlings were placed one-each in a pair of cylindrical growing booths, one of which had a black rod for support nearby and the other did not. Examination of phase planes and optical angle* trajectories reveal a substantial difference between the movements of plants with and without nearby supports. Plants in booths with poles showed acceleration of the shoot tip's nutation as it approached the pole and slowing as it departed. At the same time, the optical angle's cycle of expansion and contraction was asymmetric about its cycle, and it's maximum expansion increased exponentially, one cycle to the next, over the course of the experiment. Neither slowing, nor the asymmetry, nor the exponential increase were observed for plants without supports. The next step for this analysis is determination and modelling of applicable control laws. This research establishes an innovative and rigorous approach to the study of perception and action in the plant kingdom.
*Between shoot tip and the two sides of the pole, or where they would be if present.

The Missing Pulse Revisited: Comparing Dynamic Models With Expert Listeners
Mina Golmohammadi (University of Connecticut)

Pulse is the perceptual phenomenon in which an individual perceives a steady beat underlying a complex auditory rhythm, as in music. A number of studies support the hypothesis that synchronization of neural oscillations is the mechanism of pulse perception, however this remains a topic of current debate. This study examines stimulus rhythms that have no spectral energy at the intended pulse frequency, called missing pulse rhythms. Behavioral studies with missing pulse rhythms show that people do perceive the pulse at frequencies predicted by neural synchronization. Further, EEG and MEG steady-state evoked response potentials (SS-ERPs) reveal the predicted frequencies, and have shown that their amplitudes correlate with perception. In this study, we first trained a neural model consisting of oscillatory auditory and motor networks with complex rhythms, and showed that pulse frequency oscillations arise in the motor planning network. Next we recorded EEG in expert listeners and analyzed only those trials for which perception of the missing pulse frequency was verified. We observed 1) strong pulse-frequency SS-ERPs to missing pulse rhythms, but not to a random control; 2) strong coherence between model-predicted SS-ERPs and brain responses; and 3) differing pulse-frequency localization for missing pulse rhythms versus isochronous controls. Comparison of these results with model predictions support the theory that pulse perception occurs as the result of an emergent population oscillation in motor planning networks that entrains at the pulse frequency.

1:2 Frequency Task Guidance and Training with Pendulums: The Helpful and the Harmful
Steven A. Masi (University of Connecticut)

For most people, performing smooth, rhythmic coordination patterns outside of 1:1 requires practice. Even simple ratio movements (e.g., 1:2) tend to require practice to go from jerky, irregular movements to a more fluid and consistent movement pattern. We instructed participants to rotate two handles in a 1:2 ratio using forearm

pronation-supination movements. One group of participants received ‘guiding’ pendulums (tuned to a 1:2 frequency ratio – 0.667 Hz and 1.333 Hz), while a second group had unweighted handles without a preferred orientation. Participants who received the pendulum guidance then had the guiding pendulums removed and were instructed to perform the movements with the unweighted handles. We expected that when compared with the participants in the un-aided condition, participants in the guiding-pendulums condition would have higher accuracy and faster acquisition of the 1:2 movement pattern both when the participants had the pendulums and after the pendulums were removed. We found that participants who had the guiding pendulums more rapidly acquired and performed with less error the 1:2 movement pattern than participants who never had the pendulums; however, two groups emerged when those guiding pendulums were removed. One group of pendulum-trained participants seemed to perform better than the average un-aided participant (as expected). However, a second smaller group of pendulum-trained participants performed considerably worse than the average un-aided participant. In future studies, we plan to elucidate the specific learning trajectories that lead to the observed differences in skill transfer from the pendulum-aided to un-aided contexts.

The Seven-Layer Symphony: How Multisensory Engagement and Music Enhance and Optimize Neural Networks

Donna Syed (North Arrow Consulting)

Background:
Music is widely recognized as a powerful tool for cognitive, motor, and emotional engagement, but its full potential is often limited to auditory and rhythmic processing. While research has established that music therapy, rhythmic entrainment, and movement-based interventions support neuroplasticity, and neurogenesis, the potential of concurrent multisensory activation and personalized music selection remains largely underexplored. Expanding upon traditional music-based approaches by systematically engaging seven sensory input channels—proprioceptive, vestibular, tactile, auditory, olfactory, gustatory, and interoceptive (including musculoskeletal and vocalization sensations)—alongside movement and rhythmic stimulation. This process integrates multi-channel sensory input, nervous system regulation, and both top-down and bottom-up cognitive processing to optimize flow state, motor learning, and brain-body coordination.
Objective:
This interactive and experiential presentation explores how multisensory engagement, personal music selection, movement synchronization, and vibration work together to enhance and optimize neural networks beyond conventional music therapy. A critical factor in this process is the use of an individual’s preferred music, which enhances salience, emotional connection, and memory activation. When preferred music is combined with specific, simultaneous multisensory stimulation with simple, yet novel movement patterns, neural network recruitment is exponential. These novel patterns with layered multi-channel sensory input link brain areas that are not typically activated together with minimal cognitive load, optimized neuroplasticity, and significant improvements of sensory-motor integration. Systematic repetition of multi-channel sensory input leads to the formation of new cue patterns, which may have valuable applications for motor learning, neuro-recovery, and cognitive performance enhancement.
Methods & Application:
This interactive presentation will demonstrate and address:

1. The neural mechanisms of multisensory engagement—how intentionally activating multiple sensory channels simultaneously strengthens network connectivity and neuroplastic adaptation.
2. The impact of personalized music selection—how familiar and novel rhythmic structures stimulate memory, reward pathways, and cognitive processing, creating unique neural activation patterns.
3. The role of movement and sensory feedback—how engaging multiple input channels optimizes proprioception, balance, and executive function beyond traditional rhythm-based interventions.
4. Cue pattern formation and cross-network activation—how music-driven multisensory engagement recruits diverse brain areas, forming novel pathways with long-term neural activation potential and neuropathway differentiation.
5. Preliminary observations—exploring how this integrated approach may enhance cognitive aging, neuro-recovery, and motor performance.
Conclusion:
Music is most powerful when it is personally meaningful, paired with movement, and layered with full-body, multisensory engagement. By enhancing and optimizing neural networks through concurrent sensory activation and cue-based learning, this approach provides a novel framework for expanding music cognition research, brain health interventions, rehabilitation strategies, and performance enhancement across a wide spectrum. This presentation invites further discussion on how integrating multisensory inputs with personal music selection can refine and advance existing models of music-based therapy and neural optimization.

Neural Resonance and the Embodied Dynamics of Musical Groove
Susan Tilbury (University of Connecticut)

The pleasurable urge to move to music is a ubiquitous, often involuntary, human response to groove-based music. From an ecological perspective, perception-action interdependence would suggest that the embodied response to musical groove is a fundamental aspect of its perception. Timing deviations in the form of syncopation are necessary to the experience of groove, with rhythms proceeding in an arc from low syncopation (low groove), to moderate syncopation (high groove), to high syncopation (low groove). Predictive coding models explain this phenomenon in terms of weighted priors and violations of inferred expectation. In contrast, our theory accounts for groove in terms of direct perception via nonlinear resonance in nested perceptual-motor systems. Here, we present a dynamical systems model of musical groove as a consequence of nested multifrequency oscillator networks with Hebbian plasticity. From this perspective, nonlinear coupling elicits cascading dynamics, resulting in steady-state behaviors and motor learning. Thus, the physical dynamics of interacting organism-environment systems can explain why it feels so good to move to the groove, without the need for brain-bound cognitive models.

Is Perceptual Timing Shared with Emergent Motor Timing?
W. Ryan Waite (Brown University)

Feedback-based error correction is important in all forms of learning, including learning of motor skills, whether in sports, physical therapy, or a new hobby. However, most research so far has only focused on learning long sequences or adaptation of well-learned actions, and not on learning novel skills, which relies more heavily on

domain-specific sensorimotor information to correct errors. Unlike domain-general discrete information (words, objects, numbers, etc.), which can be verbalized, motor parameters (speed, angle, posture, or timing) are not easily converted into verbal form and must rely on sensorimotor information (the colloquial “feel” of 3-point throw, for example). We investigate whether timing information critical to a novel precision-based motor task is stored as domain-specific sensorimotor information or as domain-general timing information. If motor timing information is stored domain-generally, having to store timing information for a different timing-based task is expected to disrupt the motor timing information and thus affect motor learning. Over two days, participants learned a precision throw task, where they must throw a virtual ball over an obstacle to hit a small target. Between each throw, participants performed an interference task, in which they memorized and then responded to either task-relevant (timing) or task-irrelevant (pitch) information about a sound, or did not have to respond to the sound. Preliminary data analysis has shown that participants improved in their throw accuracy and throw timing variability across the two sessions. Individual sensitivity to auditory timing predicted both accuracy and learning rate in the motor task, while sensitivity to auditory pitch only predicted throw accuracy.

Local Arrangements

Registration

Registration fee ($40 for faculty, $25 for students/postdocs) can be paid on site by cash, check or Venmo (breakfast, lunch and dinner will be provided).

Technology

Presenters will be asked to share their slides via the standard HDMI port. Please bring any dongles!

A **Live Stream** link for virtual presentations is available here: http://www.kaltura.com/tiny/lg2d6

Wi-Fi is available via the UConn-Guest network or EDUROAM network.

Venue

University of Connecticut
Bousfield Psychology Building, Room A106

Address: 406 Babbidge Rd, Storrs, CT 06269
Google map: https://maps.app.goo.gl/NUXT1UnKjdjJ78Rq9

Evening cocktails & dinner will occur at Ed Large's home.

Parking

Parking is available in the following lots:

- South Parking Garage (there will be signs to the conference site; see here for parking fee; payment is required at the time of entry and can be made via the Flowbird mobile app or at the kiosk near the elevator on the first floor.)
- There are also a limited number of on-street parking spaces on Whitney Road that are free on Saturdays.
- Lot S (free on Saturday)
- Fine Arts Lot 1 (free on Saturday)

Handicap Parking is available at the back of the Bousfield Building & in the South Garage.

If you need transportation from the parking lot, please contact the UConn Accessible Van Service: **(860) 486-4991** to make arrangements.

Other parking venues can be found on UConn's parking map (ArcGis interactive, PDF). Please make sure **not** to park in spots marked as restricted or limited: you WILL get a ticket!

Food & Refreshments

Registration costs will cover breakfast, lunch, and dinner.

If you need to purchase your own meals, a few restaurants within walking distance offer vegan/vegetarian, gluten free, and other options. Here are some of our favorites (links go to Google maps):

- Dog Lane Cafe (Vegetarian, GF options)
- Kathmandu Kitchen & Bar (Vegan/vegetarian options)
- Little Aladdin Mediterranean (Halal, vegetarian options)
- Moe's Southwestern Grill (Vegan/vegetarian, GF options)

A CVS pharmacy and Price Chopper are also available within walking distance.

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