

Neurally Decoded Art

Constructing Stimuli



Anna Fríða Jónsdóttir

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S 066776

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Virgil Widrich

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Abstract

Like any other art form, music is a way of communication. Reaching far beyond language and sometimes even to a level so deep within our souls we get goose bumps. Our thoughts and memories are provoked and sometimes we are even able to forget time and space. Music has powers we don't fully understand. Just like any other art form, the creation of music can be considered a stream of sound directly from the artists soul.

This essay aims to look into the journey of Anna Fríða Jónsdóttir through the department of Art and Science and explain her research for an upcoming masters project Constructed Stimuli. Looking into what is behind the pieces created during this time and a personal view of influences and research.

The experimental performance Constructed Stimuli is aimed at visualizing this stream from person to person which happens through art. The goal of the experiment is to construct a particular stimuli, a sound, that interprets a particular emotion. An expressive time-form created in an art performance containing an abstracted image of emotional pathways and information streams in our brain. Picking out a specific element of the experience of music and construct from it an image, an experience and hopefully a key to trigger the emotion in the receiver with the touch of a sine wave.

Influences and Previous Works

The fluid department of Art and Science has been both at the same time my heaven and my hell. What can we learn there and what is there to teach? Is it even possible to teach art, to teach curiosity, to teach wonder? Before entering the department I thought I knew exactly how it could be. I had envisioned the whole structure of such a department and how I wanted it work. Turns out I had a very narrow view, simply the view of an artist. At the end of these studies I still am simply an artist but a whole new world of perspectives has been gained but the journey has not been without strains.

On our first school day, Berndt Kraeftner said: "We will not use our knowledge as a weapon." This particular problem turned out to be one of the most straining ones. This was a problem I did not anticipate, I didn't even fully understand the extent of it until now towards the end of my studies and how incredibly much the philosophy of this sentence would shape my path.

A classroom filled with people with such a diverse background, as doctors in science to artist and everything in between, coming from far corners of the world and in all ages is a bit of a challenge of its own. How on earth can I as an artist expect to do anything remotely scientific in the presence of a published scientist and other highly educated people, or talk about emotions to people that know war first hand?

This is where insecurities begin. This is where the weapon slowly starts hitting the self, first and foremost, but there is no way of noticing. It's simply the ever growing nagging voice in your head that kills curiosity and creativity by criticizing ideas till there is nothing left off them. In a group so diverse the fear of lacking was ever growing and the term "the more you know, the more you know how much you don't know" was becoming painfully more apparent with everyday, with every lecture. The miracle than is to overcome this fear and for me f.eks. to "dare" to call my art scientific in front of such a crowd is the true victory. Because that is the exact thing with art or any project, an idea is nothing until it is executed. The only way to learn and move on is to make mistakes and to have the guts to start drawing on an empty canvas. The incredible lesson learned here is to trust our own abilities and not feel ashamed for the lacking we may feel and just go ahead with our projects and trust that your own field of intelligence shines through all the cracks we may see in our own works.

The part of gaining confidence in your work is the root of every art education there is. How people reach this is as different as we are many. There simply is no recipe on how to deal with such inner workings. After two and half years of suffering through these basic insecurities I now see that all the work that I have done in this time aims indirectly towards me accepting my strengths and trusting them to be valid for what they are as well as simply trusting that the process will lead me to a conclusion that works in my opinion.

The first semester project turned out to be one of the best projects through out my studies. That nagging voice of disapproval was not so over bearing yet and the feeling of just doing blindly was still strong at heart. For the project we were assigned coworkers and we were supposed to go out into the field and choose an institution and see how science affected their operation. Along with Rudi Friemel we chose to explore the sewer system of Vienna.

At this point I was new in Vienna and was a little overwhelmed with being surrounded with such amounts of people every day. Everywhere I went there were so many people. I also found it very interesting to all of a sudden spend time everyday underground, in the metro. Every house has a connection underground through its pipes, like trees standing tall but all connected to this central station which is the sewer system.

When living in a new country, where you don't understand the language, calls for inventive ways of communication since language is only one part of the way we communicate. I started wondering if somehow I could feel people in a new way since words were out of the question on many occasions. Turns out that quite a few researches have looked into that topic, such as how on earth we know when someone is looking at us from behind. These thoughts led me on a quest for something so human but yet so unexplainable. Namely instinct and these little ticks we get from other people that we don't even think about, but we all know they affect us.

Understanding people without saying a word. Somehow existing in a world where life is not about content but simply existence itself.

I didn't even really realize at that time that that would be the main theme of the work. The requirement of the project were so focused on the science side, or seemed so for me since I had never conducted any sort of scientific research. Allowing us, Rudi and me, to get a bit lost in trying to come up with some sort of research question to work from. My esoteric ideas of this

fluid from everyone in the city getting combined into one state were sort of getting in the way of our actual science conduct. We set out trying to find out if the cleansed water from the sewer system had some effects on the water quality of the Danube, since it gets pumped into the river after a 24 hour purifying process. We decided to take samples from 3 parts of the river, before the city of Vienna, in the middle and after the outlet of the sewer system. Our results and our methods were not very scientific since neither one of us had the skill set to maintain a rigorous scientific method. In the end that didn't matter the least bit when we stumbled upon wonder. In a way you could say we set out looking for some signs of people, both through my esoteric ideas and through the research, trying to see if there were signs of some contamination. Our wonder was hair. We found so much hair on the river basin. We found physical signs of people. The river quality turned out to be better after the sewer system so in some ways our hypothesis failed but as an art and science project it was a perfect success in my opinion. It's simply not only about proving a point or even getting to a concrete end result. It's about the journey and how it affects your project. Our end result was a very clever program and a not so beautiful sculpture but I continued working on translating our results and ended up coming up with my best work till date, the Thought interpreter.

The Thought interpreter is a piece that was somewhat specifically made for our class exhibition called Parameter World which is for sure one of the highlights of the two years spent in the department. The piece then got accepted into a rather big digital festival called Paraflows, in Vienna, where the concept of the exhibition was reverse engineering. A rather clever concept that really applies strongly to our way of working in the department. Engineering a system to explain a system. (see image nr. 1)

As my journey in the department continued I started feeling increasingly compelled to go further into the science side. Our second project was merely a written report of our scientific findings, leaving the artistic process out of the equation. This was an interesting journey I took, still trying to understand this aspect of communication that reaches beyond words. Without doubt I wrote the craziest essay I ever have, trying to combine theories that are not related in an attempt to construct some sort of curious image of where science could hypothetically take us. My essay wasn't a very scientific one even though it was solely based on scientific theories. It was rather

a rant of a person completely lost in a rabbit hole of theories in an attempt to understand. I couldn't help but present my essay as a speech performance ranting out all my misunderstandings and frustration. This project was in a way an intense learning process about just how lost you can get in a world filled with theories and how meaningful and meaningless they can be at the same time. I learned to tune some sort of balance towards how much I can allow theories and science to influence my art process which affected my coming projects.

For the exhibition at the Natural History Museum I wanted to mock this new found balance of mine and how seriously I needed to take science. Coming from an island makes a person really attached to the ocean and I had been doing some research into the garbage patches in the ocean and how it is affecting the whole ecosystem. What inspired that quest were also the micro pieces of plastic me and Rudi found in our samples, during the research of the Danube. I felt daunted by the idea that plastic doesn't go away, it simply gets smaller. I wanted to see if anyone was coming up with some solutions to the problem but actually the only solution is simply to go get it. After our Bio Art class with Sonja Kratz my head was filled with all sorts of magic solutions as to how science could work and perhaps will someday so I decided to "make up" my own specialized organism that would come save the day. A plastic eating bacteria has already been discovered so I fantasized about a plastic eating barnacle. My end result, my artwork, was a plastic eating barnacle that I carved out of soap. My original idea was to have them rather big and living on the walls of the museum but the setting and the circumstances did not allow it this time so what was exhibited was a scaled down version that worked beautifully. I called the species *Cirripedia Ganeum*, referring to its gluttonous eating and its abilities to rid human kind of its over indulgent waste. (see image nr. 2)

After the NHS exhibition I had a growing need to do some video again and work from a different starting point. I decided to work with a theory I had presented in the first semester, the double slit experiment and what it entails regarding consciousness. I wanted to somehow visualize how things come into existence like a flow of colors and shapes as a metaphor for all the different things we create by noticing them. The video itself somehow didn't feel like a finished piece though. The summer of 2012 I did a music performance with the video, along with a friend of mine called Ásta María Kristjánsdóttir, who accompanied me on the cello while I sang lines from

the concept of the piece. The performance was held at a gallery called Ve.Sch in Vienna. The outcome of the performance was a rather surprising one since what stood out for most people was the intimacy shared through the music and their interpretation of the mood, instead of focusing on the concept of the piece. The thing was though that in a way that was part of it but I didn't expect it to become so personal. I found that element so interesting that it has become the main theme of my coming masters project, looking into just what can be shared through sounds and how they affect us. I took singing lessons for one semester which caused me to understand how much mental state is related to how well I reached the tones I aimed for. I loved the idea of such a physical and in the moment act as singing became for me. Making art directly from my diaphragm and making sounds that have different effects on the audience but all the while looking at it from a visual art perspective. Working with music or sounds to interpret my concepts. For me that is a rather unexplored territory but in the end the modern art has overcome media in general and mostly attempts to explain concepts. (see images nr. 3-4)

Concept for Masters piece

Like any other art form, music is a way of communication. Reaching far beyond language and sometimes even to a level so deep within our souls we get goose bumps. Our thoughts and memories are provoked and sometimes we are even able to forget time and space. Music has powers we don't fully understand. We listen to music that reflects our psychological state, ranging from upbeat happy music to down tempo depressive music.

We choose music dependent on our moods but at the same time the music affects it. Emotions are being transmitted to us in sound waves from the composer. The composer creates the music, reflecting his/hers inner state, from some given parameters or even from images.

My project is about the intangible emotional transfer between sender and receiver during a musical performance. Sound provides such a spectrum of colors that provoke different reactions in the listener. Another layer is that classical or standard songs can sound or have a completely different feel to them by how, or from what feeling they are performed. What interests me is how directly the audience perceives this. My aim is to interpret this space in between the composer and the audience and trying to visualize it by having a performance where the music is improvised on some levels. The visualization will then happen through an EEG reading of my, the composers, state of mind. Ranging from meditation to concentration. The beat of the music is controlled by these given parameters and affected by the state of my mind. Therefore trying to control the creation of the music directly from the speed of neurons firing in my head. Since it is an improvisation the mood of the audience and the scenario is also influencing the creation of the music/sounds.

Most of the research I have done in the department has been somewhat focused on how we communicate, where consciousness can be found, spiritual connections with other people and how science might help on these far reaching subjects. After I started singing recently, a whole new world of communication opened up to me. I felt fascinated to find out how and why we are all so addicted to music and sometimes even manipulated by it, through media and advertisement. It feels like such a direct link into our emotional life. My research is aimed to

explain these phenomena's and understand where science is on the topic. Why is it that music can make us so emotional and have such an effect on our mood?

“It is remarkable that any medium could so readily evoke all the basic emotions of our brains (and much more), coaxing us to consider our innermost nature and to savor the affective dimensions of our minds. Clearly, music gives a voice to our feelings, and it provides a unique and highly ethical way to study the emotions of the human brain/mind.” (Panksepp, Bernatzky)

Emotions alone as research topic almost seem impossible, since distinguishing non-emotions from emotions is rather impossible. The control group is out of the question. With modern technology it is becoming a tiny little bit easier to decipher where in the brain the emotions are being triggered but speculating on how music affects us is still a rather complex thing to decipher since choice of parameters is not really a rich one. Distinguishing to what extent emotional changes are caused by music, rhythm and melody, as a posed to personal memories or cultural understanding. Or do these classify as the same emotional trigger. Can we even analyze such a thought process?

I will try to explain where my research has led me and construct an image of my understanding of what I have gathered. I have a tendency in my research to continually zoom in on a topic until reaching micro or even macro level. My original interest was to figure out what happens in the ear when we listen to music. Finding out how sine waves hit the eardrum and figuring out what then happened, how they get processed to this miracle we call music. This element turned out to be a very far reaching one within neuroscience alone. What happens and why is a question that does not have an easy answer when it comes to the complicated construction of a unified experience. Does our emotional life have some sort of formula or map?

Manfred Clynes a concert pianist, scientist and an inventor, has an amazing lifework on the subject of music and emotions. In his research he successfully managed to interpreted emotions into shapes. He used a pressure sensitive device he called a sentograph and asked

his subjects to exert a finger on it to express a particular emotion. He found out that the shapes were in fact very similar in all his subjects and from his research came up with a certain pressure print to describe emotions. The shapes were then mathematically translated into sound shapes. Subjects from all over the world, to rule out effects of cultural references, were able to distinguish the emotion the sound interpreted. Clynes managed with this research to suggest that perhaps our emotions are prewired since the responses are so concurrent from person to person. The question is then if this result or this indication fit with modern neuroscience understanding of emotional pathways.

There are distinct brain systems that mediate anger, fear, joy and sadness, as well as a variety of other social emotions, and there is increasing evidence that music can activate the body 'symbolically' in emotion specific ways.

(Panksepp, Bernatzky)

It is in fact safe to say that Clynes found a way to translate an output image for these particular brain systems. To be able to translate something as intangible as emotion and turn it into a line in a graph and then take that and translate it again into an intangible sound is simply a perfection of art and science practice.

Clynes believed that every composer had his/hers own inner pulse or sense of rhythm that was audible in their music. He discovered that when great artists conduct pieces, by a particular composer, with their finger on his sintonogram, while mentally rehearsing the piece, showed very similar patterns for each composer. The particular pattern he found was applied throughout all the particular composers work. A pulse that was distinctively the composers own. Clynes believed he had found what he called: "a glimpse of the intimate personal nature that can be precisely measured, recorded and reproduced." (Phillip W. Warren)

In neuroscience music is studied as, one of many, stimulus on the brain. Neurons create signals, electric pulses, called action potentials that travel down nerve fibers. With the presence of stimuli the sensory neurons create a pattern of action potentials, electric pulses, that works similarly to Morse code. Containing information about the stimulus, encoded in the pattern of

action potentials which get transmitted into and throughout the brain. The pulse pattern is then what contains the information of the stimuli.

The field of studying the neuronal responses, characterizing the relationship between the stimulus and the individual is called neural coding.

The link between stimulus and response can be studied from two opposite points of view. Neural encoding refers to the map from stimulus to response. The main focus is to understand how neurons respond to a wide variety of stimuli, and to construct models that attempt to predict responses to other stimuli. Neural decoding refers to the reverse map, from response to stimulus, and the challenge is to reconstruct a stimulus, or certain aspects of that stimulus, from the spike sequences it evokes.

(ref: Neural Coding)

Clynes theories are based on his ideas that our central nervous system generated specific basic emotions with unchangeable expressive time forms. These time forms he called sentic forms and they are the image of a pulse that happens over time as shown in image nr. 5. Clynes showed that given the same stimuli, everyone has a common way of processing as if there was a map of how humans respond to evoked emotions.

The pulse pattern of a single neuron and Clynes expressive time forms seem to have something in common. A stimulus creates a specific pattern depending on what information it contains. A pulsing pattern like rhythm in a song. In my project the music, the melody and the rhythm, will be controlled directly from neurons firing in my head whilst singing out Clynes line interpretation of emotions. An experiment to construct particular stimuli, a sound, that interprets a particular emotion. The pulsing pattern of the stimulus is not known before hand. Therefore an expressive time-form is created in the art performance containing an abstracted image of emotional pathways and information streams in our brain. Picking out a specific element of the experience of music and construct from it an image, an experience and hopefully a key to trigger the emotion in the receiver with the touch of a sine wave.

Performance

The performance Constructed Stimuli will be based on neuroscience definition of neural decoding. Creating stimuli from given responses in the brain. The headset is what interprets those responses and from them a sound is created. A translation, interpretation and construction of stimuli using sound like a brush stroke or an element in an installation. The artist takes the role of a composer, performing a sound piece which is orchestrated from mind and body alone. Tapping into the emotional life of the artist and the audience by using Manfred Clynes lines of emotions to create another layer of tones. The two sound outputs will not fit to each other so the result will be a bit of a cacophony of the mind. In the background there will be a video playing which will provide a visual output of the mental state of the artist. The meaning of this piece is to explore the role of the artist and perhaps point out that creation does not come from nowhere. By taking the creation itself and making it so physical and in the moment is the experiment. The outcome of that will hopefully be a beautifully shared moment of mutual understanding between the art created and the audience. That is the risk every artist needs to take every time something is made public but in this case that is the element of discussion. How things get sent and how they get received and the immense gap that can sometimes happen there in between.

Mindwave headset and execution

The mindwave headset is the creation of a company called Neurosky which invented a single dry sensor for EEG reading. In the past an EEG reading has involved multiple sensors using conductive gel which is not ideal for the consumer market. Neurosky created a headset that is intended for any average user, either to control video games, for research or mental training. The Neurosky headset outputs two parameters, attention and relaxation, which are referred to as the Neurosky eSense meter. These outputs are the result of a complex calculation of noise reduction and signal amplification.

(see image nr. 6)

The brain waves recorded by the device are in fact a reading of the millions of neurons in our head that generate small electric voltage field. A combination into one superposition of many simpler signals is what makes up the EEG reading. The reading of these electric signals is analyzed with a mathematical process called FFT (Fast Fourier Transform) and refers to the composition of the EEG signal gathered. The signal is then described with frequency in Hz with a certain bandwidth relating to a certain brain state. The amplitude of the frequency is highly various depending on internal mental state or by a given stimuli.

(ref: Brain Wave Signal (EEG) of Neurosky, Inc)

As example, brainwaves between 12 and 30 hertz, Beta Waves, are associated with concentration, while waves between 8 and 12 hertz, Alpha Waves, are associated with calm relaxation. (ref: Brainwave Technology)

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation
Gamma	30Hz to 100Hz	Motor Functions, higher mental activity

These measurements of brain waves strongly relate to measurements of sound waves.

Interpreting brainwaves in sound waves is the task I set out to do. Reading electricity in the brain in some way and looking into what kind of information we can get from it.

After getting the device, which I thought would be a brilliant solution to these brain reading ideas of mine, it has been a rather long way of reaching some sort of conclusion as to what to do with it and how to technically achieve it.

The initial idea was always to somehow obtain the output in numbers and make it control something. Make some sort of program that would be controlled by my brainwaves. The idea to have it control a patch in MaxMSP was born rather early on but the technical difficulty of that was immense. In the end after getting some well received help I managed to get the numerical output from the headset through a script in the python scripting language. That output then gets written, every second, into a file that Max can read from with the help of a mindwave external to Max that I found. After all the research I have done online I thought that the best possible refresh rate would be every seven seconds but with the help of the python script the output rate is the same as the device provides. Once every second. Not such a high sampling rate but just enough for what I need it for. With the numbers so quickly refreshed it was interesting to allow the numbers themselves create the music as opposed to my original idea of having them triggering ready made samples. The trick is then to go much deeper into Max and figuring out how far I want to take it and how I want the tone to sound. The number output controls the frequency given to the oscillator patch in max but getting the desired effect will take a lot of fine tuning.

Final words

The core of Art and Science practice is translation. Translating data into images or an art performances for that matter. The data in the case of my project are the numbers from the EEG device. What can they tell me and how do they matter and then in return how do I translate them. Finding a balance in these matters has been the main learning curve of the department. How far does a subject need to be abstracted for it to even count as art.

My projects during this time reflect in many ways what I was looking for in my previous B.A studies in art. What makes art art. Where does it come from and what does it take for ex. a photograph to become art. Looking into the unconscious and how it works. Combining art and spirituality but at the same time trying to make some sense of the world. Looking into science to understand how the human race perceives the world. Reestablishing over and over again that the more I understand myself the better I am able to communicate art.

The translation of data, in my opinion, has to become somewhat personal or relate to human elements for it to ever have a chance of becoming art. Art stands for the intangible within us and we cant necessarily obtain that by logic. Somethings move us and somethings don't, but we don't necessarily always understand why and it doesn't matter because it's supposed to go beyond that. Reaching the point accepting that has been the key of my studies with in the department. In so many ways my journey through the department has been very successful. I come out of it thankful for all the amazing people I meet through it and for all the opportunities that have come from this time. I hope the department will continue to grow and continue to collect interesting people. Giving new perspectives and gathering experience through the years.

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MaxMSP external

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Images

Image nr. 5 from web 30. May 2013

<<http://www.rebprotocol.net/senmanfredclynes2.pdf>>.

Image nr. 6 from web 30. May 2013

<<http://store.neurosky.com/products/mindwave-1>>



Image Nr. 1



Image Nr. 2



Image Nr. 3



Image Nr. 4

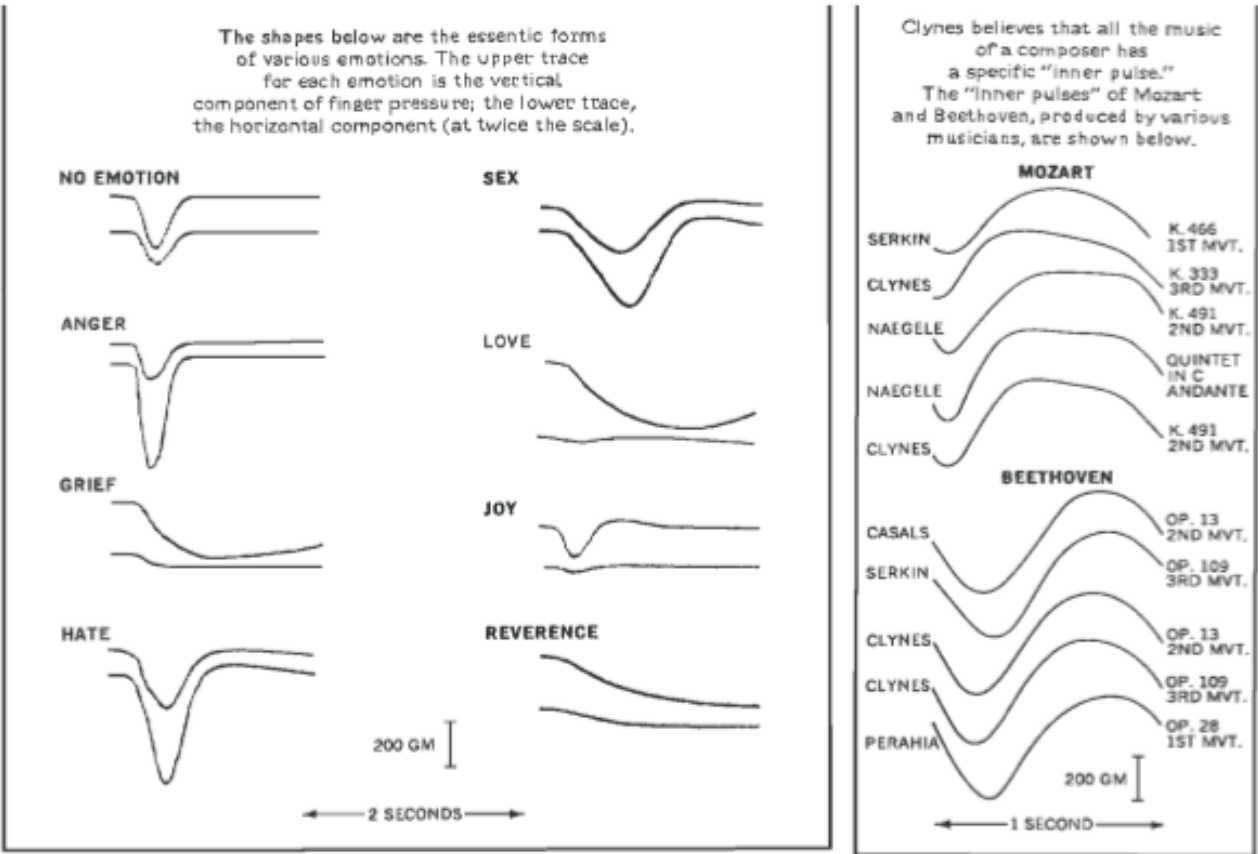


Image Nr. 5



Image Nr. 6