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

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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[1], or modify their own actions (e.g. speed actions, reduce variability).[2]

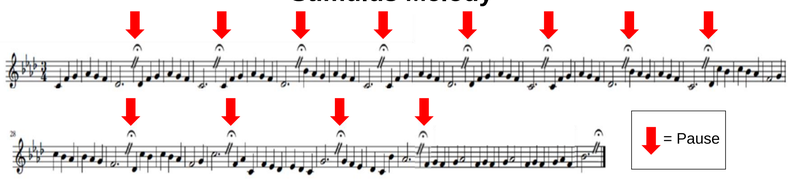
✓ **What are neural correlates of action preparation during pauses in auditory-motor interaction?:**
Cortical beta oscillations (13-30 Hz) reflect action preparation in other tasks[3], may reflect level of certainty about upcoming actions.[4]

✓ **We address these questions in the context of music performance.**

Design & Methods

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

Stimulus Melody



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

(1) Solo	**(2) Duet**
Perform melody alone (right hand, 5 trials)	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

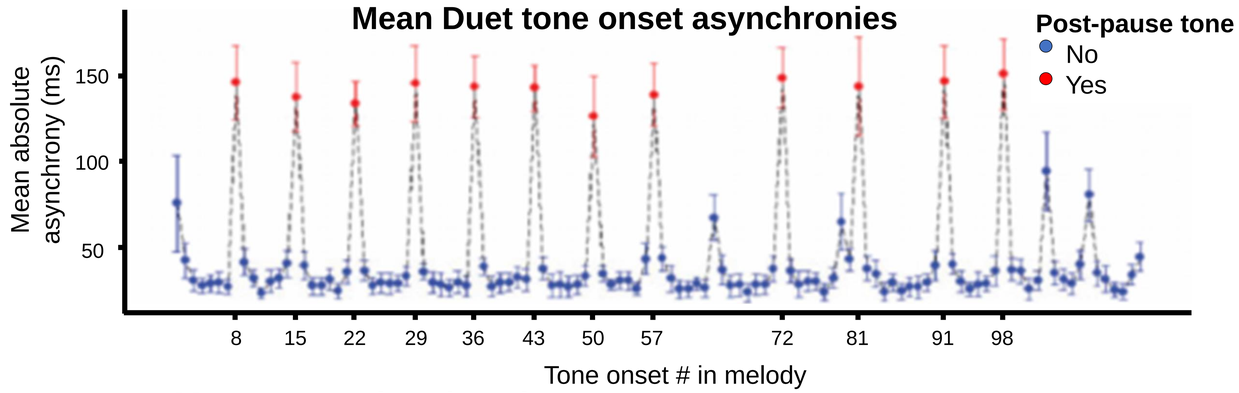
❑ **EEG preprocessing:** ICA artefact correction for eye blinks/movements, re-referenced to linked mastoids, 13-30 Hz filter, epoched relative to pause onsets (-1-6s), divided into deciles

❑ **Behavioural DVs**: Pause durations, Duet asynchronies

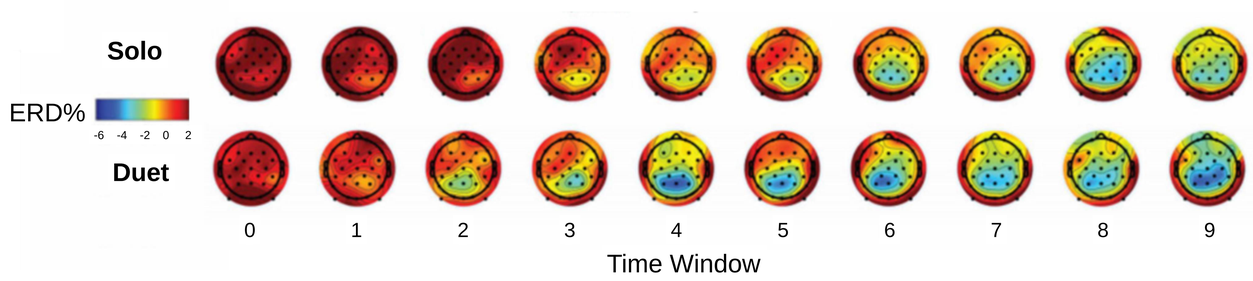
❑ **EEG DVs:** Beta ERD% (proportional difference from baseline amplitude, baseline = -.5-0s), computed for pause Time Windows (deciles)

Results

Mean Duet tone onset asynchronies



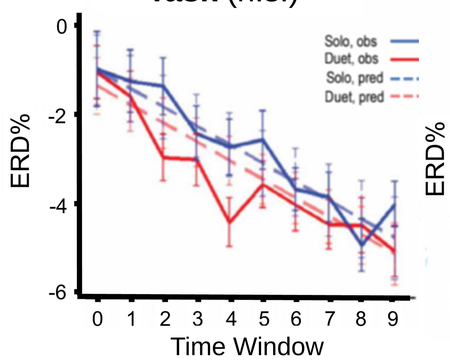
Mean Beta ERD% during musical pauses



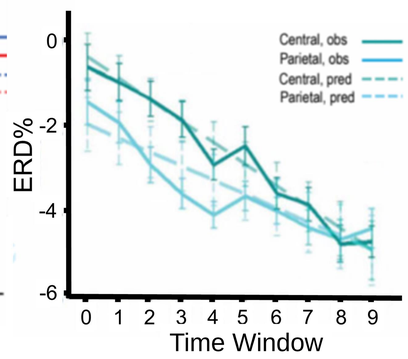
Linear Mixed Effects Model Predicting Beta ERD%

Sig. main effects ($p < .05$) = Time Window, Pause Duration, ROI; no sig. interactions
Significance levels computed using Satterthwaite's method
ROI = Central (C3, C4, Cz) & Parietal (P3, P4, Pz, P7, P8)

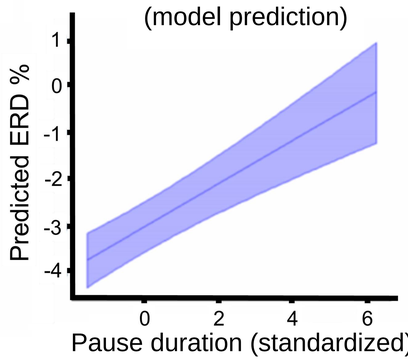
Task (n.s.)



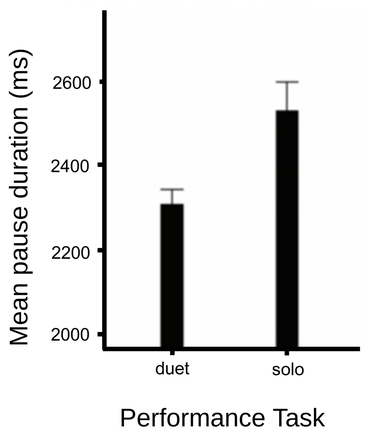
ROI



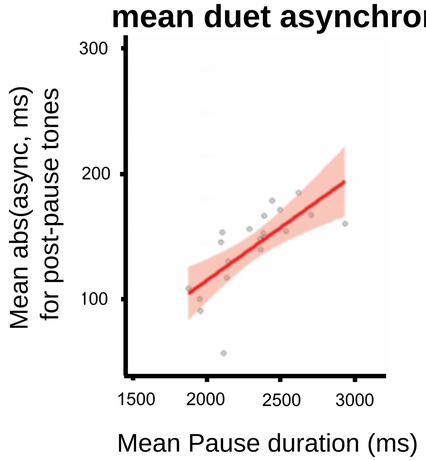
Pause duration
(model prediction)



Mean pause durations by Performance Task



Mean duet pause duration vs. mean duet asynchrony



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

✓ [1]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.

✓ [2]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.

✓ [3]Engel, A. K., & Fries, P. (2010). Beta-band oscillations—signalling the status quo*?. Current opinion in neurobiology, 20(2),* 156-165.

✓ [4]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.