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Bringing knowledge to life

Functional Segregation of Self and Other in Joint Action. A Dual-EEG study with piano duos.

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Exploring Integration and Segregation of Self and Other in Musical Joint Actions

- Music as a microcosm of (or a window on) social interaction.
  - Ecological, widespread, ancient human capacity
  - Limited but versatile/complex movement
  - "Neuroimaging-friendly"

  Keller 2008, 2012, 2014

- Successful joint (musical) action relies heavily on the brain capacity to *integrate* Self- and Other-related motor outputs, as well as maintaining autonomy (*segregation*) between the two.

  De Jaegher et al., 2010, Pacherie 2012

Novembre & Keller (2014)
Keller, Novembre, Hove (forthcoming) Phil. Tran. Royal Society B.

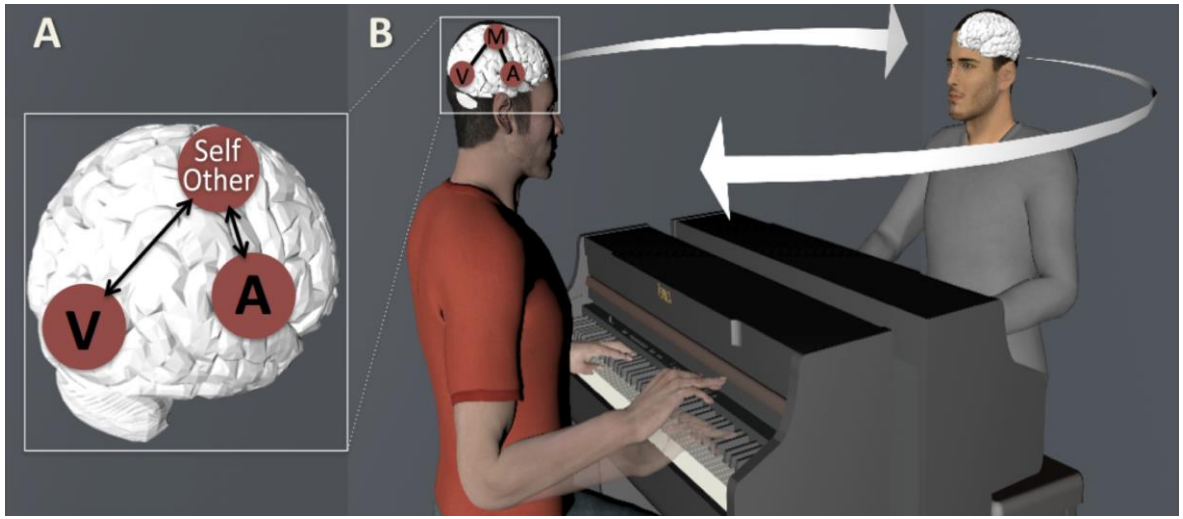
Two fundamental psychological constructs

1) Inter-personal synchrony (e.g. level of self-other timing adaptation)

Tognoli et al., 2007, Repp & Keller 2008, Hove & Risen, 2009, Saenger et al., 2012, Fairhurst et al., 2013, 2014

2) Co-representation (e.g. action familiarity)

Sebanz et al., 2006, Novembre et al., 2012, 2013, Ragert et al., 2013, Loehr et al., 2013



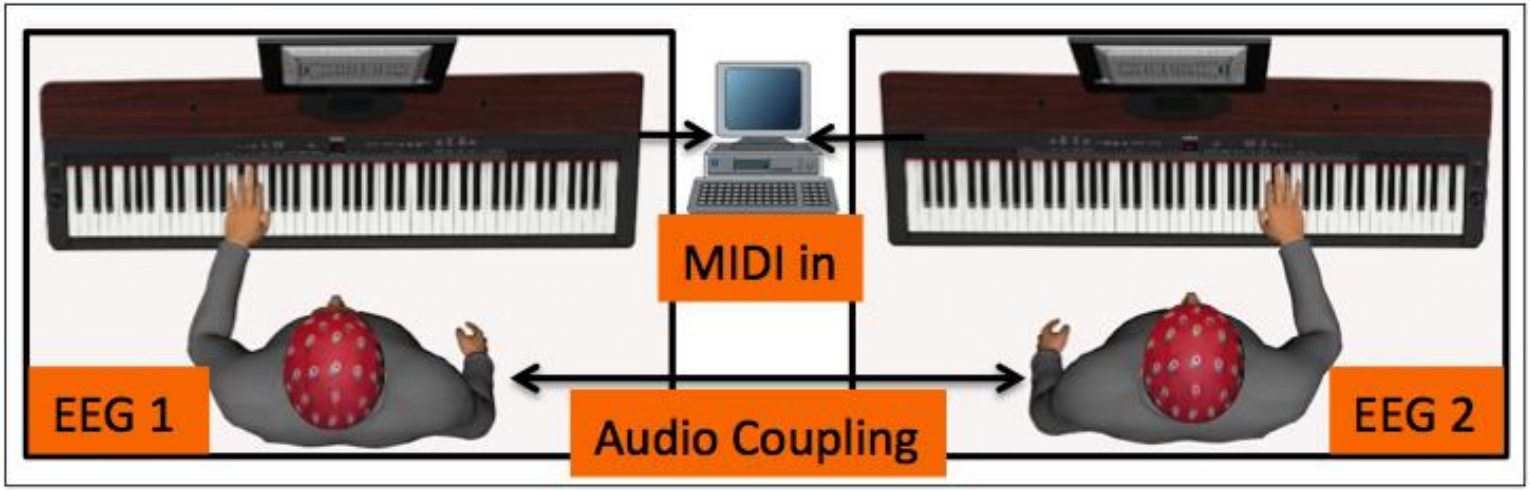
Research question: how are these constructs mapped in terms of neural oscillations during real-time joint musical action?

Novembre & Keller (2014)

Keller, Novembre, Hove (forthcoming) Phil. Tran. Royal Society B.

DUAL-EEG recordings with Piano Duos

- 28 pianists (14 pairs)
- Data Recorded: EEG (29 channels) and MIDI (to assess keystroke timing)
- Dependent variables: EEG power estimates, behavioral synchrony.
- 2x2 Factorial Design:
  - 1) Inter-personal tempo adaptation
  - 2) Action familiarity



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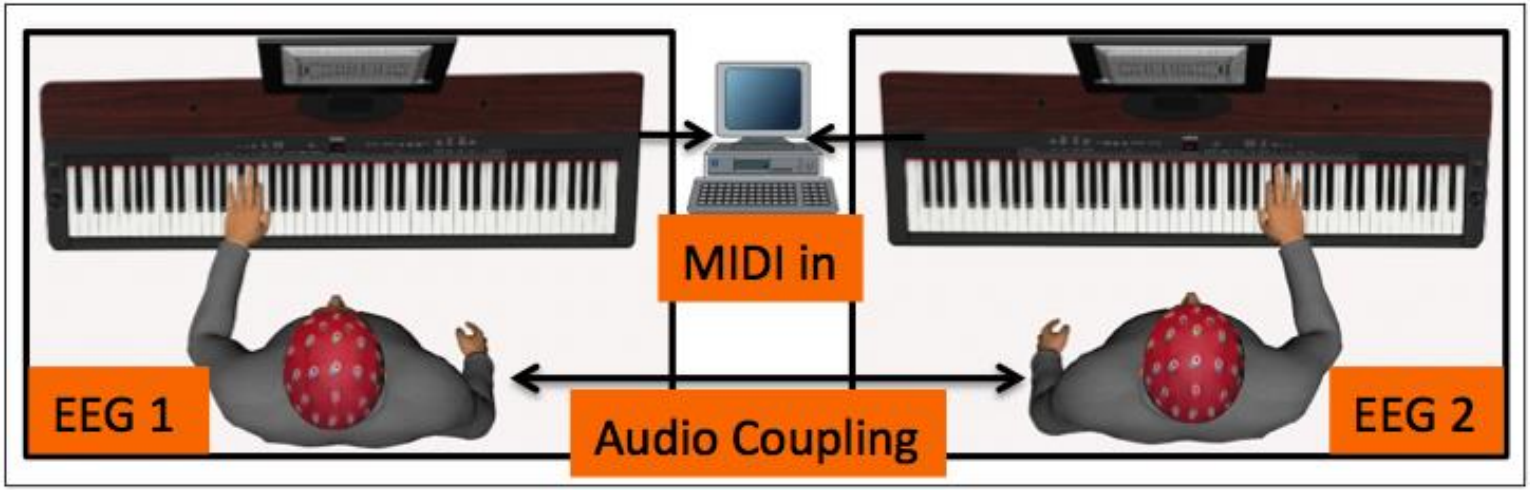
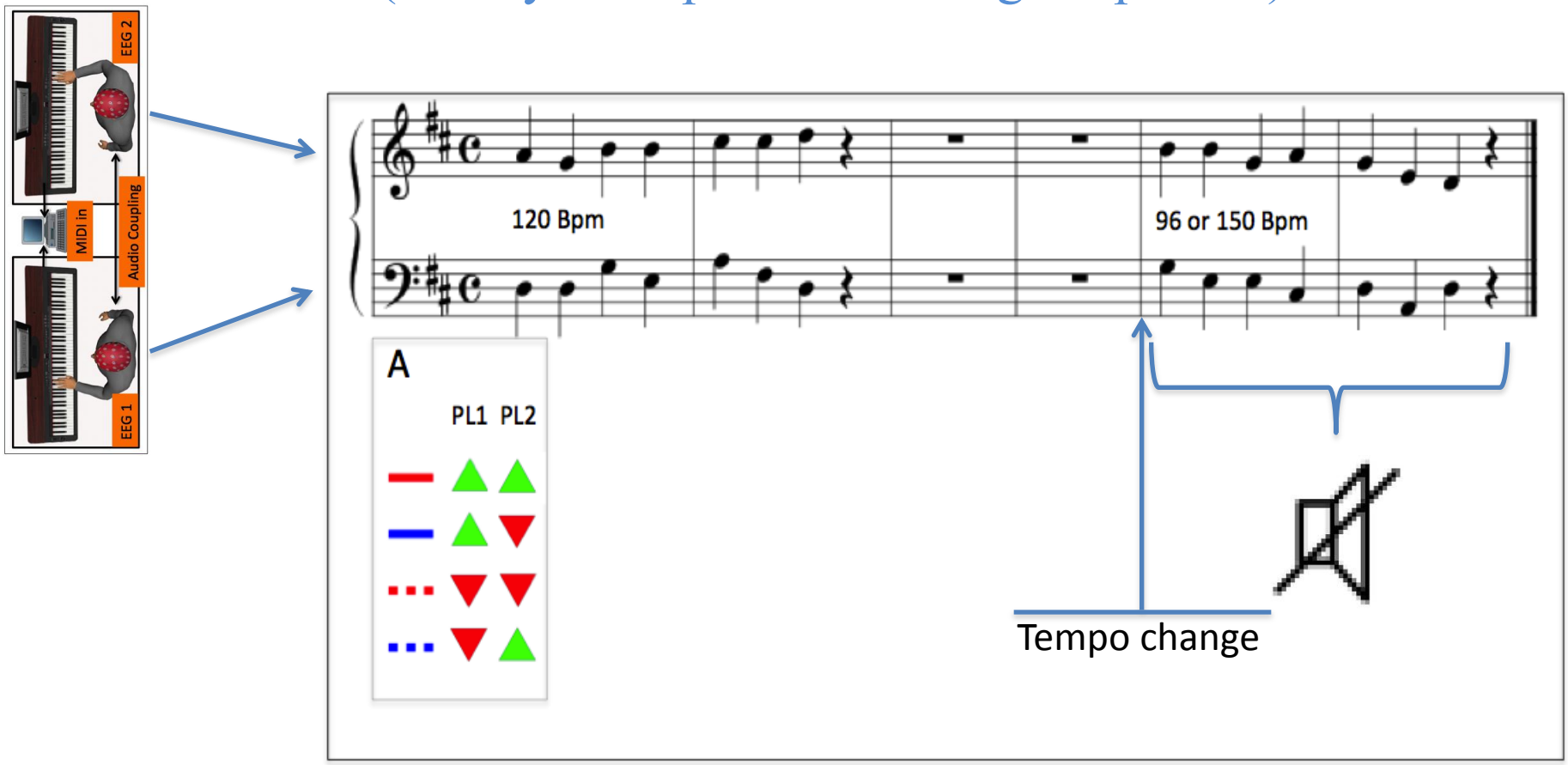


TEMPO manipulation

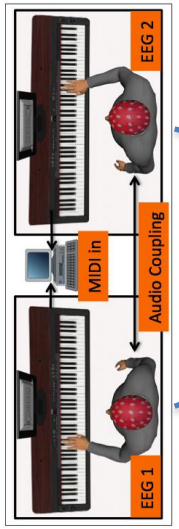
(to vary inter-personal timing adaptation)

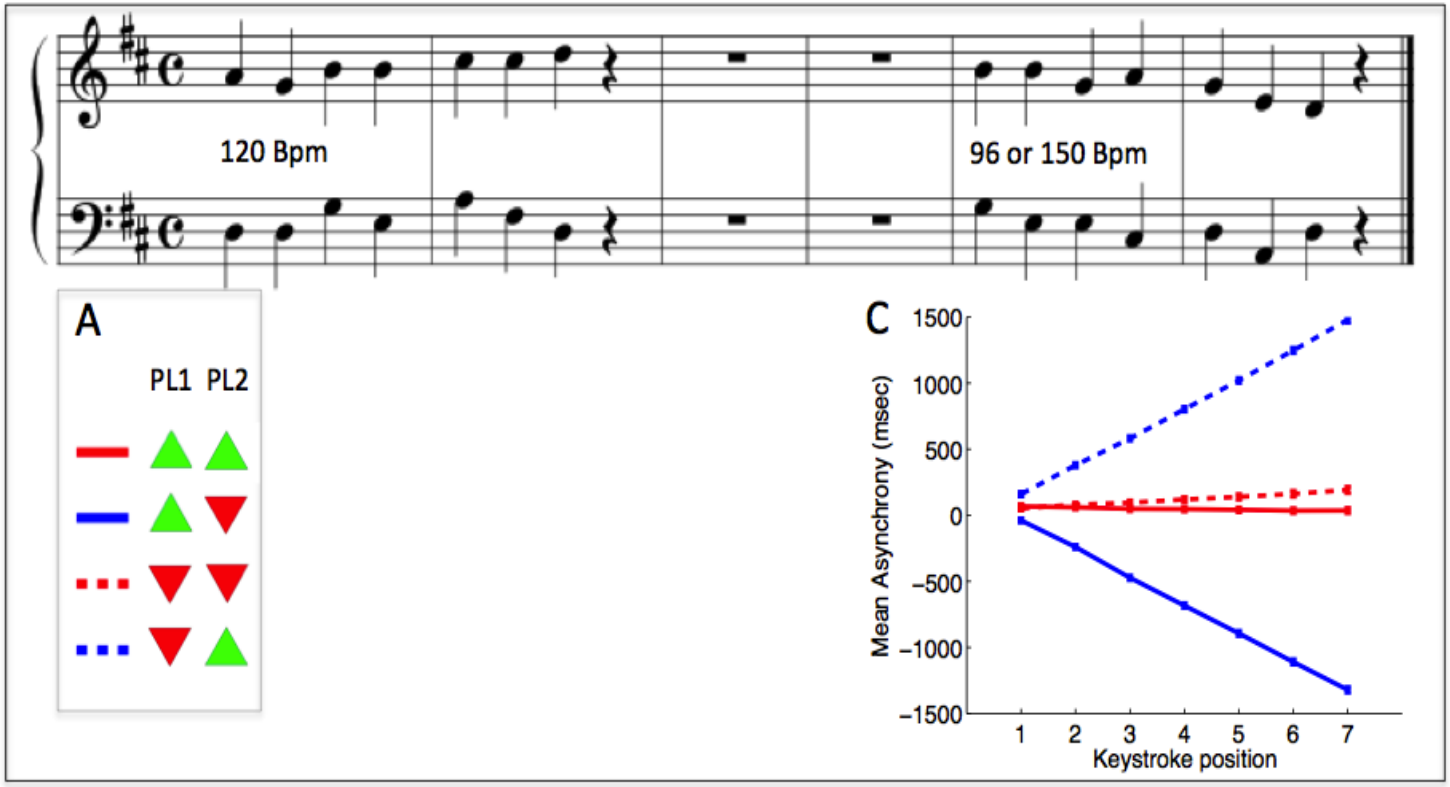


In the initial part (left), pianists play 2 complementary parts at the same tempo (120 Bpm) … in the second part (right), pianists change tempo congruently or not (with no feedback).

TEMPO manipulation

(to vary inter-personal timing adaptation)

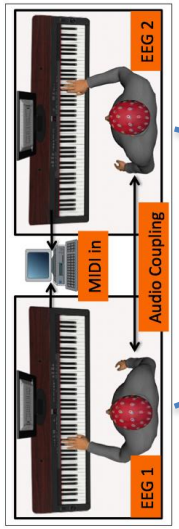


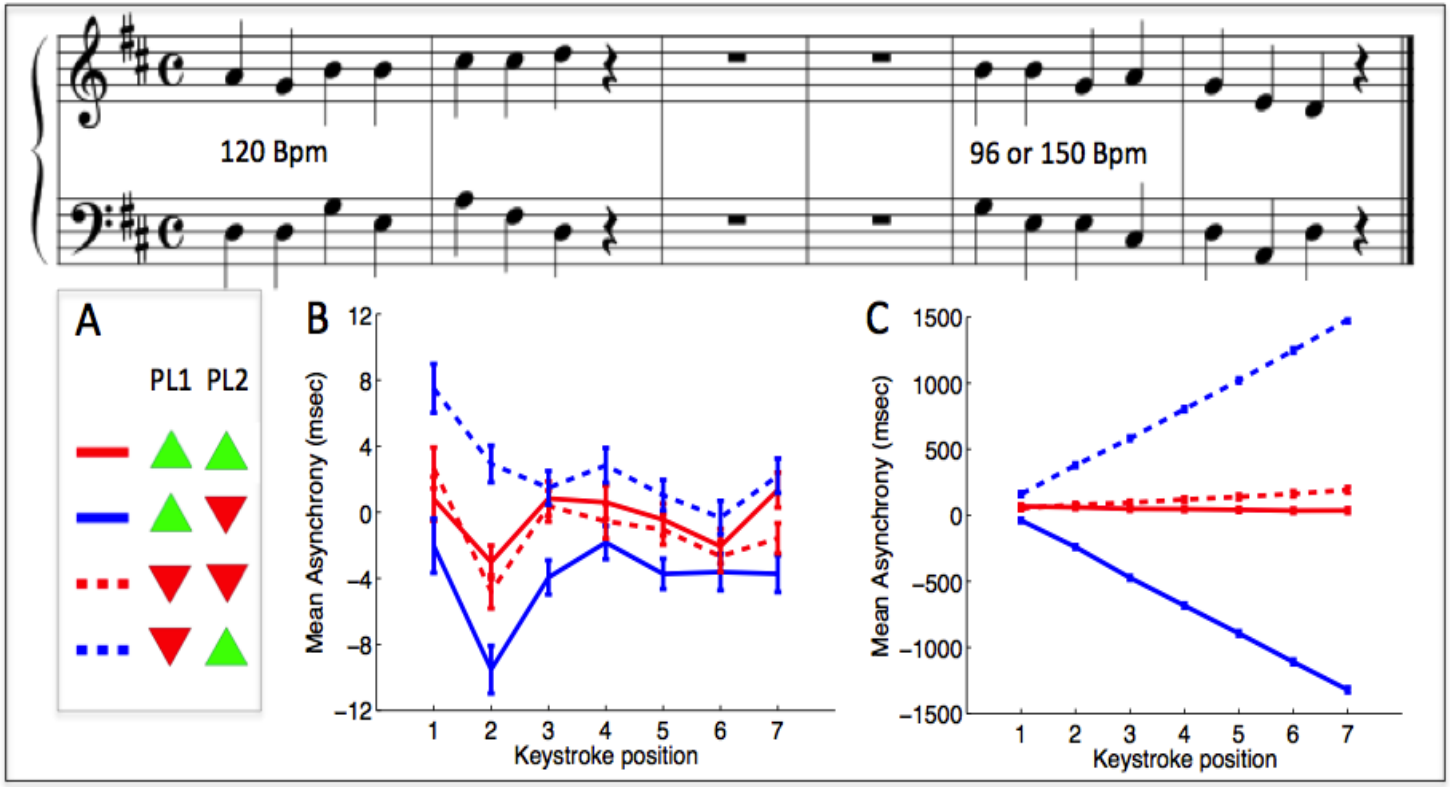


In the second part (right), pianists were changing tempo as instructed.

TEMPO manipulation

(to vary inter-personal timing adaptation)

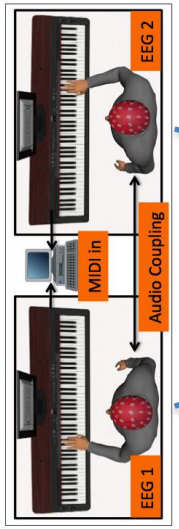


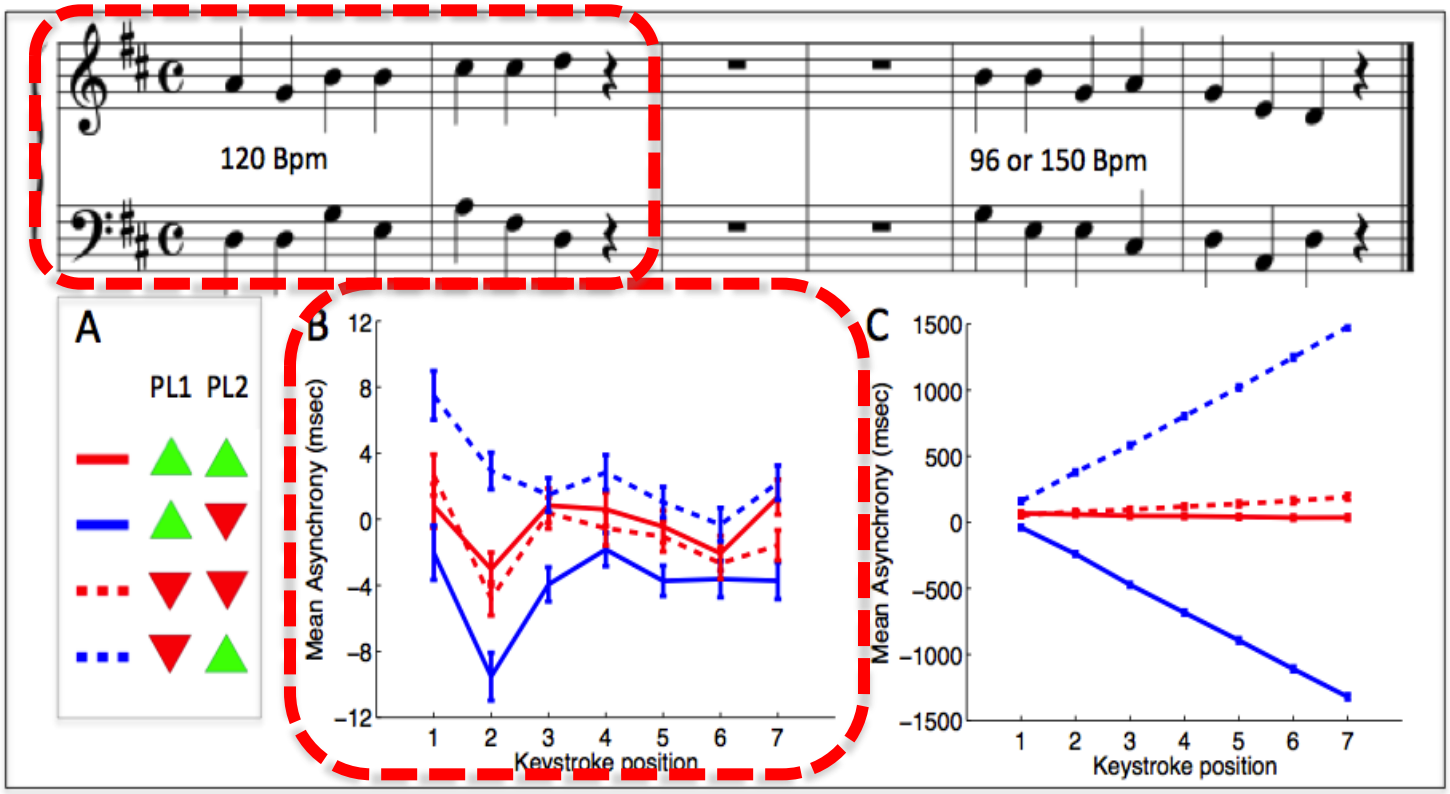


In the initial part (left), subtle changes in inter-personal synchronization (~5 msec) indicated that the pianists were reliably ($p<.001$) anticipating the tempo to be played in the second part.

TEMPO manipulation

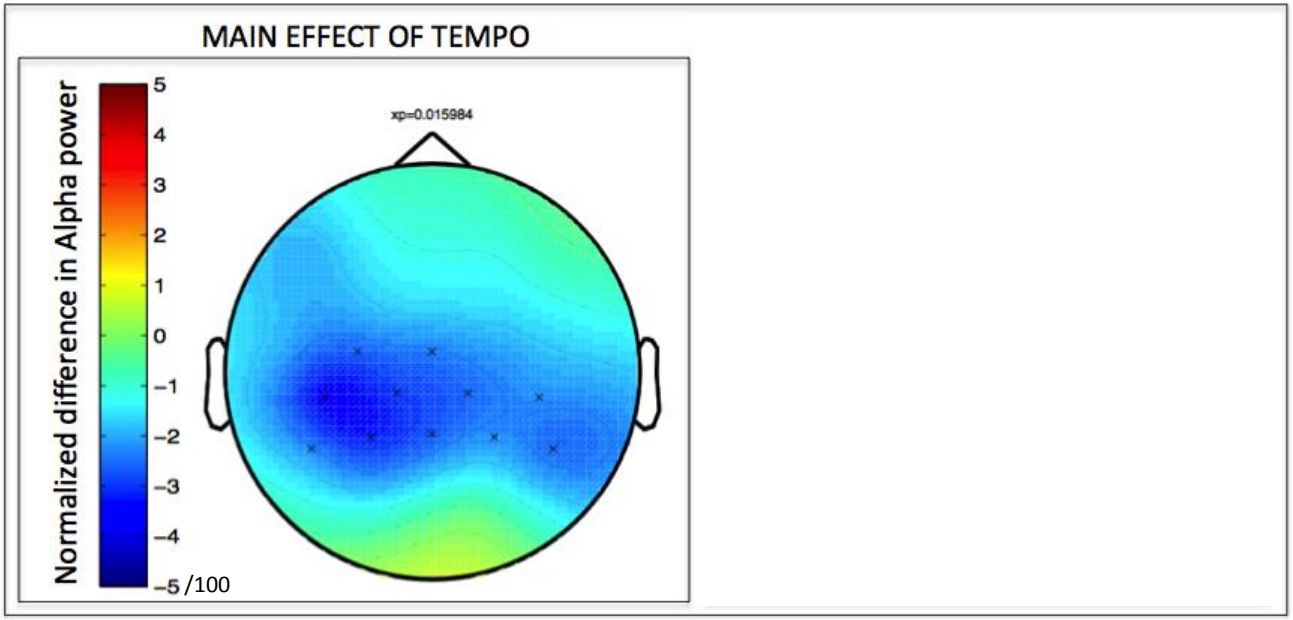
(to vary inter-personal timing adaptation)





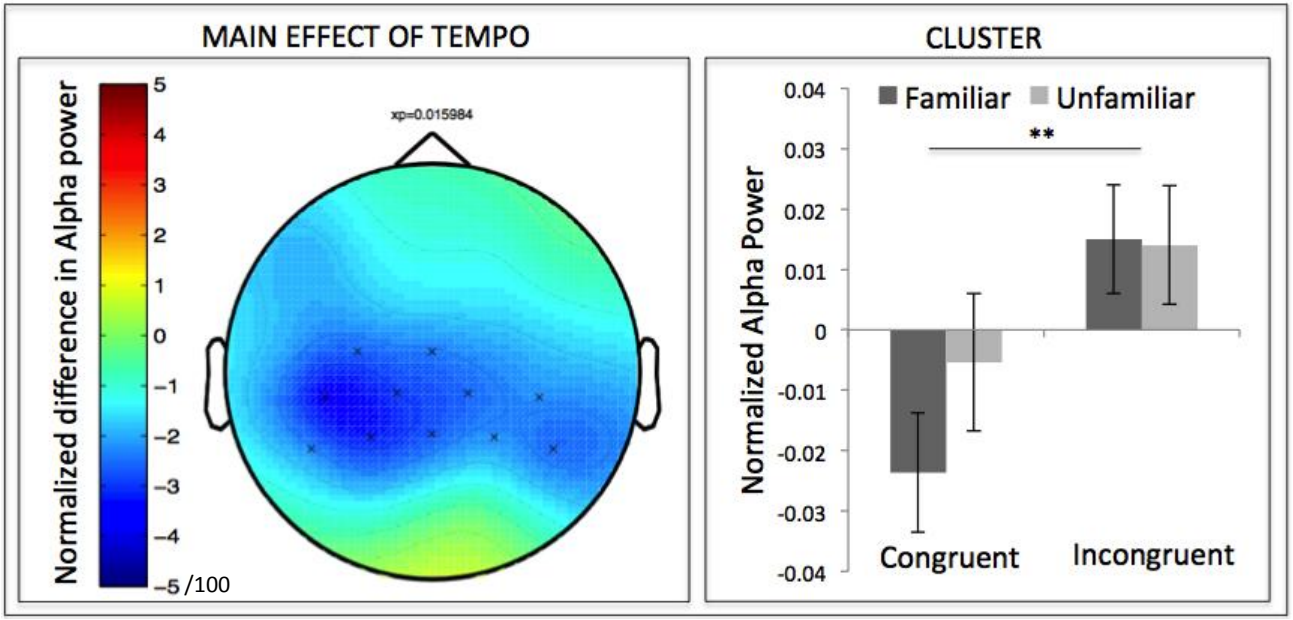
This lead to overly adaptive inter-personal timing – how do neural oscillations respond to that?

TEMPO manipulation



Overly adaptive trials (Tempo congruent) were associated with stronger alpha power (8-12 Hz) suppression over centro-posterior brain regions…

TEMPO manipulation
x
FAMILIARITY manipulation

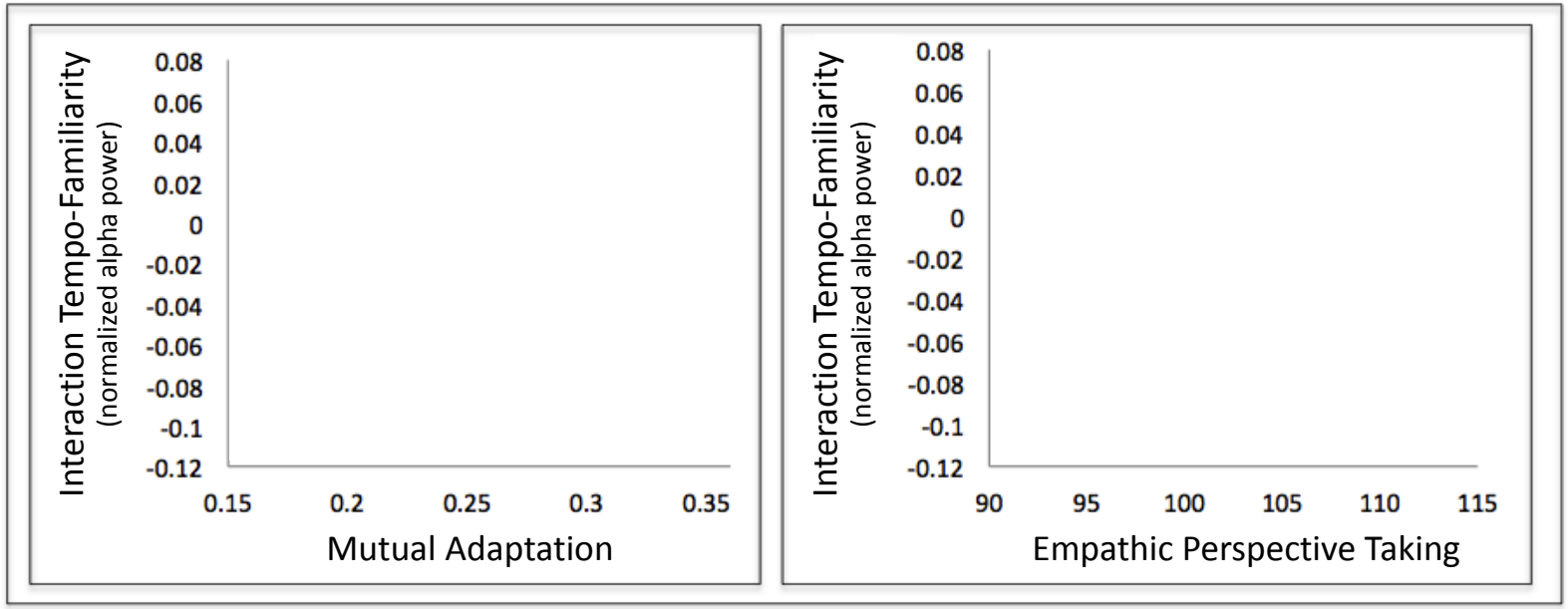


Overly adaptive trials (Tempo congruent) were associated with stronger alpha power (8-12 Hz) suppression over centro-posterior brain regions…

… furthermore, this difference was particularly enhanced when the pianists were familiar with each others actions (Tempo - Familiarity interaction).

Individual differences

Strength of the Tempo-Familiarity Interaction



Konvalinka et al., 2011, 2014

Novembre et al., 2012, 2013

Individual differences

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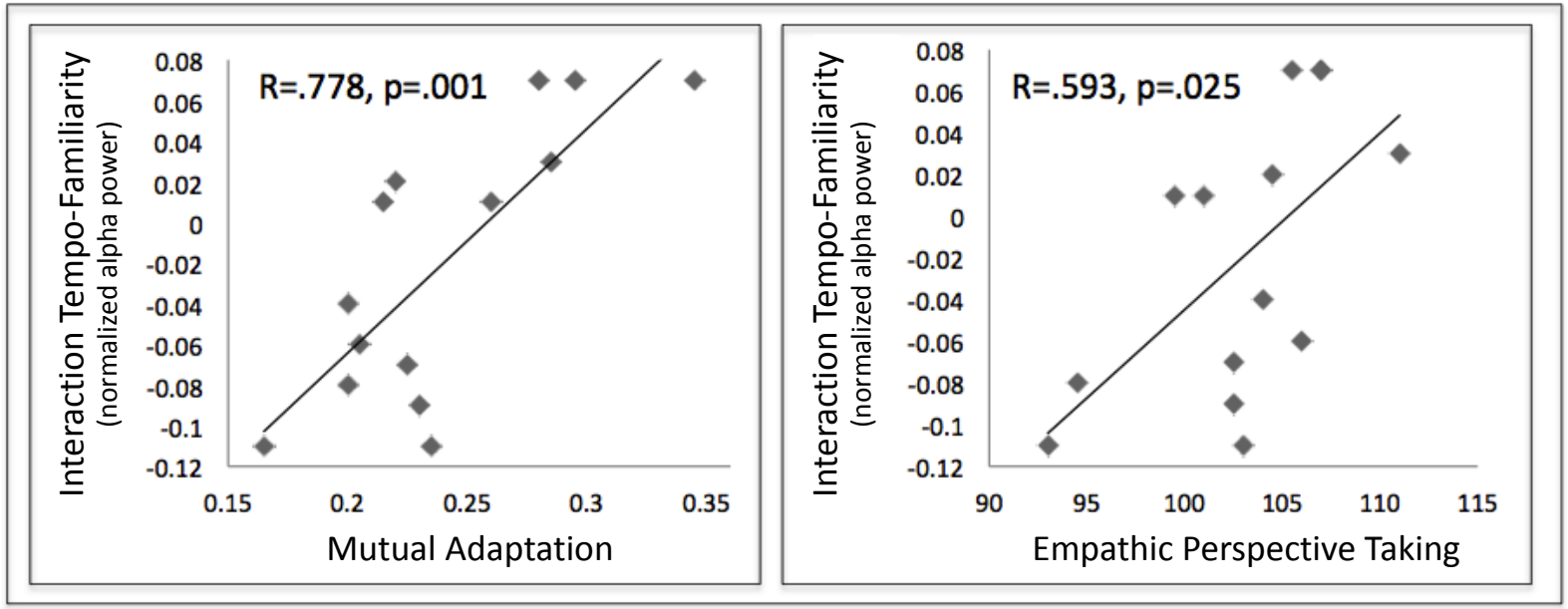

Konvalinka et al., 2011, 2014

Novembre et al., 2012, 2013

The interaction between Tempo and Familiarity was particularly strong in pairs having relatively *lower* mutual adaptation or empathic perspective taking.

Conclusion

Key findings:

1)Alpha suppression was enhanced during overly adaptive trials.

2)… particularly so if familiar with others' actions.

3)These effects were stronger in pairs having relatively *lower* mutual adaptation or empathic skills.

Thus, these data suggest that alpha suppression is a neuromarker of ***Segregation*** of actions produced by self and others in real-time social interaction.

Discussion

By manipulating tempo adaptation, co-representation and (by exploring) individual differences, our study suggests that alpha oscillations might likely underpin the successful *segregation* of Self and Other during joint action.

A mechanism regulating the optimal balance between segregation and integration? Implications for leadership, cognitive autonomy…

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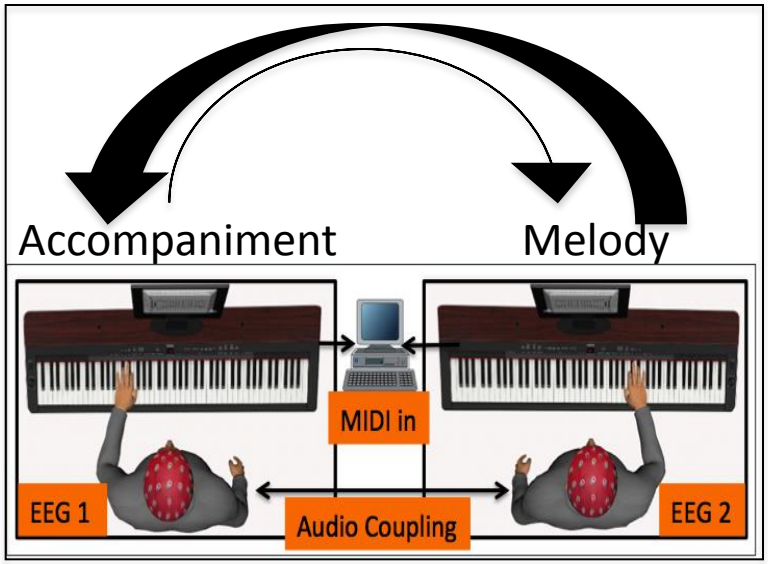
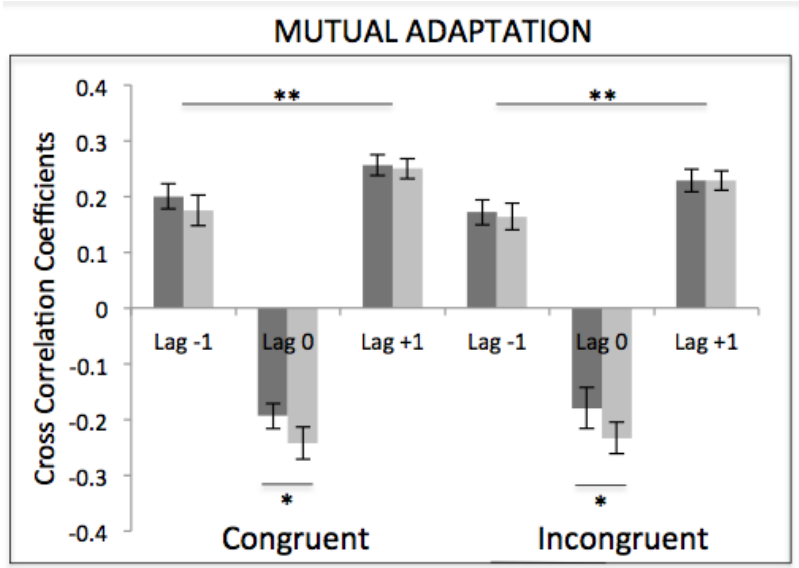
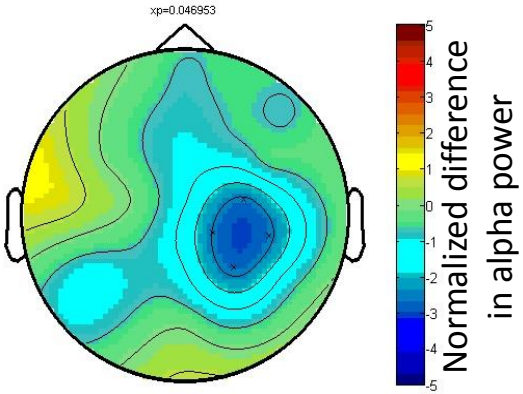
Thank you.

Asymmetry & Leadership





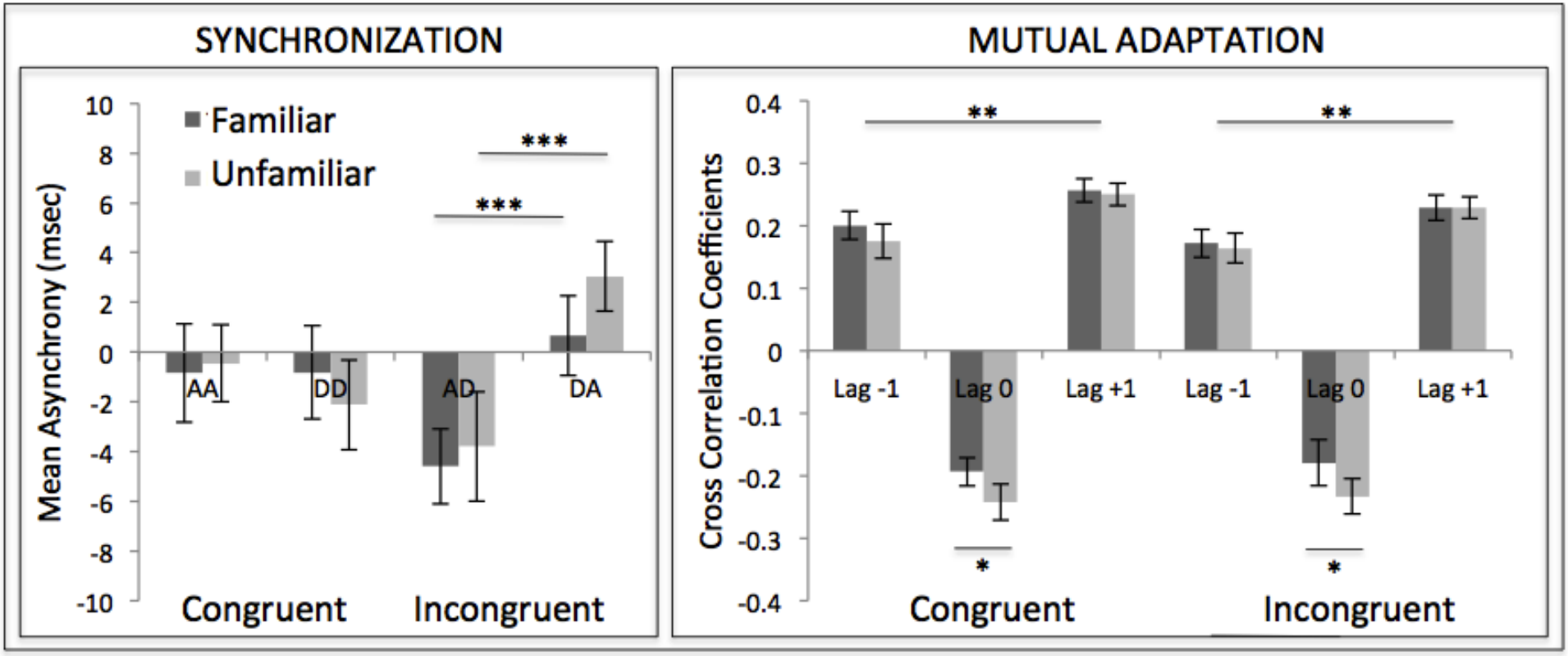


Effect of TEMPO
(Melody vs. accompaniment)

Higher adaptation of accompaniment (left hand) to melody (right hand) than vice versa

Stronger effect of TEMPO in melody vs. accompaniment player (with right lateralization).

Asymmetry & Leadership



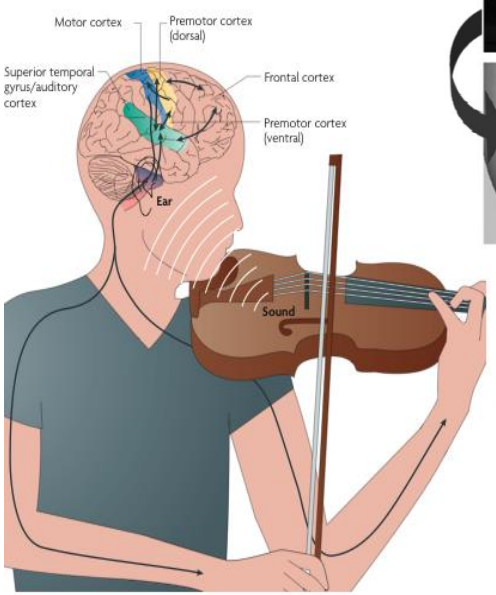
1) Tempo Anticipation lead to a synchronization difference between Tempo congruent and incongruent conditions

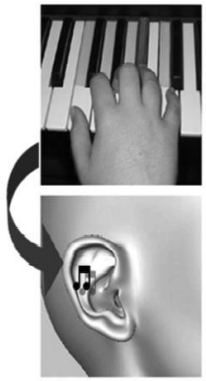
2) Higher adaptation of bassline to melody

3) Higher integration of unfamiliar pieces

Motor simulation of perceived actions

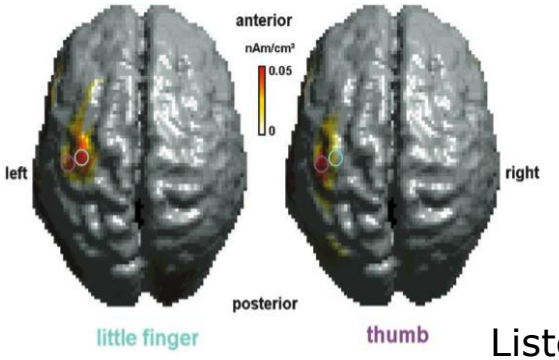
Auditory perception of (trained) musical sequences trigger motor representations in musicians' brains and behavior

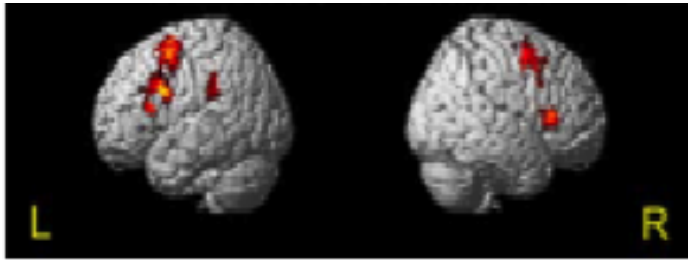




Converging Evidence:

Behavioral → Drost et al., (2005) Psych Res
TMS → D'Ausilio et al., (2006) Eur J Neuro
MEG → Haueisen & Knösche (2001) J Cogn Neuro
EEG → Bangert & Altenmüller (2003) BMC Neuro
fMRI → Lahav et al., (2007) J Neuro





Listening to trained vs. untrained sequences

Source: Zatorre, Chen, Penhune (2007) Nature Neuroscience

Discussion

Other reports of alpha power suppression being associated with inter-personal coordination tasks.

Tognoli et al., 2007, Naeem et al., 2012a,b, Dumas et al., 2012, Konvalinka et al., 2014

However, most of these studies interpreted alpha suppression as a marker of *integration* of Self and Other actions

By manipulating tempo adaptation, co-representation and individual differences, our study suggests that alpha oscillations might more likely underpin the successful *segregation* of Self and Other actions.

A mechanism regulating the optimal balance between segregation and integration? Implications for leadership, cognitive autonomy…