Just: a chamber suite for musicians and BCI

Artists:

Grace Leslie, flute
Scott Makeig, violin
Alexander Khalil, cello
Tim Mullen, brain/computer interface

Technical Support:

Christian Kothe, sequencing software and EEG classification
Nima Bigdely Shamlo, EEG classification
Grace Leslie, music software
Dev Sarma, technical support

Composition:

Scott Makeig

'World Premiere' performance at the 4th International BCI Meeting,

Asilomar Meeting Grounds, Carmel, California

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First San Diego performance

Sonic Diasporas, UCSD

January, 2011

Program Notes

The Background

Is it possible to interpret EEG dynamics to learn what a subject is feeling? And if so, could we use EEG to communicate our feelings to others?

So far, the brain-computer interface (BCI) field has focused in large part on developing abilities to make one or more discrete action choices (yes/no, on/off, left/right, etc.) or to use written language (spelling out words). Yet our sense of personal fulfillment derives not only from these kinds of communication and agency. Many of our most deeply felt and influential experiences involve communication of our feelings to others by gestures, facial expressions, eye movements and nonverbal sounds. Inability to fluently communicate feeling to others burdens not only truly locked-in patients but also many other physically and mentally handicapped subjects (stroke, palsy, Alzheimers, etc.).

Onton & Makeig (*Front. Hum. Neurosci.*, 2009) explored the first of these questions by using a method of guided imagery to induce 32 eyes-closed subjects to imagine situations in which they would feel a series of 15 suggested emotions while attending to their somatic impressions to intensify their emotional experience. In a de-briefing survey, subjects generally indicated that they experienced most of the suggested emotions moderately to strongly. Multidimensional scaling of median broadband high-frequency power levels during the 15 emotion imagination periods returned a two-dimensional 'emotion space' in which one dimension loaded strongly on emotional valence (Onton & Makeig, 2009a). Furthermore, even a few seconds of data removed from each emotion period could be assigned its original emotion label in most instances by comparing its dynamics to those of the remaining data from the same subject Onton & Makeig, 2009b).

In this ensemble musical piece, 'Just,' we test whether a similar data modeling method can be applied to musician subjects who imagine different musical notes or intervals by imaginatively experiencing their emotional or affective natures. Be so doing we create a unique musical *emotion BCI* that allows musical subjects to select and play (slow) expressive sounds with 'heartfelt' intent by EEG alone, thus effecting emotional communication with listeners. If successful, it might further suggest more general emotional BCIs might be developed for use by normal and/or handicapped subjects.

The Piece

'Just' was written to fulfill a request by Theresa Vaughan, the BCI Meeting organizer, for some musical entertainment for the BCI Meeting at Asilomar. Makeig jokingly proposed to compose 'a concerto for brain and orchestra' as this sounded suitable to the occasion. After some months of wondering how best to do this, an idea arose about how to proceed. The goal was to make the BCI aspect of the performance have some legitimate effect, but to make the performance 'fail-safe' in the sense that any BCI imprefections would not

destroy the musical quality of the performance. The solution here was to make the BCI classification select only the order of the movements of the piece, which are selected by classifying the state of EEG dynamics of the BCI performer (aka, the 'brainist') as he/she imagines the emotional feeling, character, and atmosphere of the next intended two-tone musical interval or ground sound.

The Score

To make the BCI aspect of the performance legitimate, we include here the 'score' the brainiest is asked to 'perform.' Musically knowledgeable listeners can follow it during the performance to note the degree of success of the 'brainist' and the EEG classification algorithm in conveying his emotional intent. The ground tone is a low G. The intended order of the five ground sound intervals is:

5/4	45/32	15/8	3/2	2/1
B	C#	F#	D	G

Tim gave the following personal interpretation of the feelings of the five intervals as he imaginatively experienced them during training sessions.

5/4 – shy, sensitive, subdued ...

45/32 – frustrated, sullen, angry ...

15/8 – hopeful, longing ...

3/2 – at home, at rest, surrounded by love ...

2/1 – triumphant, glorious, exultant ...

The Sounds

The low tones that act as a drone during each piece are synthesized from recordings of open cello notes. The frequency of the upper of the tones is tuned (by an Apple pitch shift utility) to the five integer ratios shown in the score (relative to the lower ground tone). These are 'just' tuned intervals that do not exactly match the notes in the modern tempered scale. (Over thirty years ago, Makeig wrote a Master's thesis in music theory on the affective nature of these intervals). The structure of the training sessions and the online presentation uses the method of guided imagery inspired by the work of Helen Bonny.

The Performers

The performers are all researchers at the Swartz Center for Computational Neuroscience, UCSD.

Grace Leslie (flute and music computer) is a PhD Student in Computer Music at UCSD, where she is researching musical gesture and emotion at the Center for Research in Computing and the Arts and the Swartz Center. During the 2008-2009 year she was a researcher on the *Espaces acoustiques et cognitifs* team at IRCAM in Paris, where she collaborated on an interactive sound installation used for perceptual tests studying the effect of active involvement on listening. As a student at the Center for Computer Research in Music and Acoustics (CCRMA) at Stanford she developed a system for spatialized performer feedback and researched performer response to latency in networked performance settings

Alexander Khalil (cello) earned a Ph.D. in ethnomusicology from UC San Diego. He directs the Indonesian gamelon orchestra program at the Museum School of San Diego, is one of few certified US liturgical chanters in the Greek Orthodox church, and teaches and plays in concerts on several instruments including the Chinese chin and the Middle Eastern oud. Cello was his early instrument he is happy to return to it for this performance.

Tim Mullen (brain) was born in La Plata, Argentina and raised primarily throughout the Indian subcontinent, South America, and Europe. He obtained BAs in Computer Science and Cognitive Science from UC Berkeley and conducted research at Helen Wills Neuroscience Institute and Palo Alto Research Center (PARC) where he developed novel applications of wearable brain-computer interface technology for human-computer interaction. He is currently pursuing a PhD in the Dept. of Cognitive Science at UCSD with research interests in causality and information flow in neural systems and brain-computer interfaces. Since 2007, he has developed new-media installations and performances that, through interactive audiovisual representations of electrical signals recorded from the brain/body, invite the participant to explore the intricate coupling between mind and matter. Some recent works include Mindchill 1 and 2.0, EEG Ocean, and 'In Tones', Music for Online Performer (in collaboration with new classical/electroacoustic composer Richard Warp).

Christian Kothe (BCI computer) came to UCSD from the Berlin Technical University where he earned a Masters in Computer Science developing software and analysis methods for brain-computer interface experiments by Group Phypa in the department of Human Factors Engineering.

Scott Makeig (violin and composition) earned a BA, 'Self in Experience,' from UC Berkeley in 1972, and a Masters in Music Theory (ABT) in 1979. He entered the UCSD Music department program in Experimental Music Theory and completed a PhD, 'Music Psychobiology,' in 1985. Thereafter he has worked in the field of human cognitive neuroscience and since 2001 is now the Director of the Swartz Center for Cognitive Neuroscience at UCSD and an Adjunct Professor of Neurosciences. The violin is a rather recent instrument for him, taken up to accompany his son's songwriting. He has been an infrequent composer for nearly 50 years.