

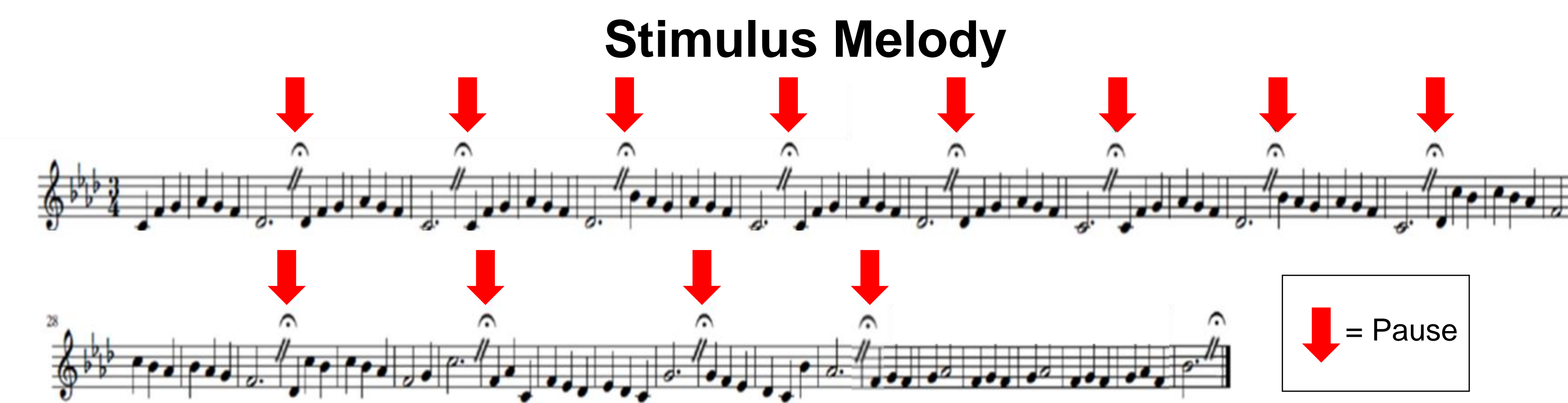
# Silence in the brain: An EEG study of expressive silence in individual and joint musical action

## Introduction

- ✓ **Silence is an integral feature of auditory-motor communication:**  
Musicians & speakers often pause between phrases
- ✓ **How do partners in auditory-motor interaction coordinate the duration of pauses to ensure seamless interaction?:**  
Partners may simulate & predict one another's actions<sup>1</sup>, or modify their own actions (e.g. speed actions, reduce variability).<sup>2</sup>
- ✓ **What are neural correlates of action preparation during pauses in auditory-motor interaction?:**  
Cortical beta oscillations (13-30 Hz) reflect action preparation in other tasks<sup>3</sup>, may reflect level of certainty about upcoming actions.<sup>4</sup>
- ✓ **We address these questions in the context of music performance.**

## Design & Methods

N = 40 pianists (20 pairs), > 6 yrs piano training, right-handed



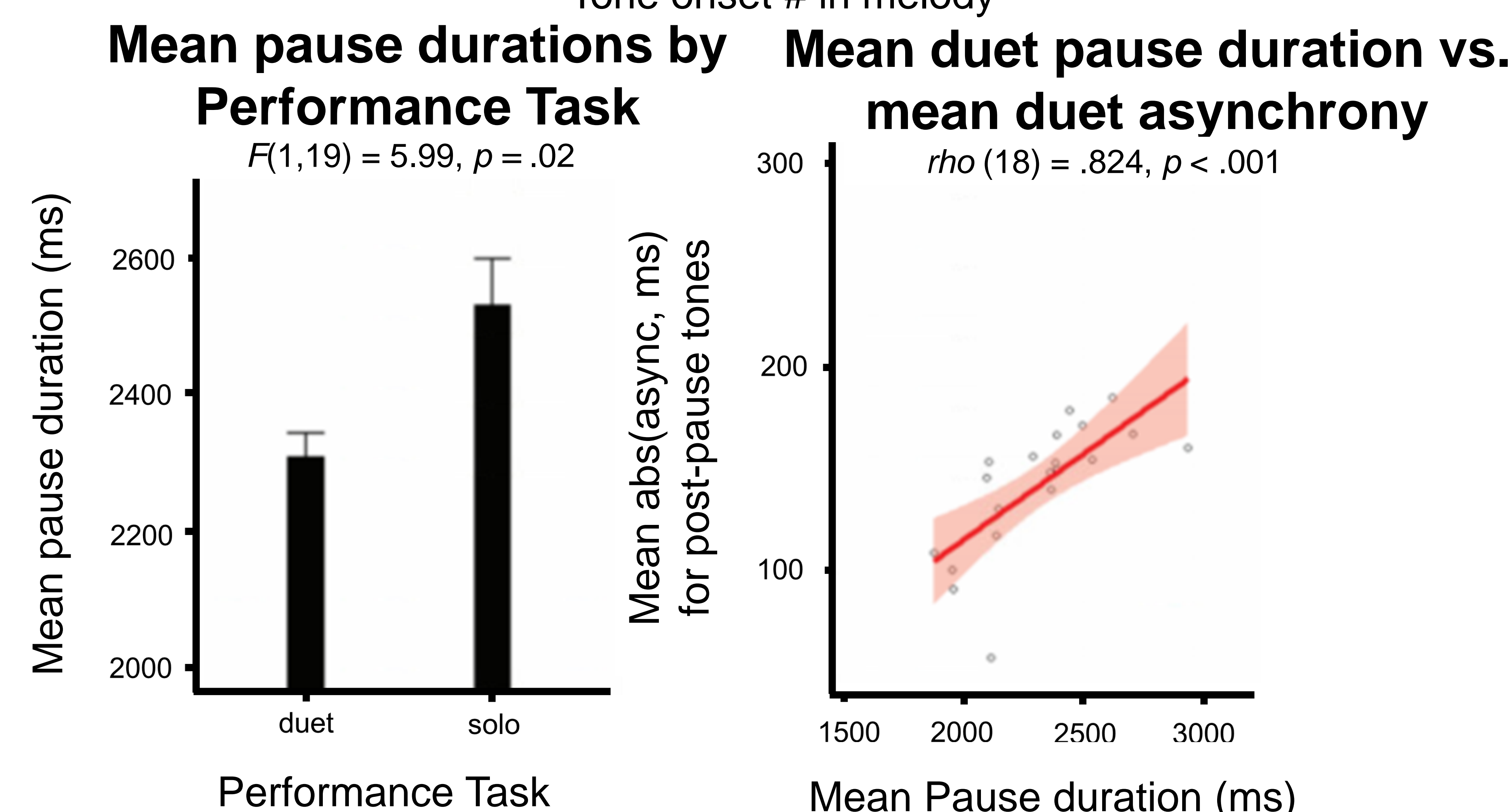
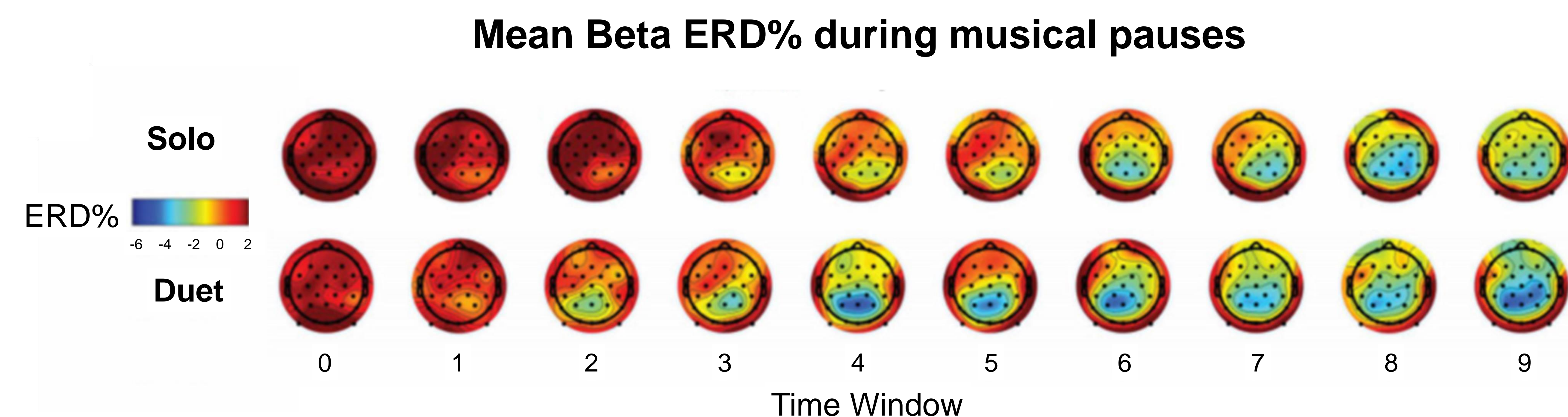
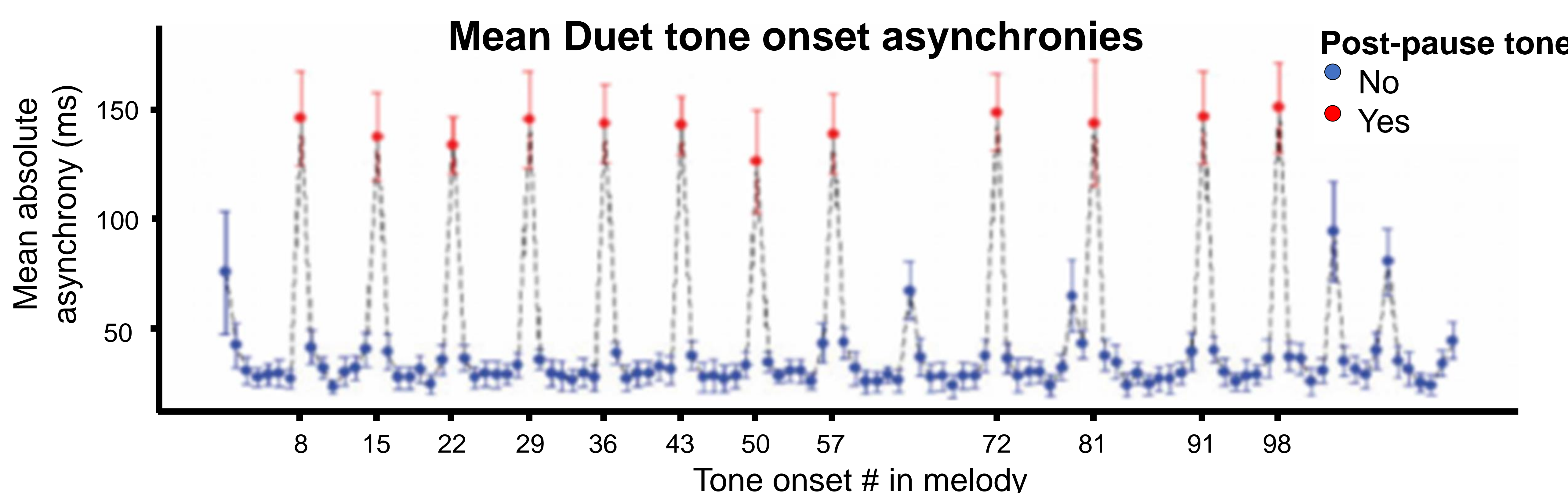
**Design & Procedure:** 2 Performance Tasks  
Pianists instructed that pauses should be expressive, intuitive, unique

**(1) Solo**  
Perform melody alone  
(right hand, 5 trials)

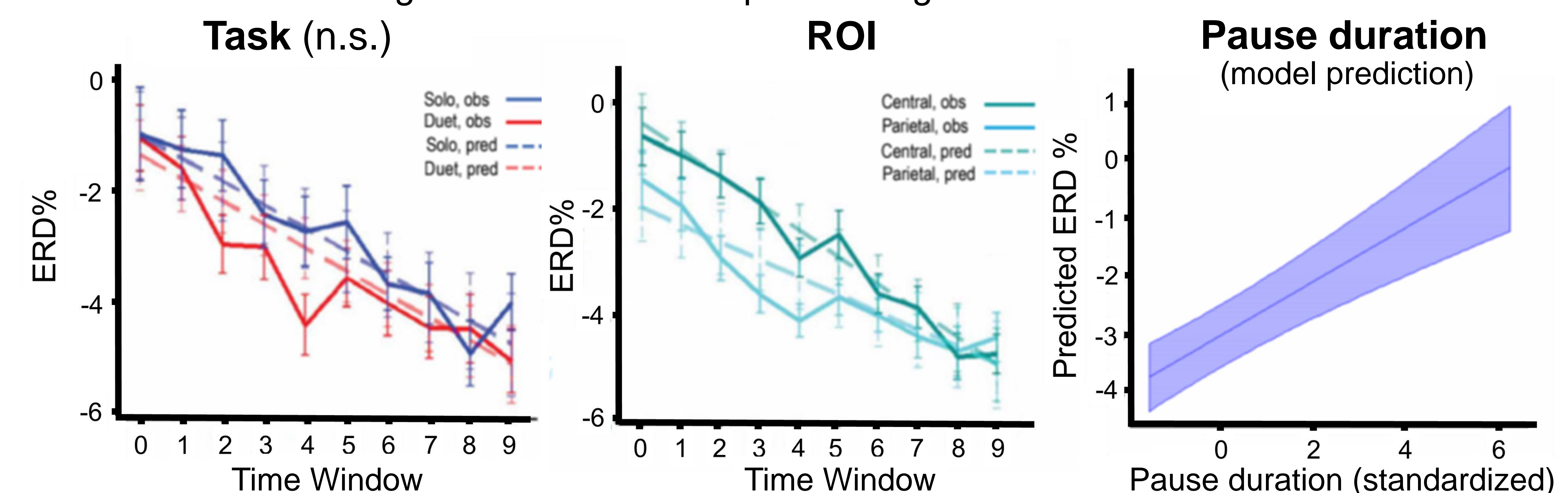
**(2) Duet**  
Perform melody w/partner  
(right hand, octave unison, 5 trials)

- **Data acquisition:** 32-ch EEG data were acquired per subject using 2 BrainAmp DC amplifiers (BrainProducts GmbH, DE), ref=FCz, while pianists performed on MIDI keyboards
- **EEG preprocessing:** ICA artefact correction for eye blinks/movements, re-referenced to linked mastoids, 13-30 Hz filter, epoched relative to pause onsets (-1-6s), divided into deciles
- **Behavioural DVs:** Pause durations, Duet asynchronies
- **EEG DVs:** Beta ERD% (proportional difference from baseline amplitude, baseline = -.5-0s), computed for pause Time Windows (deciles)

## Results



**Linear Mixed Effects Model Predicting Beta ERD%**  
Sig. Effects: ( $p < .05$ ) = Time Window, Pause Duration, ROI\*Timewindow  
ROI = Central (C3, C4, Cz) & Parietal (P3, P4, Pz, P7, P8)  
Significance levels computed using Satterthwaite's method



## Conclusions

- ✓ **Musical silence represents challenge to interpersonal coordination:**  
Larger asynchronies for post-pause tones relative to other tones
- ✓ **Partners overcome this challenge by reducing pause durations:**  
Pauses shorter on average in Duets than Solo performance  
Shorter pauses associated with lower asynchronies for post-pause tones
- ✓ **Beta ERD% reflects action preparation during pauses:**  
Beta ERD% shows classic desynchronization that anteriorizes;  
Shorter pauses show enhanced ERD > may facilitate action readiness

## References

- <sup>1</sup>Kourtis, D., N. Sebanz, and G. Knoblich. 2013. "Predictive representation of other people's actions in joint action planning: An EEG study." *Social Neuroscience* 8 (1): 31–42.
- <sup>2</sup>Vesper, Cordula, Robrecht P. R. D. Van Der Wel, Günther Knoblich, and Natalie Sebanz. 2011. "Making oneself predictable: Reduced temporal variability facilitates joint action coordination." *Experimental Brain Research* 211 (3-4): 517–30.
- <sup>3</sup>Engel, A. K., & Fries, P. (2010). Beta-band oscillations—signalling the status quo?. *Current opinion in neurobiology*, 20(2), 156-165.
- <sup>4</sup>Tzagarakis, C., Ince, N. F., Leuthold, A. C., & Pellizzer, G. (2010). Beta-band activity during motor planning reflects response uncertainty. *Journal of Neuroscience*, 30(34), 11270-11277.