

Technical Notes

Intelligence in the Human-Machine

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Katinka Kleijn, cello

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Around the 17th week of prenatal development neural activity of the human brain begins. It is held by many researchers that the electrical signals generated within the brain report not only the functioning of the brain, but also the status of the entire body. *Intelligence in the Human-Machine* seeks to uncover through sound the effects and communications that occur between performer and music during the act of performance.

Does the brain make any sounds?

The brain itself does not make any sound, but through the use of an EEG (electroencephalogram) headset and a computer we are able to record the electrical impulses made by the brain at work, and reinterpret those electrical impulses as sound.

What will you hear?

Most of the brain's electric impulses occur at frequencies well below those that we can hear. To put it in perspective, the cello has a frequency range from 65 to about 880 hertz. The human brain's electrical impulses operate from around 0 to 30 hertz. Our ears only have the ability to hear frequencies ranging from 20 to about 20,000 hertz, which means that if the brain's electrical impulses were translated directly into audio, and not affected in any way, we would only be able to hear the impulses that occurred in the 20 to 30 hertz range, missing out on all the other activity below 20 hertz. In order to best interpret the raw sonifications (simple translation of non-audio data into audio) of the brain's electrical signals into meaningful sonic structures, we have made recordings of Kleijn's brain prior to the performance. What you will hear during the performance are the raw recordings of Kleijn's brain being processed by her brain's live states via the analysis of her current brainwaves strengths and distributions.

Brainwaves

The brain is a collection of billions of brain cells called neurons. These neurons communicate with each other by emitting small electrochemical impulses at varying frequencies. The combination of these impulses results in a large amount of localized electrical activity measurable on the scalp with an EEG. The EEG headset and its accompanying software capture these electrical signals from the impulses and categorizes them into four main wave types.

Delta	0 - 4 hertz	Unconsciousness, or deep sleep.
Theta	4 - 8 hertz	Sleepy/drowsy with reduced consciousness.
Alpha	8 - 13 hertz	Physically/mentally relaxed, but aware.
Beta	13 - 30 hertz	Alert, agitated, tense, or afraid.

Brain States

As the headset receives live input from Kleijn's brain it performs an analysis of these four brainwaves and rates her affective levels in four categories: meditation, engagement, excitement, and frustration. These four categories are then used to manipulate the sonifications of Kleijn's brain in order to give sonic feedback on her current states during the performance.

What do the affective levels control?

The four affective levels are mapped onto almost every aspect of the sounds heard coming through the speakers. Although the input from the EEG machine has been incorporated in almost every aspect of the electronics, the most noticeable parameters that they control are:

The Sonifications: The electrochemical impulses of the brain captured by the EEG headset and translated into audio.

Meditation:

- a) Rate of the sonifications
 - Higher levels = slower
 - Lower levels = faster
- b) Low frequency volume
 - Higher levels = louder
 - Lower levels = quieter

Engagement:

- a) Transposition of the sonifications
 - Higher levels = transposed higher
 - Lower levels = transposed lower
- b) Mid-low frequency volume
 - Higher levels = louder
 - Lower levels = quieter

Excitement:

- a) Mid-high frequency volume
 - Higher levels = louder
 - Lower levels = quieter

Frustration:

- a) High frequency volume
 - Higher levels = louder
 - Lower levels = quieter

The Lighting: Colored spotlights indicating the current strength of Katinka's four affective states.

Meditation: Blue
Engagement: Green
Excitement: Yellow
Frustration: Red

The Score | The Words on the Wall

To focus on the act of performance the score has been created in such a way to constantly present Kleijn with different performance and musical scenarios. The score is composed of two parts, (1) a musical fragment, and (2) a guiding word to be found through the performance of the musical fragment. Kleijn has two pedals to advance through each of the two elements individually. The word being projected on the wall is the current word that Katinka is seeking to discover for herself in the performance.



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