Analysis of music performance.

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Collaborators:

David Dolan - Guildhall School of Music and Drama

John Sloboda - Guildhall School of Music and Drama

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Fatimah Abdul Razak - Imperial College London

A complex systems perspective

- Look for collective emergent behaviour
- Interconnectedness
- Study correlations - mutual information, etc.
- Identify the "observables"

Outline

1) Some background

2) Music experiments

3) Improvisation: performer <---> audience

4) Your contribution to the project

Other EEG experiments on high cognitive tasks

Background: Correlations and behaviour

Consciousness and EEG (Electroencephalography) ?

ELSEVIER

International Journal of Psychophysiology 48 (2003) 35–42

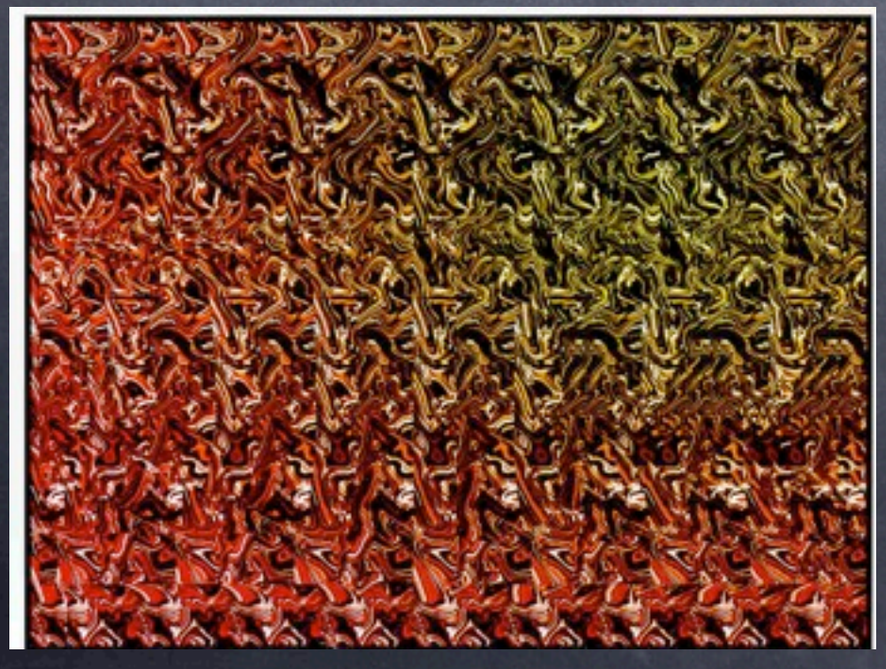
www.elsevier.com/locate/ijpsycho

Changes in neural complexity during the perception of 3D images using random dot stereograms

Adrian P. Burgess[a,*], Joseph Rehman[a], John D. Williams[b]

Person look at random dot stereogram

1) Puss button when 3D images is consciously recognised



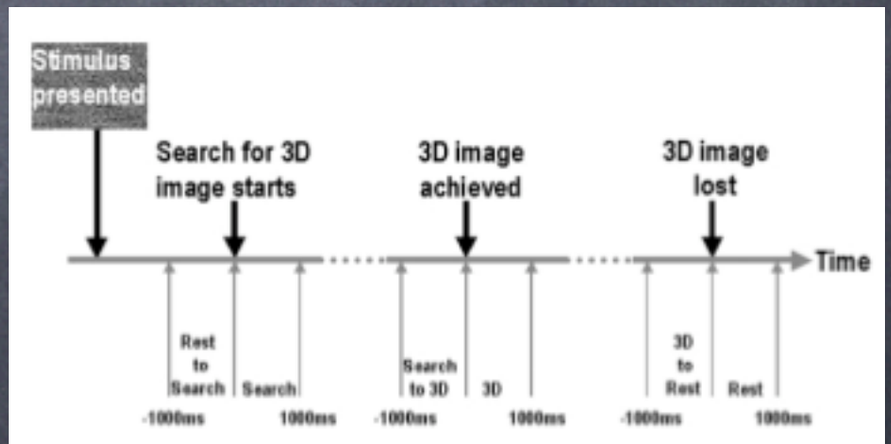
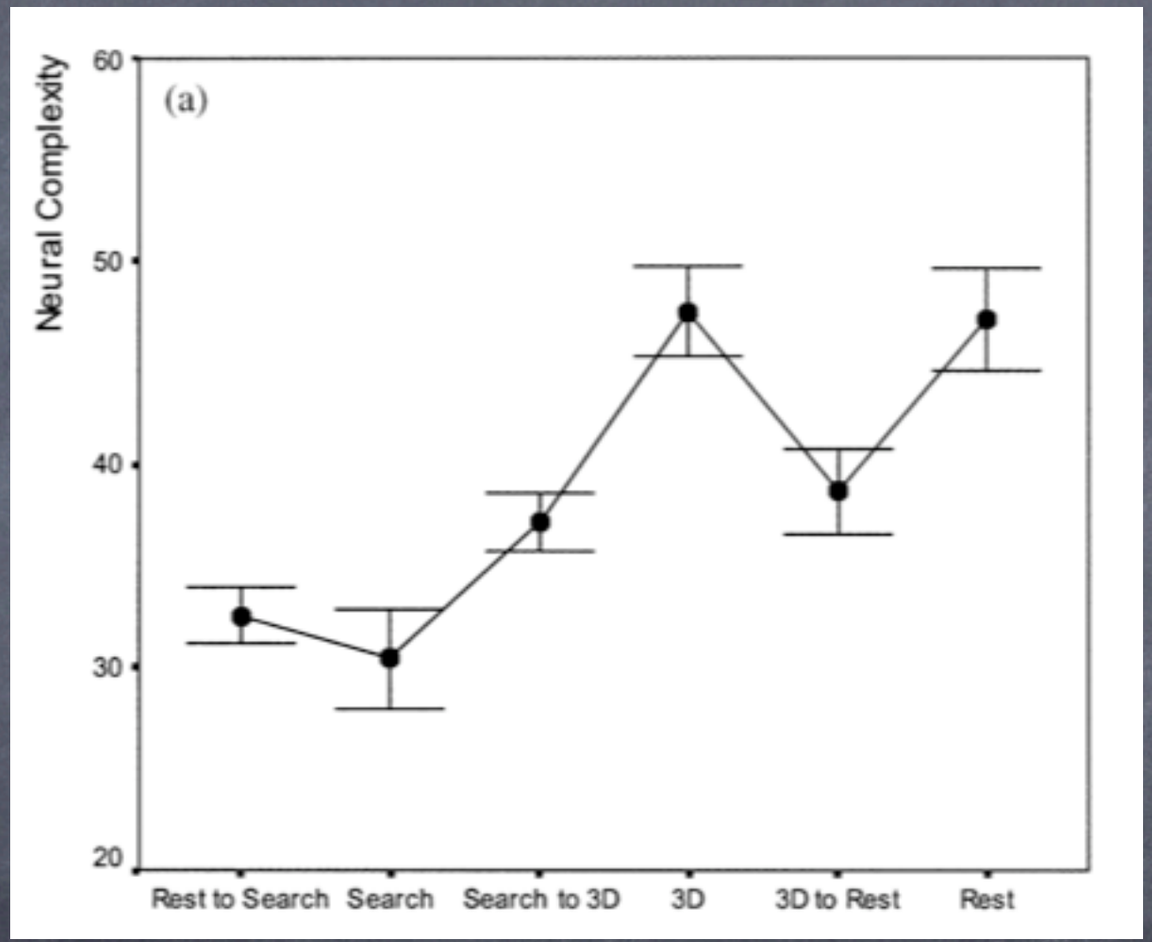


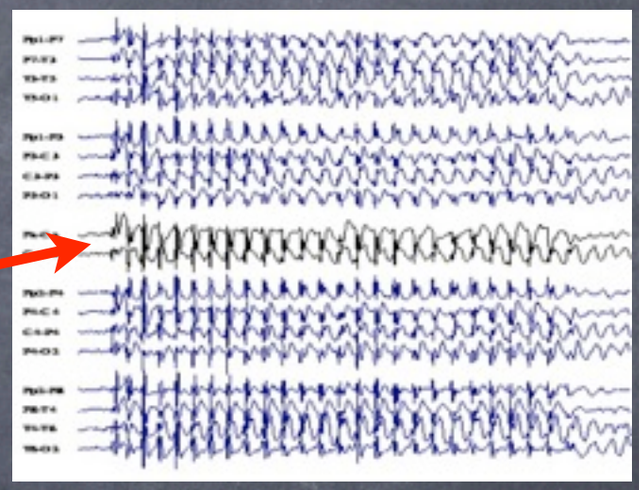
Fig. 1. Showing the time course of a single trial. Red arrows indicate the points at which the participants made motor responses. Blue arrows indicate the boundaries of the time periods used in the analysis (±1000 ms either side of the motor responses).

Background: Correlations and behaviour

Consciousness and EEG (Electroencephalography) ?



Other EEG experiments on music



Professors Joe Williams and Jason Themanson will use the NFS grant to purchase a new EEG machine.

EEG bands (From wikipedia)

Delta (<4Hz)

- adults slow wave sleep
- in babies
- Has been found during some continuous attention tasks

Theta (4-7Hz)

- young children
- drowsiness or arousal in older children and adults
- idling
- Associated with inhibition of elicited responses (has been found to spike in situations where a person is actively trying to repress a response or action).

Alpha (8-13Hz)

- relaxed/reflecting
- closing the eyes
- Also associated with inhibition control, seemingly with the purpose of timing inhibitory activity in different locations across the brain.

EEG bands

Beta (14- 30Hz)

- alert/working
- active, busy or anxious thinking, active concentration

Gamma (>30Hz)

- Displays during cross-modal sensory processing (perception that combines two different senses, such as sound and sight)
- Also is shown during short term memory matching of recognised objects, sounds, or tactile sensations

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Signal Processing 85 (2005) 2161–2177

SIGNAL PROCESSING

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Phase synchrony analysis of EEG during music perception reveals changes in functional connectivity due to musical expertise

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Available online 27 July 2005

Level of synchronization

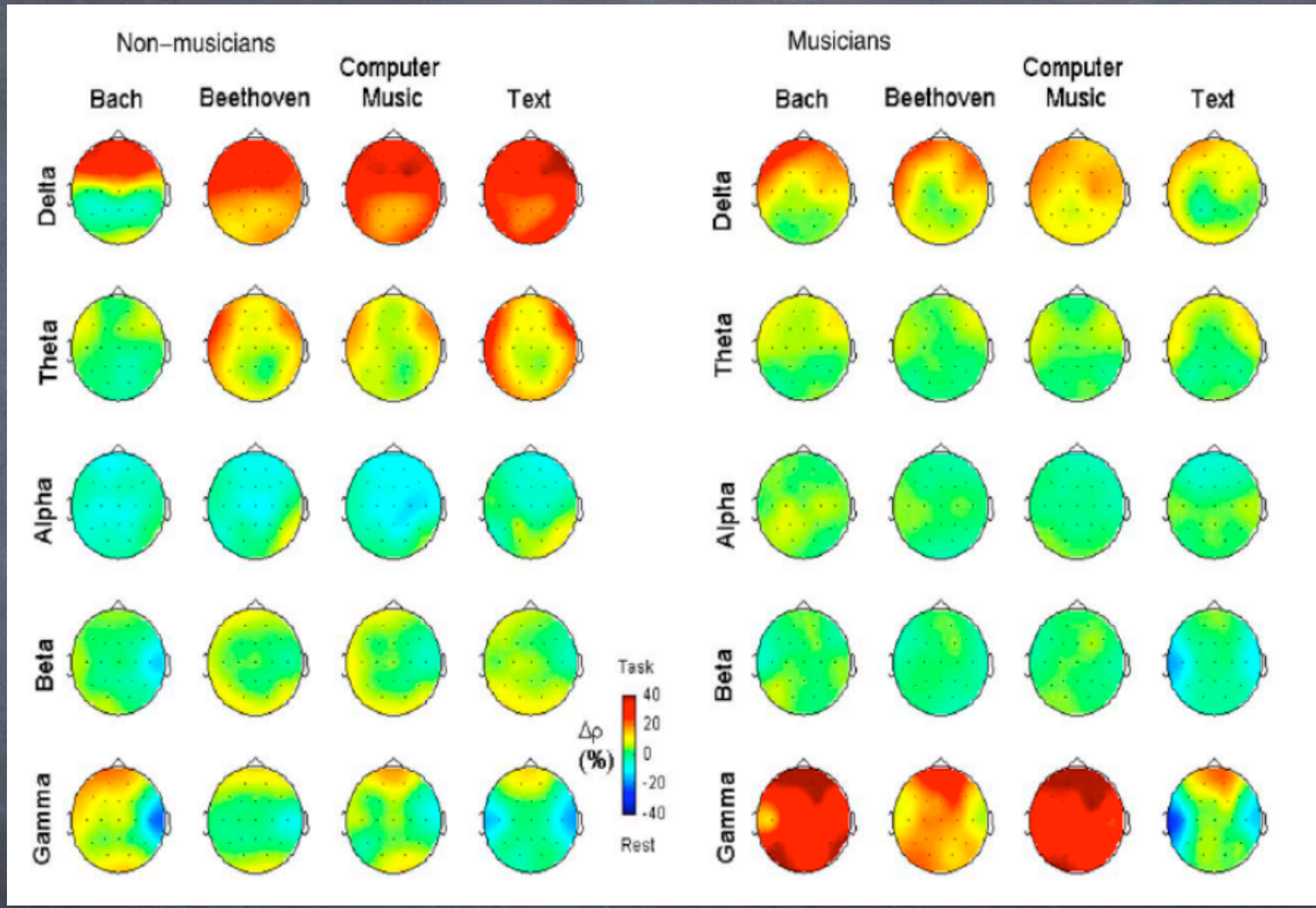
Delta (<4Hz)

Theta (4-7Hz)

Alpha (8-13Hz)

Beta (14- 30Hz)

Gamma (>30Hz)



Delta (<4Hz)

Has been found during some continuous attention tasks

Gamma (>30Hz)

Also is shown during short term memory matching of recognized objects, sounds, or tactile sensations

Long and short range couplings - correlations of phase synchrony

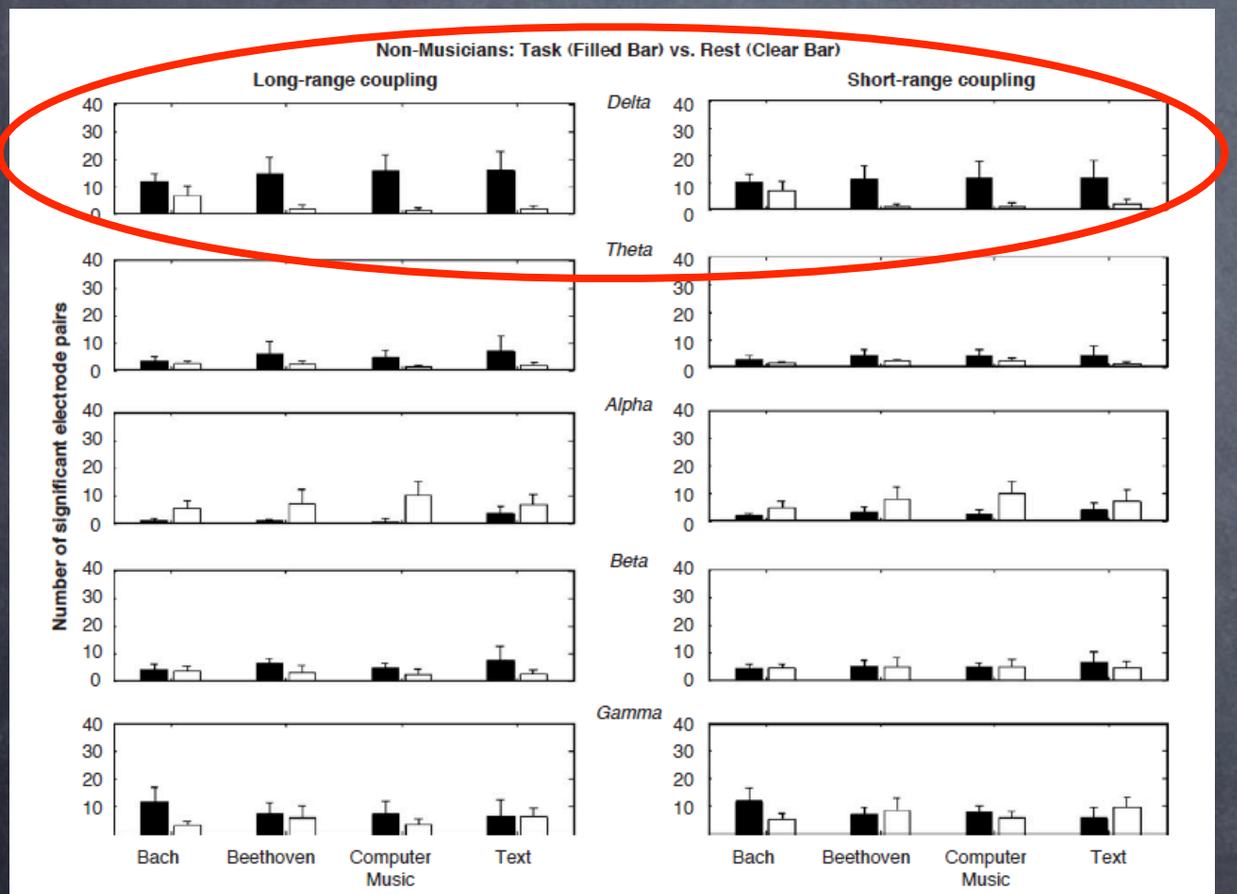


Fig. 4. Statistical comparison in terms of long-range (left panel) and short-range (right panel) phase synchrony in different frequency bands, as expressed by the number of electrode pairs showing significant ($p<0.001$) changes in the values of phase synchrony while comparing between task and base-line condition for the group of non-musicians. Filled bar indicates enhancement in the phase synchrony during task as compared to rest with eyes closed, whereas clear bar indicates decrease in synchrony values during the task. The increase was primarily in delta frequency band.

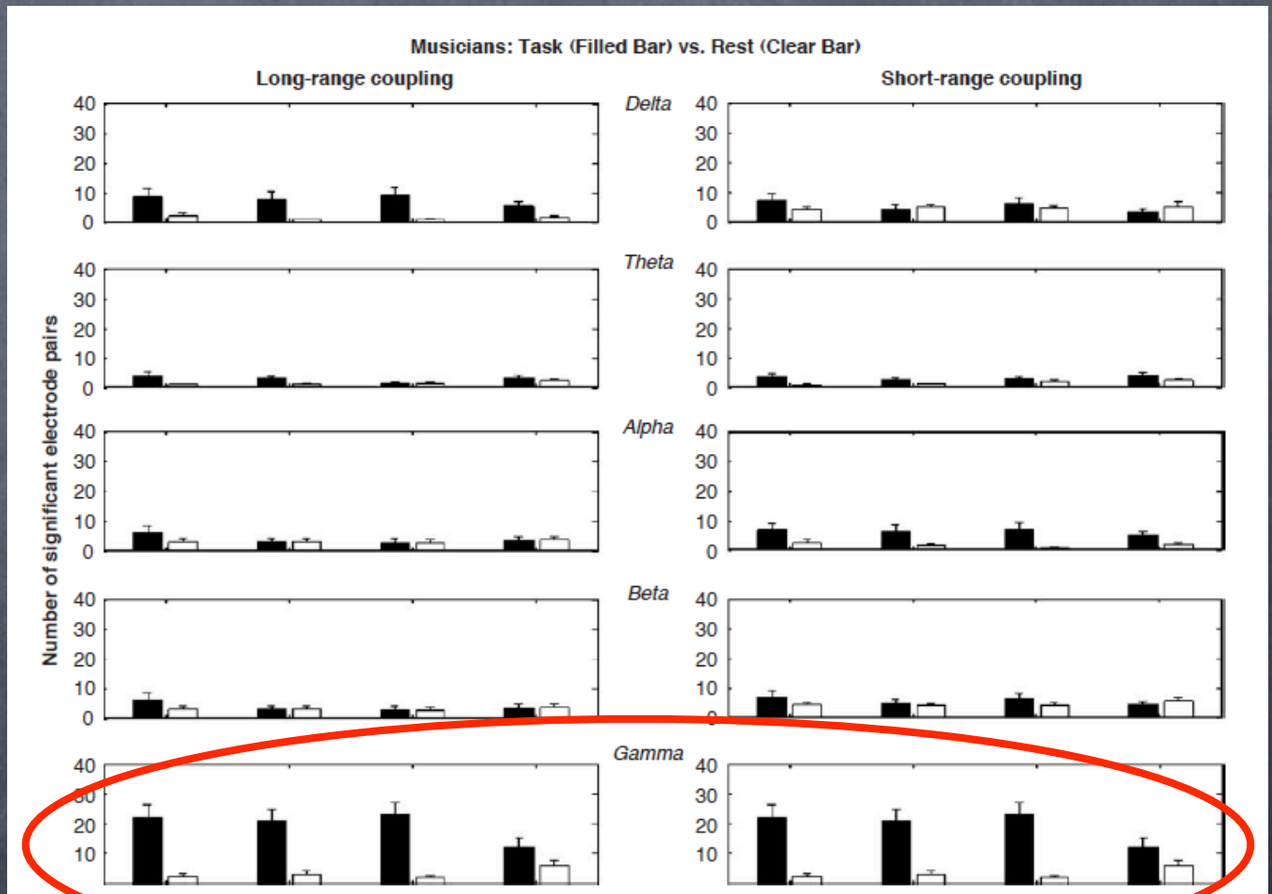


Fig. 5. Same as in Fig. 4 but for the group of musicians. During listening to music, note the increases in delta band phase synchrony like musicians, but most pronounced increases were found in gamma frequency bands. The degree of phase synchrony was lower during listening to text as compared to listening to music.

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Brains swinging in concert: cortical phase synchronization while playing guitar

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Within

Phase synch during prep

Between

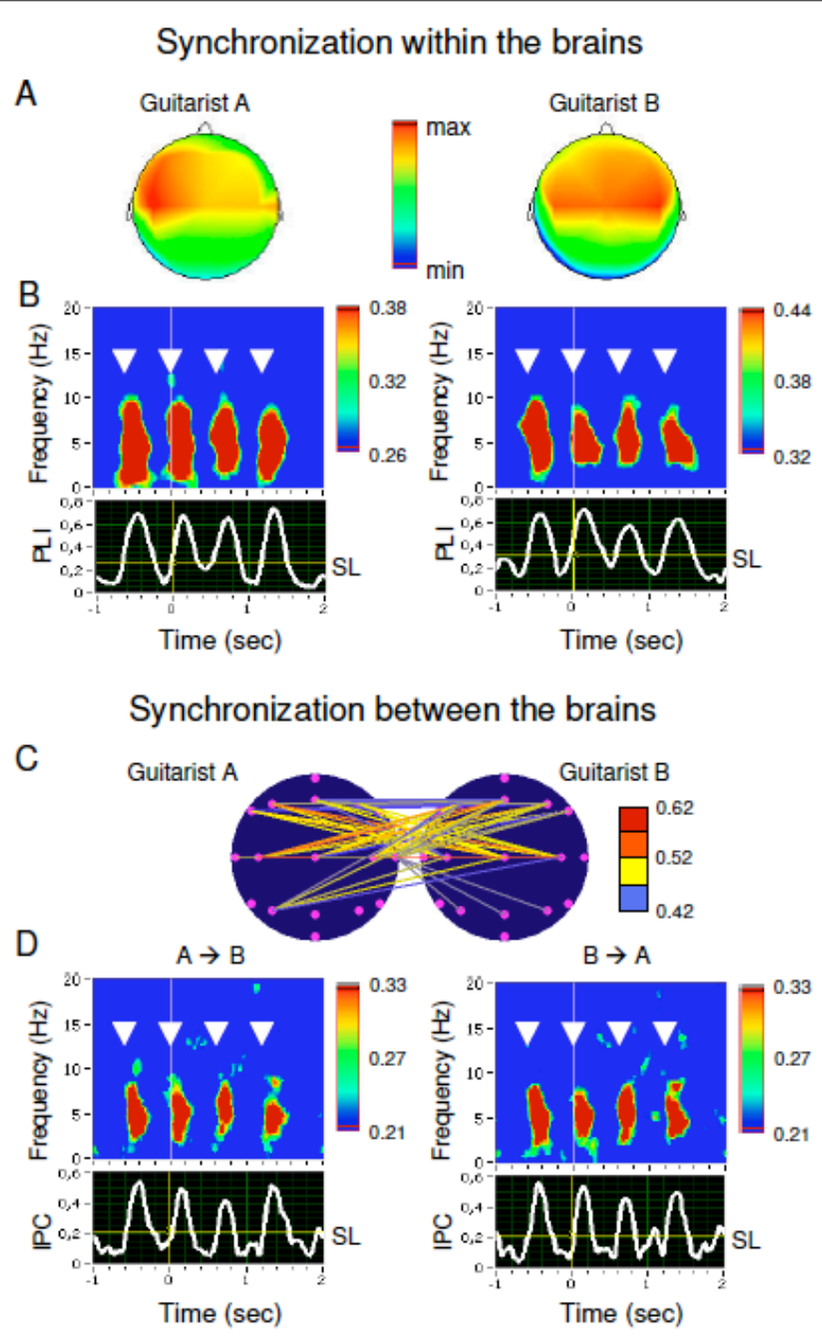


Figure 1
Phase synchronization within and between brains during the preparatory period of metronome tempo setting. (A) Topological distributions of PLI in a representative pair of guitarists, A and B, at the theta frequency (4.95 Hz) 140 ms after stimulus-onset (second metronome beat). Fronto-central maxima of PLI are shown. (B) Time-frequency diagrams of average PLI for guitarist A and B separately. PLI was averaged across six fronto-central electrodes. Only significant PLI-values ($p < 0.01$) are highlighted. Time zero is time locked to the second metronome beat. Metronome beats are shown by white arrows. The time course of PLI values at the theta frequency (4.95 Hz) is depicted below the time-frequency diagram. (C) Interbrain synchronization between the two guitarists measured by IPC at the theta frequency (4.95 Hz) 140 ms after stimulus onset. Colored lines indicate synchrony between electrode pairs of the two guitarists, corresponding to significant interbrain synchronization. Only IPC values higher than 0.41 are highlighted. (D) Time-frequency diagram of the average IPC averaged across six electrode pairs. In the left diagram (A -> B), the selected electrode pairs represent phase coherence between one electrode of guitarist A (Cz) to the six fronto-central electrodes of guitarist B. Conversely, the right diagram (B -> A) refers to one electrode of guitarist B and the six fronto-central electrodes of guitarist A. Only significant IPC-values ($p < 0.01$) are highlighted. The time course of IPC values at the theta frequency (4.95 Hz) is depicted below the time-frequency diagram. SL = significance level.

Within

Phase synch during play

Between

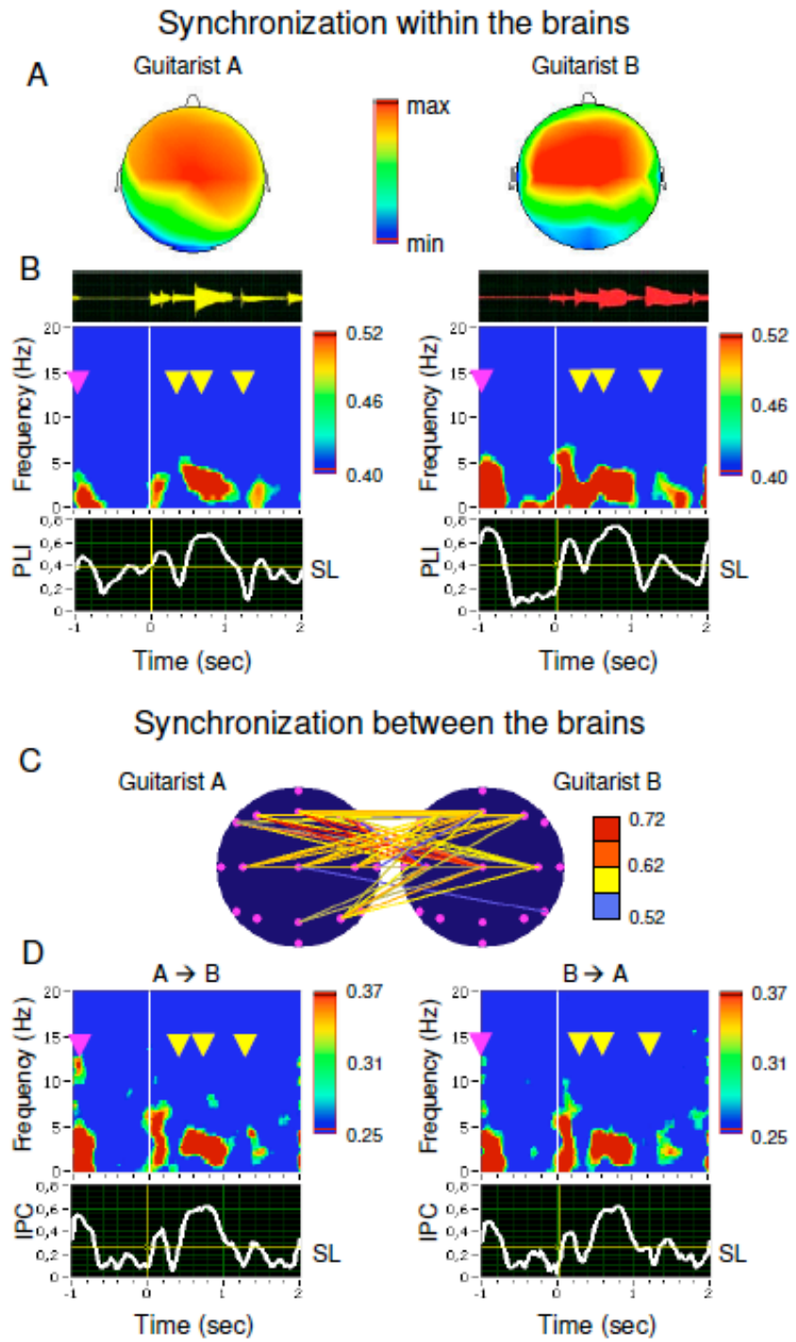


Figure 2
Phase synchronization within and between the brains during the period of guitar playing. (A) Topological distributions of PLI in a representative pair of guitarists, A and B, at the low theta frequency (3.3 Hz) 800 ms after play beginning of guitarist A. Fronto-central maxima of PLI are shown. (B) Guitar traces and time-frequency diagrams of average PLI for guitarists A and B. PLI was averaged across six fronto-central electrodes. Only significant PLI values ($p < 0.01$) are shown. Time zero is time locked to play onset of the leading guitarist A. The leading guitarist's finger gesture to start playing together is indicated with a red arrow. The yellow arrows refer to individual guitar strokes. The time course of PLI values at the low theta frequency (3.3 Hz) is depicted below the time-frequency diagram. (C) Interbrain synchronization between the two guitarists measured by IPC at the low theta frequency (3.3 Hz) 800 ms after play onset. Colored lines indicate synchrony between electrode pairs of the two guitarists. Only IPC values higher than 0.51 are highlighted. (D) Time-frequency diagram of the average IPC averaged across six electrode pairs (for further explanation, see Figure 1D and 2B). The time course of IPC values at the low theta frequency (3.3 Hz) is depicted below the time-frequency diagram. High phase synchronization within (PLI in 2B) and between (IPC in 2D) the brains took place not only at play onset but also at the time point of the gesture serving as starting signal, and at the individual guitar strokes. SL = significance level.

Synch mainly at onset

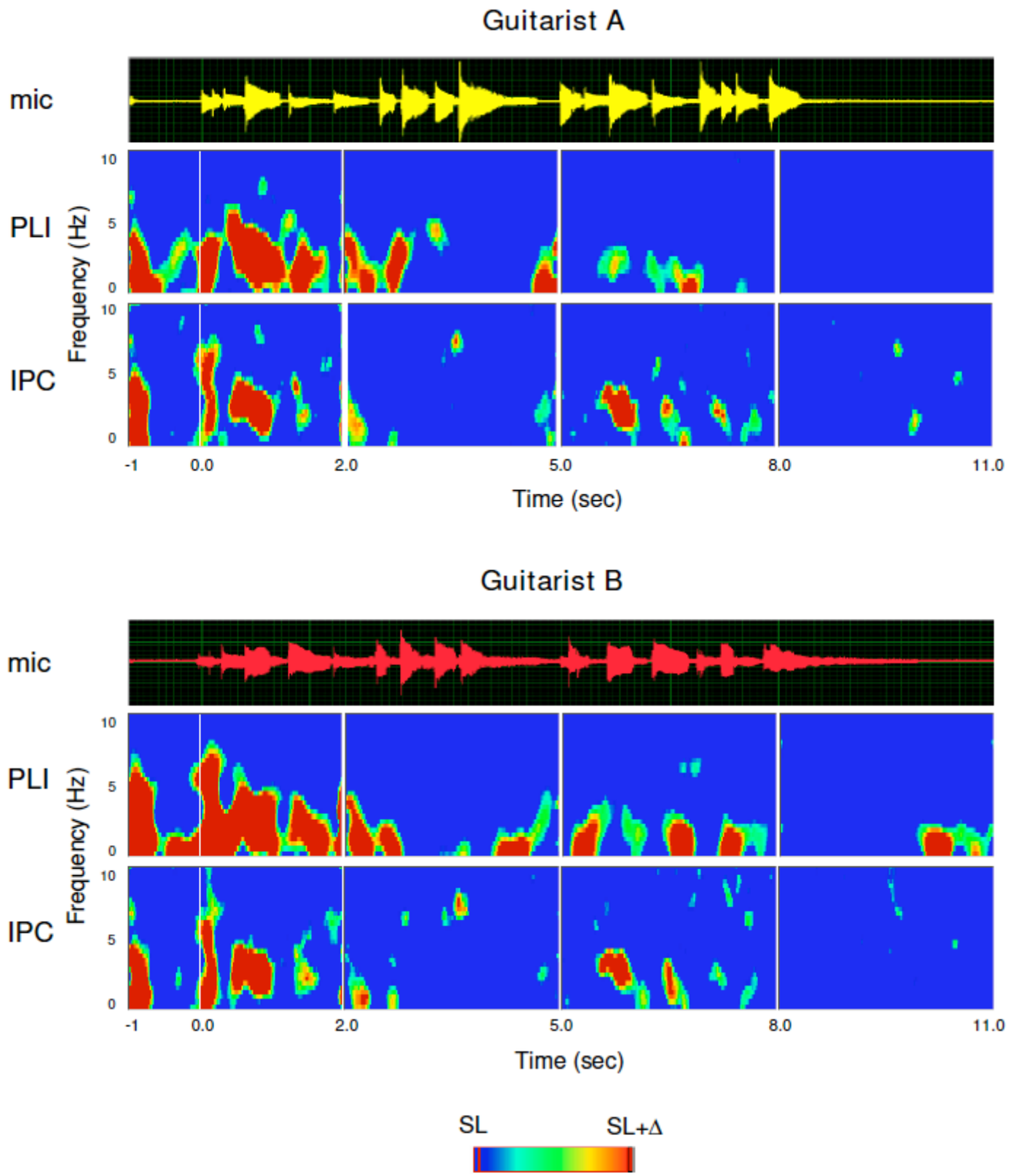
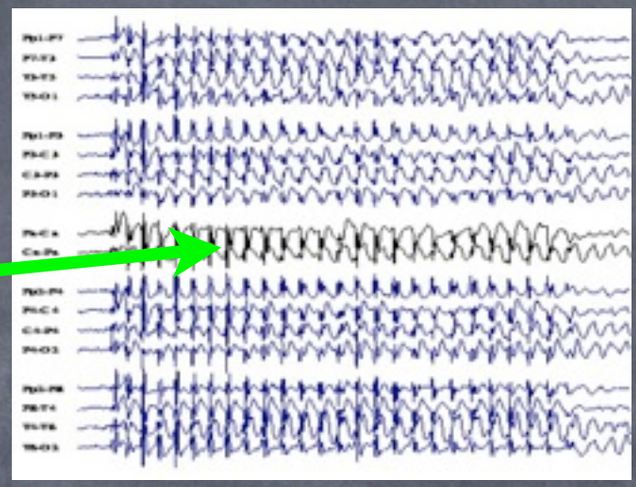


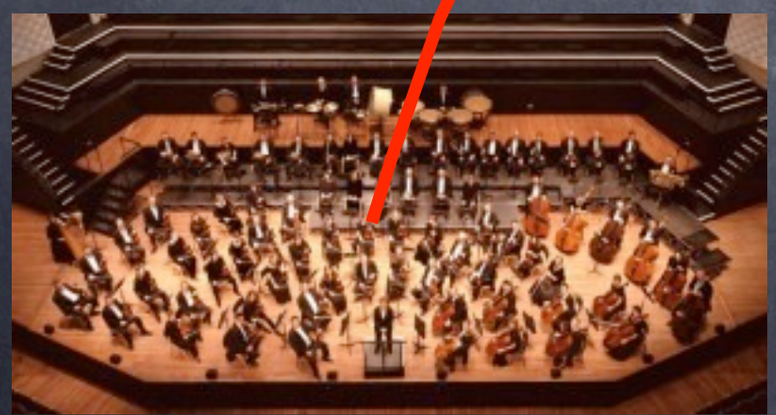
Figure 3
Phase synchronization within and between the brains for the entire music sequence. Acoustic guitar traces (mic) and time-frequency diagrams of average PLI and IPC for guitarists A and B. For analysis, the entire sequence was subdivided into four consecutive sections of equal length. Only significant PLI and IPC values are shown ($p < 0.01$). The overall significance level was set to the mean value across the four sections. Time is locked to the play onset of the leading guitarist (Guitarist A). In contrast to Figures 1 and 2, the time-frequency diagram is restricted to the frequency range of up to 10 Hz. SL = significance level; $\Delta = 0.12$.

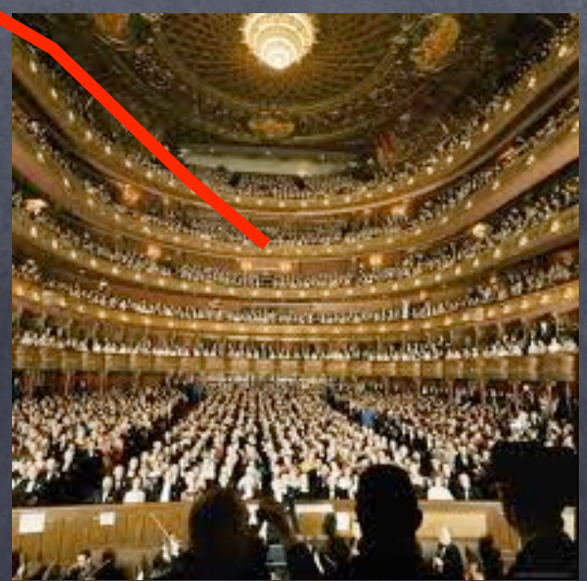
The experiment with Guildhall

Focus on correlation of high cognitive processes between performer and audience

The experimental setup







EEG and Improvisation:

Does creative performance leave an imprint in the EEG (Electroencephalograph) of:

1) performers ?
2) audience ?

Play a piece:

1) as written
2) or with a degree of improvisation

The EEG team

Björn Crütz
Anica Crütz
+ two assistants

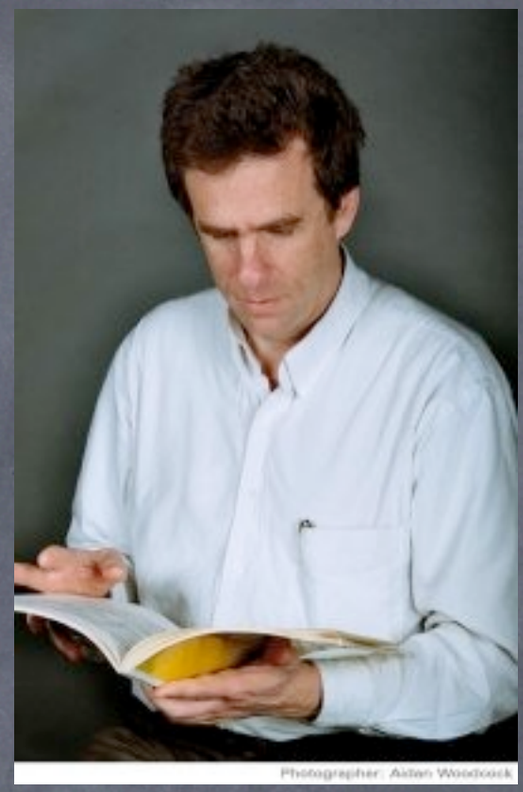
The audience

Various people

The first experiment

The musician

Dr David Dolan



http://www.david-dolan.com/

David Dolan is also a professor of piano, chamber music and Interpretation through Improvisation at the Yehudi Menuhin School of Music and the Guildhall School of Music and Drama. He is frequently invited to give masterclasses in music centres such as Bloomington (Indiana), Paris and Geneva conservatoires, The Rubin Music Academy in Jerusalem, the Tchaikovsky Conservatoire, Moscow and the Julliard School.

The Music

Piece 1: Schubert – Impromptu in G flat major Op.90 No.3, neutral mode, uninvolved

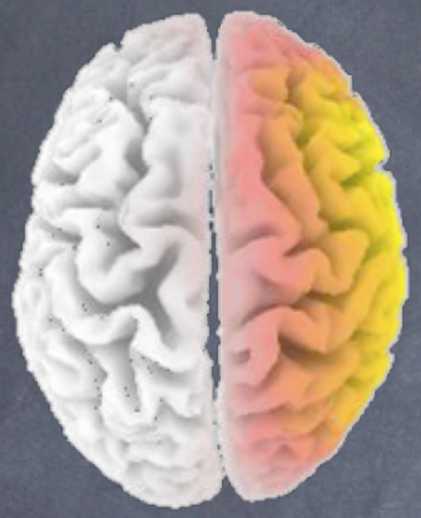
Piece 2: Schubert – Impromptu in G flat major Op.90 No.3, fully involved

Piece 3: Improvisation, polyphonic, intellectual exercise

Piece 4: Improvisation, polyphonic, emotional letting go

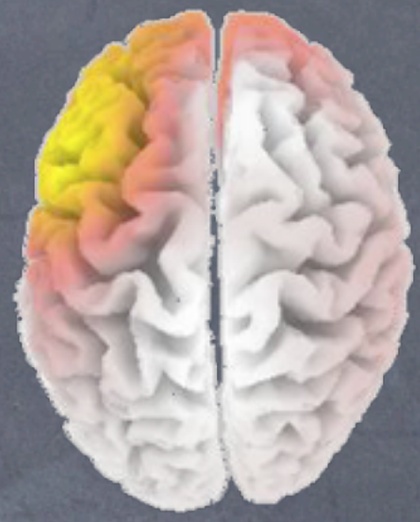
Uninvolved

Pianist - piece 1

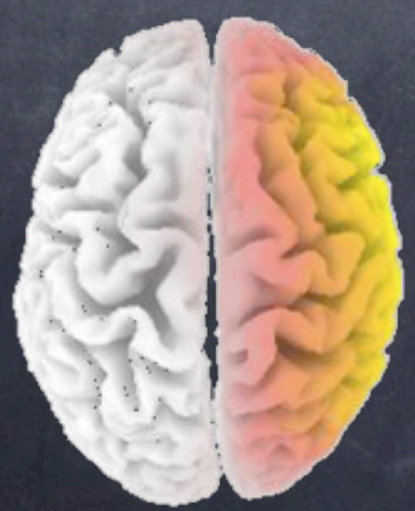


Letting go

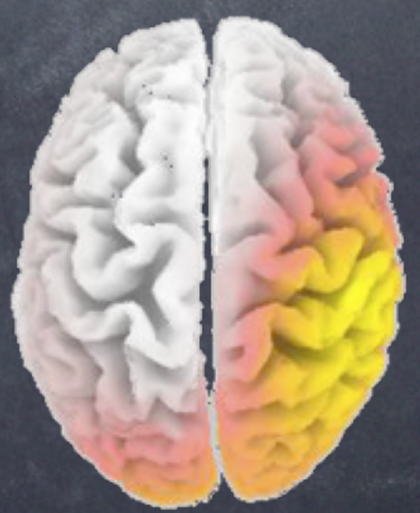
Pianist - piece 4



Listener - piece 1



Listener - piece 4



Björn Crütz

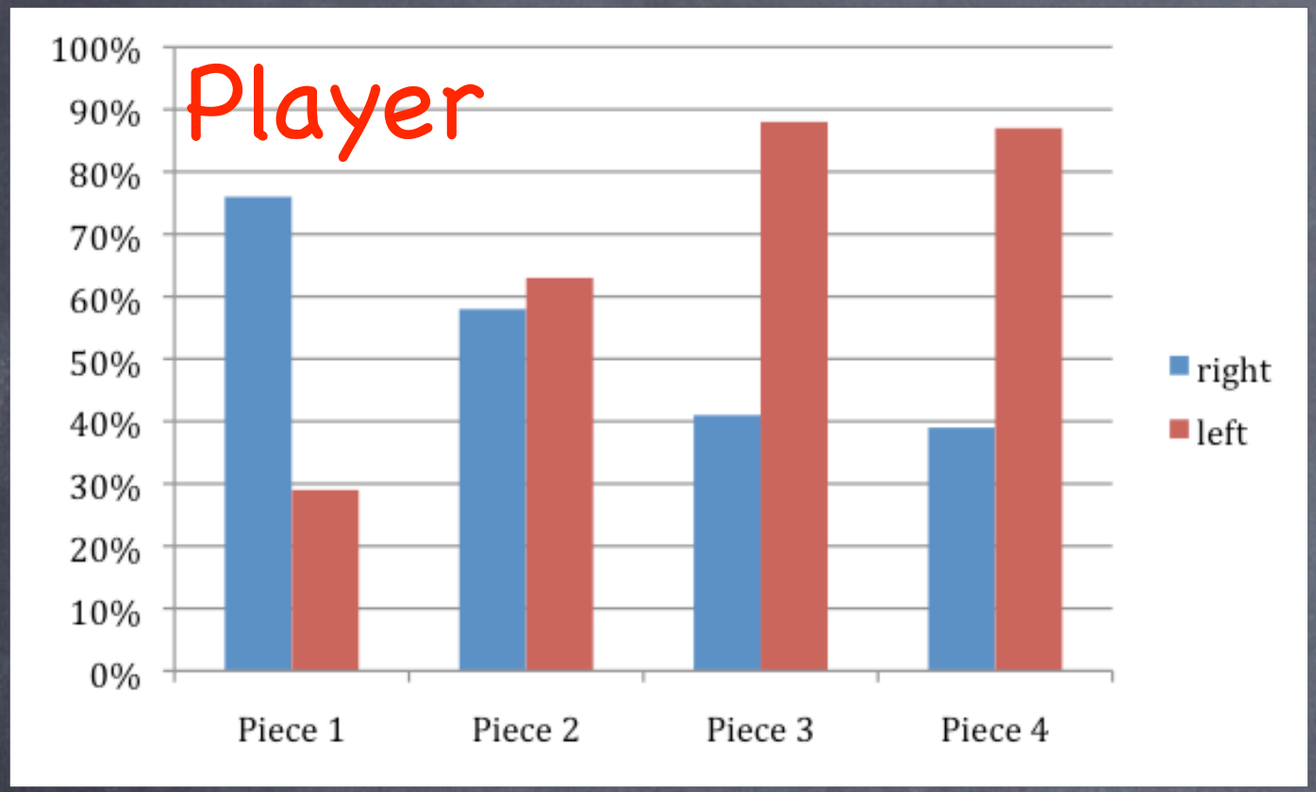
Coarse grained

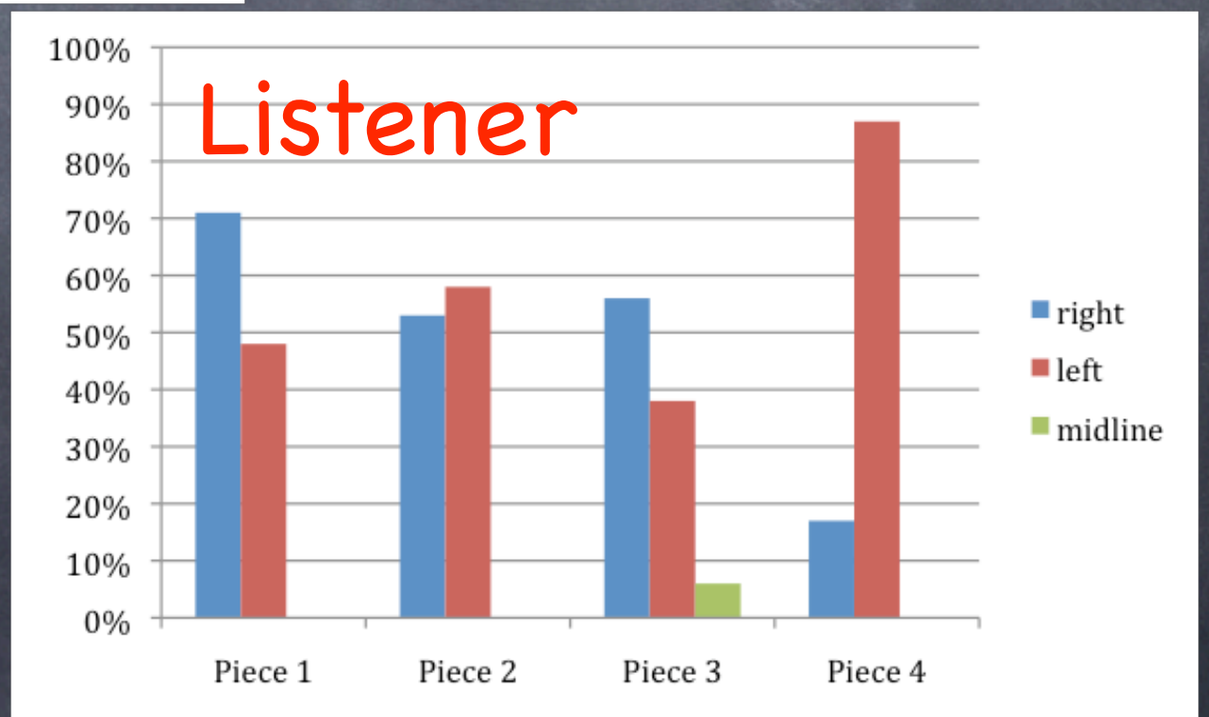
Piece 1: Schubert – Impromptu in G flat major Op.90 No.3, neutral mode, unvolved

Piece 2: Schubert – Impromptu in G flat major Op.90 No.3, fully involved

Piece 3: Improvisation, polyphonic, intellectual exercise

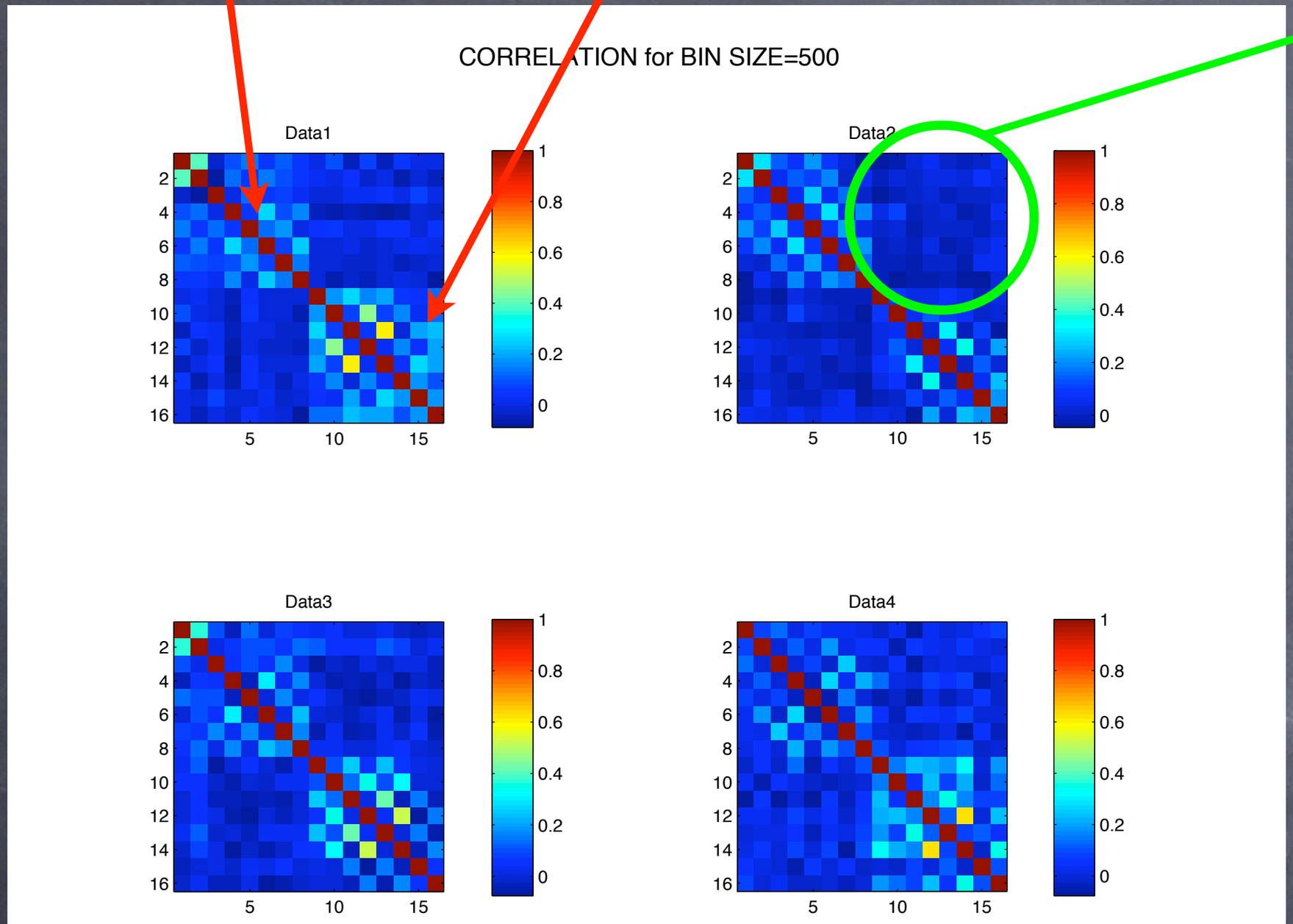
Piece 4: Improvisation, polyphonic, emotional letting go





Björn Crütz

Channel 1-8: listener Channel 9-16: pianist



Focus on cross correlations

Piece 1: Schubert – Impromptu in G flat major Op.90 No.3, neutral mode, unvolved

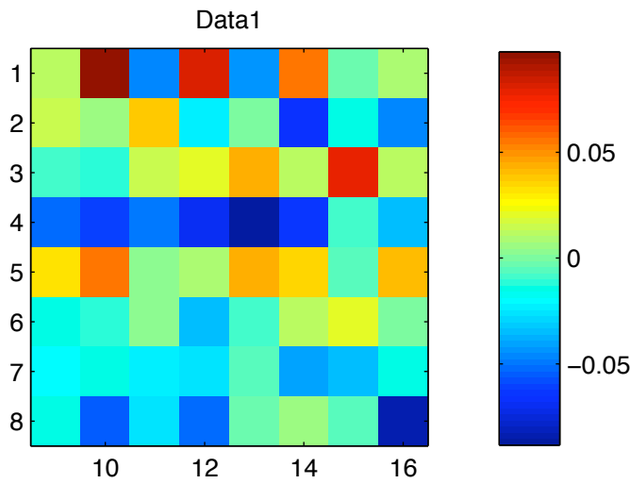
Piece 2: Schubert – Impromptu in G flat major Op.90 No.3, fully involved

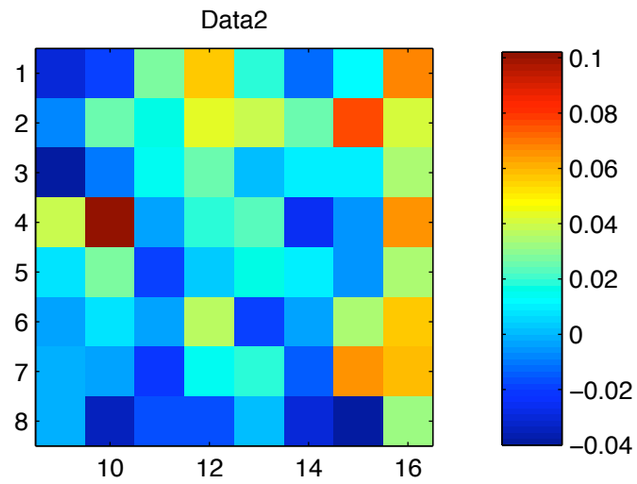
Piece 3: Improvisation, polyphonic, intellectual exercise

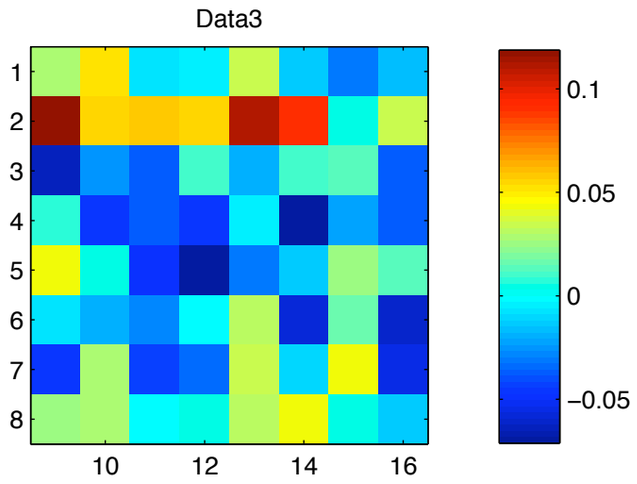
Piece 4: Improvisation, polyphonic, emotional letting go

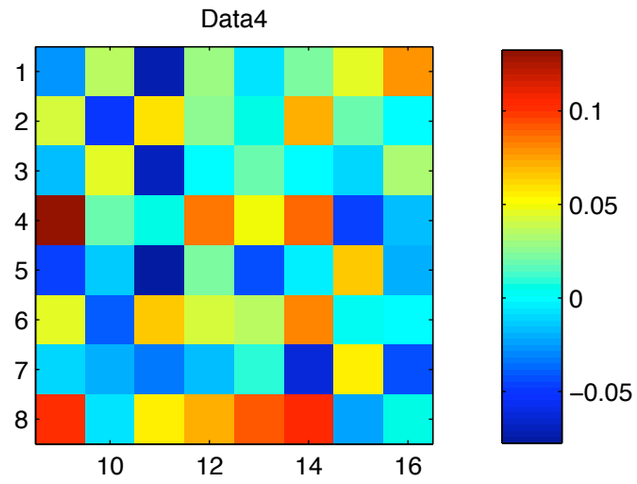
Björn Crütz +
Fatimah Abdul Razak

ZOOM IN: UPPER RIGHT HAND CORNER (BIN SIZE=500)









Björn Crütz +
Fatimah Abdul Razak

Piece 1: Schubert - Impromptu in G flat major Op.90 No.3, neutral mode, unvolved

Piece 2: Schubert - Impromptu in G flat major Op.90 No.3, fully involved

Piece 3: Improvisation, polyphonic, intellectual exercise

Piece 4: Improvisation, polyphonic, emotional letting go

Player

Conclusions:

1. There are obvious differences in sources of activation in the brain between the four pieces.

2. The sources of activation are mainly located in the frontal cortex, with increased activation from piece 1 to 4. The first piece seems to have the highest contribution of the occipital cortex. The fourth piece has, besides the frontal activation, a strong involvement of the temporal cortex.

3. There seems to be a shift from right hemispheric activation during no improvisation to mainly left hemispheric activation during improvisation.

4. The pieces that are played without emotional involvement (piece 1 and 3) are associated with mainly one-sided hemispheric activation (right in piece 1, left in piece 3), whereas emotional involvement results in more both-sided hemispheric activation.

5. Emotional involvement results in more general activation of the brain.

Listener

Conclusions:

1. There seems to be differences in sources of brain activity of the listener between the four pieces.

2. Although the primary source of activation is mainly the frontal cortex, there are also sources of background activation widespread across the cortex.

3. There seems to be a shift from bilateral activation in piece 1 to 3 to more left-sided activation in piece 4.

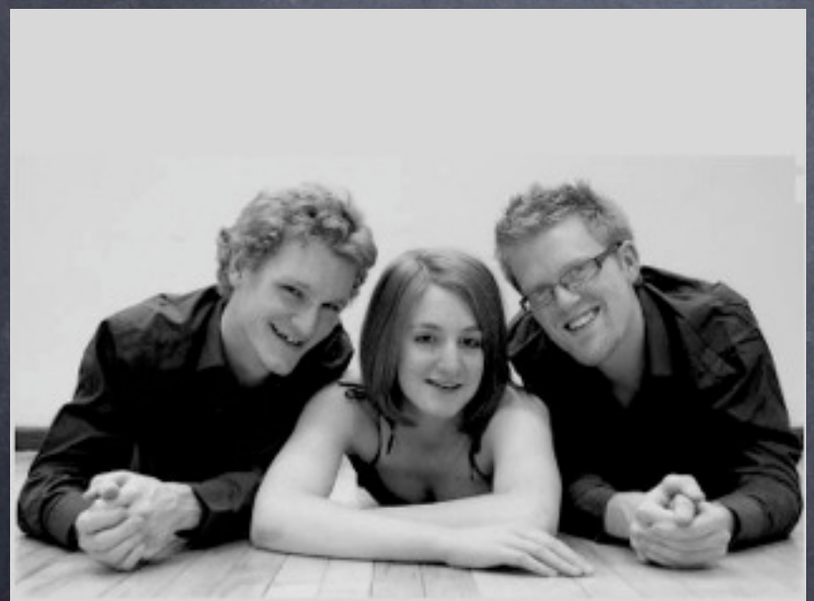
4. Improvisation of the piano player results in more general activation of the brain of the listener.

The second experiment

The musicians

Dr David Dolan http://www.david-dolan.com/

Trio Anima http://www.trioanima.com/Who.htm



* The Trio Anima & David Dolan played 12 pieces:

  1/2 with improvisation
  1/2 without improvisation

  11 were OK (sort of).

* EEG world record (presumably):

  simultaneous recording of 6 EEGs

* http://212.178.132.122:83/guildhall/index.html


PLACING THE PIANO
DIRECTLY UNDERNEATH
THIS HEATER WILL MAKE IT
IMPOSSIBLE TO STABILISE
THE TUNING AND MAY
CAUSE PERMANENT
STRUCTURAL DAMAGE TO
THE INSTRUMENT

Some examples

Get involved

http://212.178.132.122:83/guildhall/index.html

Listen to the 11 pieces and judge whether the piece is played with:

- Improvisation
- No Improvisation

	Impro	No Impro
1		
2		
3		
4		
5		
6		
...		

Email result to me:
h.jensen@imperial.ac.uk

Experiment to be repeated 11 November 2011

http://212.178.132.122:83/guildhall/index.html

Thank you

From theartofdang.com
Daniel James Gay