Aalborg University Copenhagen

Department of Medialogy

Semester: MED 10

Title: Generation of ambient background textures from a given waveform.

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Project period: **Spring 2011**

Semester theme: **Master Thesis**

Abstract:

This work aims to answer a question if it is possible to generate background sounds from any given waveform. I present an overview of ambient music and similar genres. I describe techniques for sound composition and synthesis. Basing on my research I propose three methods for generating background textures. This work provides an overview of the results of the test conducted using the methods and my conclusion on the solutions I propose.

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Members: Jakub Cioslowski

Copies: 3
Pages: 65
Finished: 26.05.2011

When I started making my own records, I had this idea of drowning out the singer and putting the rest in the foreground. It was the background that interested me.

Brian Eno

I would like to thank my family for giving me a chance to study Medialogy, write this thesis and become who I am.

I would also like to thank Bob Sturm for great ideas and educational support.

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Introduction

Sound is an important factor creating the reality everybody experiences. It is crucial for understanding the basic level of sonic word like environmental sounds, but it also serves to give a pleasure, like listening to music. In this work I research the possibility of creating background sound textures that could be used as sonic wallpaper. I synthesize the definition of ambient background sound and apply it in order to create universal methods that could be used on any given waveform to produce background sounds. I create set of sounds using methods described in this work and provide the results of a test I conducted.

This work gives the reader an overview of an algorithmic music and ways to create it. I present the concept of ambient music with its sub genres and similar kinds of sound. Next I talk about the sound synthesis and especially concept of sound grains. I apply results of this research and present three different approaches that in my opinion are capable of producing background music textures. I verify my assumptions with testing results that I discuss in the last part of my work.

After the initial research of the topic of background sound generation I state the following hypothesis.

Hypothesis

Can one create ambient background sound texture from any waveform?

Background

Motivation

In this chapter, I review topics related to sound synthesis and music composition in relation to generating sound textures and background music. These topics include: algorithmic composition, ambient music in general, and the art of soundscapes; techniques of sound synthesis used in such music and formalizations of describing sound perceptually. My aim is to provide the necessary background for understanding my approach to the problem of generating ambient-like sound textures from any given waveform. I also present different automated compositional approaches that could be used when generating background sonic textures; lastly I focus on a granular approach in sound analysis and composition.

Algorithmic music

The significance of formalization of music through its history seems very important when one wants to define an automatized method for composition (Edwards, 2011). The evolution of music styles and genres makes it easier to define and systematize key features of compositions such as tempo, arrangement or pitches. Algorithmic music aims to generate music by the means of a computer, it can model composer's approach like David Cope's "Emmy" (Boden, 2007), create music based strictly on computational techniques like cellular automata (Burraston & Edmonds, 2005), apply nonlinear dynamical systems and many more (Alpern, 1995). We are able to emulate composers and create novel music based on some of those algorithms. The research by David Cope shows how a computer can automatically create novel music in the style of any composer that can impress even expert musicologists (Boden, 2007).

Mozart's dice game

One significant early example of algorithmic approach in musical composition is Mozart's "Musical Dice" ("Musikalisches Würfelspiel"). In this method Mozart, defines the grid of music building blocks first. Than the sequence of the previously defined patterns is randomized by throws of two dices. Even though the building blocks are composed, this random arrangement still results in a coherent composition, supposing that the composer defined them properly (Edwards, 2011). A more recent application of this approach is Gescom's (aka Autechre) – Minidisc album (Gescom, 1998) initially released exclusively on minidisc format. This record is divided into eighty-eight short sound fragments that are supposed to be listened to in the randomized shuffle mode, resulting in a unique composition each time they are played back.

Illiac Suite

In the mid 1950s, computers became a part of early experiments with musical composition. One of the first people involved in these experiments was Lejaren Hiller who used an ILLIAC super-computer in his work. With help of mathematician Leonard Isaacson in 1957 he released the "Illiac Suite", a result of his research on algorithmic composition. He used a random number generator and a Markov chain statistical method to simulate a composer's workflow to generate rhythms and pitches of notes. Hiller's approach tried to emulate the human composer, he implemented "generate and test" algorithm to evaluate random generated notes. If the sequence of notes, defined by the computer, did fulfill the requirements defined by an internal composer test algorithm they were added to the composition. If the sequence turned out to fail the test the process of note generation started again. This way the composition only contained notes approved by the system (Lopez & Lluis, 2002). The end result was a musical piece for a string quartet (Alpern, 1995). Although it is a matter of personal preference I think that Hiller and Isaacson did succeed in creating a coherent musical pieces that can be admired not only by computer enthusiasts but also regular music listeners.

Nodal[1]

While Hiller's software had been developed many years before the era of modern personal computers, some of his concepts of rule based software can be found in software applications developed these days. The example of such environment

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[1] http://www.csse.monash.edu.au/~cema/nodal/

where user can create rule-based solutions is Nodal software. Instead of choosing an algorithm that produces music notes, user can build graphs and nodes that visually represent musical events and their connections. Each event can trigger any number of voices that can send MIDI messages to the synthesizer. The graph can be manipulated while it's working, that gives user a chance to enable or disable nodes to alter the composition.

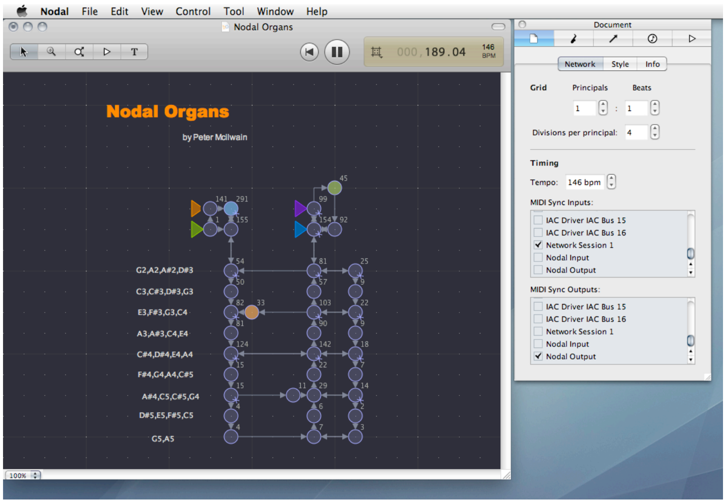

Figure 1 - Nodal circuit based sequence screenshot

The use of visual graphs is definitely an interesting approach to process of music composition. It gives user wide range of unique possibilities for music creation when it comes to style and use of instruments (melodies and percussive patterns can be obtained). While this software can be very interesting for a composer it would require an effort for a regular user to enjoy it. Because Nodal sends only MIDI messages it needs a synthesizer to produce the music, it also requires learning how to use the software and some musical knowledge to adjust the notes to make reasonable music pieces. Even though this software does not try to model Hiller's approach, it definitely has the same simplistic approach to musical composition.

Advanced techniques of algorithmic composition

Hiller with "Illiac Suite" proved that it is possible to compose music with computers. The advancement of computers and computer science gave birth to further more complex experiments with compositional techniques. Starting with Hiller's MUSICOMP software used to create one of the earliest compositions through Iannis Xenakis stochastic methods where a random number generator is connected to probability weights to produce a music piece (Alpern, 1995). Complex mathematical equations have also been used to compose music; one of the most interesting examples of such use is an adaptation of nonlinear dynamical systems and the chaos theory. Formulas describing the phenomena of the nature like mixing of fluids or Hénon map to generate notes (Alpern, 1995) The topic of simulating biological behavior in the context of music has been broadly researched. One of the most significant examples of such an adaptation is a popular use of cellular automation, especially Conway's Game of Life in producing music (Alpern, 1995). This research proves that one can create algorithmic music not only by modeling a musical style or the work of the composer, the spectrum of possibilities is much boarder and still can produce coherent music. I base this judgment on my personal experiment with application of Hénon map equation, where I mapped its results to midi notes that were transferred to a synthesizer (see attached CD – Henon map sound sample)..

Research and development of algorithmic compositional techniques resulted it creation of many software-based solutions that make use of such algorithms. I present examples of tools that can help composers creating new music and applications that generate relaxation music.

Noatikl[2]:

Noatikl is commercial stand-alone software or VST plugin designed for algorithmic composition. It is a successor of Koan application that was developed in the 90’s and used by Brian Eno in his Generative Music 1 floppy disk release.

[2] http://intermorphic.com/tools/noatikl/

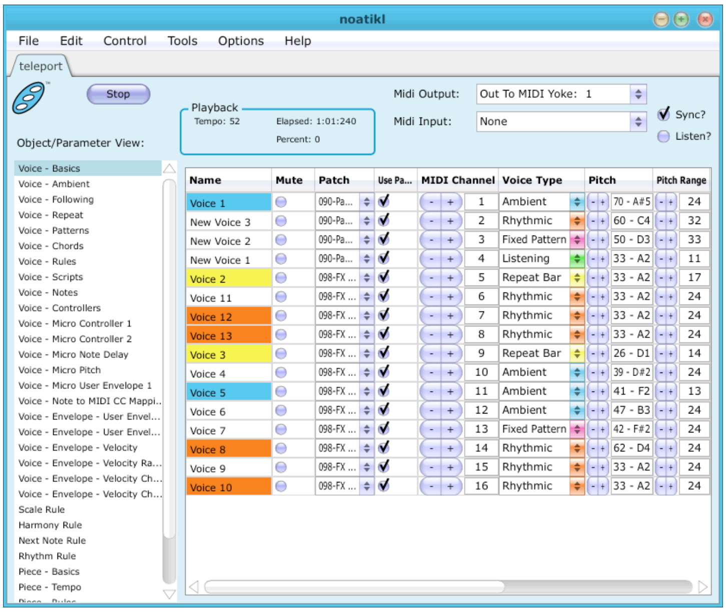

Figure 2 -Noatkl interface

Noatkl is designed to work with digital audio workstations (DAWs) or standalone synthesizers. The software doesn't synthesize sound itself but instead it sends MIDI messages to external devices. Noatkl can create MIDI signals on many channels allowing user to manipulate more than one instrument at once. Each of channels can have separate key, pitch and algorithm type, which makes this application useful for many different kinds of music. While the quality of the composition can be argued it is up to the user how he is going to set up his music creation environment. Intermorphic company, developer of this product, claims that their software can be used by composers to "create new music ideas", "reflective music" or producing "generative music". Noatikl can also be controlled by internal scripts connected to MIDI input, giving a possibility to manipulate the music piece on the fly.

Noatikl software seems like a complex and professional tool for composers. While it's not "out of the box" solution for casual listener, the user can come up with his own personalized setup that can be connected with instruments of his choice. This application seams most reasonable for people that already have some experience in making music, it is more of a tool for composing music. Moreover it requires some knowledge about connecting MIDI with DAW software and also requires user to have hardware or software synthesizer that would play notes provided by Noatikl.

Bitnotic chill[3]

While previously mentioned software was targeted to composers and music hobbyists, Bitnotic chill is created to generate sounds for the listening pleasure. There is no control over how the musical piece is being built, user also can not define what kind of instruments to use. The software provides user with couple of sliders to adjust key elements of the sound like the amount of rhythm or the "mellow" factor. It could be argued that such a controlling system is quite vague on the other hand it seams enough for users interested in starting an application and enjoying the music without interfering too much with the system.

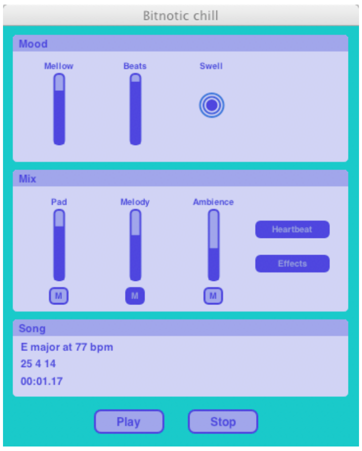

Figure 3 - Bitnotic interface with sliders

Bitnotic chill definitely is successful in generating long, changing musical background structures. It is a matter of taste but some users may find the overall sound of application very artificial and basic, because the sounds are similar to build in Mac OS MIDI instruments library.

SonicMood[4]

SonicMood represents similar approach as chill software, it provides user with background music pieces. The application uses algorithmic composition and loop playback to create relaxation moods. User can create presets, define music scales, select instruments and sound loops. Interface of the application

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3 http://www.bitnotic.com/chill.html

4 http://www.sonicmood.com/

resembles a little interfaces found in computer based music players like iTunes. That may encourage the user to switch between the saved presets as he would navigate through songs. While the software is able to create long music textures that change in time, like in the chill software, the sound of instruments may be too artificial for some users.

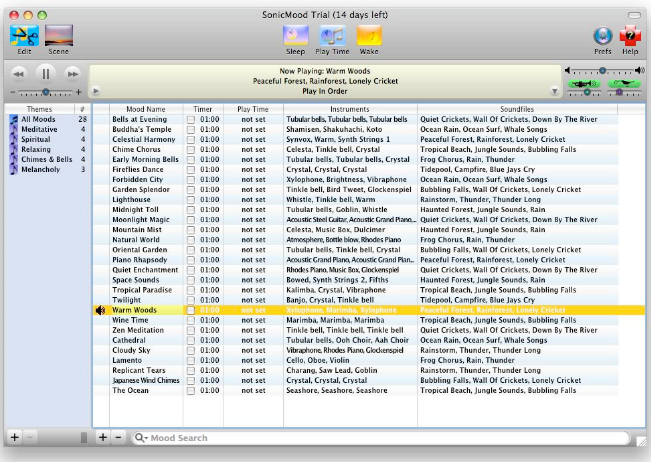

Figure 4 - SonicMood's library of presets

Artificial intelligence in music composition

One of the most significant and impressive applications of algorithms in compositions of music are experiments of David Cope's with an artificial intelligence. One of the most well known examples of his work is software called EMI (Experiments in Musical Intelligence). It uses an artificial intelligence to analyze and adopt a style of chosen composer; next it can produce new pieces of music in a style that it has previously adopted. This example is particularly interesting because David Cope's EMI software was able to produce pieces of music that even music experts couldn't indicate weather they ware written by human or computer.

It is not my aim to describe all the algorithmic composition techniques, with some of the previous examples I want to show that one can take many different approaches in the process of creating music.

Background music standalone generators

Previous examples of algorithms, the software for music composition and generation show that this process can be quite complex. On one hand one might need to know how to write software that would make use of mentioned algorithms, or at least one might need to know the technical side of connecting note generation application with DAW (Digital Audio Workstation) software. In best case the user needs to have his computer turned on to use some of the desktop based music generation applications. When looking on the number of available sound apps for iPhone it is reasonable the think that casual users need audio generators that are in the reach of their hands and that can be used anywhere. I present mobile, but not only smartphone based, solutions that in my opinion prove that a simple approach behind sound generation is also meaningful and can be used in real life. It is interesting to see that applications using basic interaction or even prerecorded sound playback can become very popular.

Bloom / Trope / Air[5]

Bloom is a popular iPhone application developed in cooperation with Brian Eno. It is part of a bigger family of apps: Trope and Air. Like most of iPhone software Bloom takes advantage of device's touchscreen. It generates background ambient textures, user can "paint" circles on the screen, and the algorithm measures coordinates of each shape and plays a sound according to its position.

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[5] http://www.generativemusic.com/

Figure 5 - Bloom interface

There is no direct control over the notes; the only rule is that the higher the shape on the screen is the higher frequency the note would have. That makes it harder to control by a professional musician, but seems friendlier for the casual user. After certain amount of time each shape and sound decay and disappear so the composition doesn't sound like one loop played back endlessly. Bloom can be also left without interfering with its interface, that would result with one of the background textures being generated on its own. Developers of this application seem to try to maintain balance between background music generator and an experimental instrument.

Immersion Station[6]

Immersion Station is an iPhone application developed in cooperation with an ambient composer Steve Roach. It has a variety of built in ambient textures that user can select and adjust. The interface consists of certain number of spheres in a 3D perspective. User can't create music from scratch; instead he can change the position of objects on the screen. Each of the spheres represents one channel of background music. Positioning the object to the left or to the right will result in changing the channels stereo panorama from left to right speaker and vice versa. Moving spheres in z-axis, meaning closer or further from the viewer changes the volume of a channel represented by current object.

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[6] http://immersionstation.com/

Figure 6 - Immersion Station interface

This software can be described more as a mixing application than a generative sound algorithm. Nevertheless Immersion Station is capable of producing long ambient textures and gives user ability to tweak its volume and stereo parameters that can result in unique sounds each time it is used. It can also be set up and left alone to provide background ambient textures.

FM3 Buddha Machine[7]

Buddha Machine is a physical box with a speaker run on batteries, containing prerecorded loops that are played back endlessly creating a long evolving sonic background that got noticed even by New York Times[8]. It is beyond the scope of this project to review such solutions, but it is important to show that this minimalistic and simplistic solution can also be an efficient way for creating a background sounds.

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[7] http://www.fm3buddhamachine.com

[8] http://query.nytimes.com/gst/fullpage.html?res=9806E0DE1731F936A15752C1A9639C8B63

Ambient music in general

Ambient

It is important to mention that ambient music has its conceptual roots in the early 20th century idea of furniture music and wallpaper music discovered by Eric Satie, who wrote some of his compositions to be performed during the breaks of the concerts. He encouraged listeners to freely talk and walk when listening to his furniture music (Trigg, 2005). Concept of such music did not get popular within his lifetime. A company called Muzak did notice commercial perspectives in producing easy listening music that was supposed to be played as a background in stores, banks and other institutions. Later on it was also called the "elevator music". Such music does not contain much of an artistic value; it is supposed to transfer into the client's income (Tamm, 1995). The focus on the background sounds and ambience in overall was not only used for commercial reasons it was also researched for artistic reasons. Composer John Cage wrote his famous piece called 4' 33'', which contained only of pauses. The piece lasted 4 minutes 33 seconds and was completely silent (Solomon, 1998). This use of silence as music was very interesting from the conceptual point of view because it proved that background sounds can also be an important part of a music piece.

The furniture music, products of Muzzak company and experiments with a background sounds by John Cage were definitely an influential force when one thinks about the origins of ambient music. It is important to emphasize that ambient music in did not aim to commercialize itself.

Brian Eno defines "ambient music" as an influence for the environment rather than a strong force that would define it. Definition of this sound can be found in one of the first albums of that kind: "Ambient 1: Music for airports" (Eno, 1978). Eno's inspiration for this album, as the title might suggest, was a waiting room in one of the airports he was spending his time in waiting for a plane. During one of the interviews he mentioned, that he realized that a very bad music was played in the background at that time on the airport. This thought inspired him to develop the concept of music for certain spaces. To fit such environment, sound has to have certain features. First of all its frequencies should not be interfering with human voice in order to let people talk without any disruptions. Eno also defined ambient music as one that could work as a background for human activities but on the other hand should also be interesting and engaging to be listened to with full human attention. In order to achieve full correlation with desired environment music has to be treated as integral part of it.

The features of ambient music

Ambient is not a formalized sound creation method, it is a common understanding of a background music with features initially proposed by Brian Eno. Because people create it worldwide, each one with slightly different understanding of this concept of music to illustrate this I quote Brian Eno and Eric Tamm, who is the author of a book about Eno.

- "Ambient music is intended to introduce calm and a space to think. It must be able to accommodate many levels of listening attention without enforcing one in particular; it must be a ignorable as it is listenable" (Eno, 1978)
- "...quietness, gentleness, an emphasis on the vertical color of sound, establishment and maintenance of a single pervasive atmosphere, regularly or irregularly repeating cycles of events, modal pitch sets, layered textures tending towards an even balance of tone and noise, and a pulse that is sometimes uneven, sometimes breathing, and sometimes non-existent" (Tamm, 1995)

Even though they talk about the same genre of music it is clear to see that their definitions are slightly different which I think is a natural when there is no formal definition of such sound. Despite this fact I think that the common features of ambient music are:

- focus on the texture of the sound
- idea that the music has to create an atmosphere
- the sound should be part of a background instead of taking listener's attention

Having those features in mind it does not matter if it is a dark ambient, space ambient, drone music, soundscape composition or even an experimental dub techno track full of repeating band-pass filtered synthesizers. They may have different names but as long as they have features mentioned before they can all be called ambient from the conceptual point of view.

I present other genres of music that can be treated as background sound, in some cases they may also fall for the definition of ambient.

Drone

Drone music mainly consists of tones that do not vary or vary a little in the pitch through the composition. This genre focuses on the texture and qualities of the sound itself rather then melodies or arrangement. The sound can be built with tone generators like oscillators, noise or feedback loops etc. One of the early pioneers of drone sound is La Monte Young who started producing this type of sounds in 1960s. The keys elements of the drone sound are long sustained notes. A piece can be built with a single tone being played back though entire composition's length. One of the attempts to create such a composition was an environment built by La Monte Young and Marian Zazeela called "Dream House". It is a continuous installation consisting of drone sounds and light. (Young & Zazeela)

Noise music

Noise music is a term that describes many sound forms. It doesn't define any particular composition approach. Like a drone sound it may consist of noise generators or feedback loops. In addition this term holds all other non-musical means like bleeps, random sounds, mechanical and acoustic sounds, digital glitches. That can be used together or separately to produce a sound composition. A reach example of noise music can be found on the 50 CD set called Merzbox released by an influential Japanese noise artist called Merzbow (Merzbow, 2000).

The art of soundscapes

In 1970s soundscape became a subject of research by Murray Schafer. He started a World Soundscape Project that initially focused on the area of the Vancouver city. “Study involved level measurements (producing isobel maps), soundscape recordings and the description of a range of sonic features” (Wrightson, 2000). Initially work of researchers gathered around World Soundscape Project focused on documentary aspect of soundscape composition. Later on it has been discovered that a soundscape can have more than a (Lopez & Lluis, 2002) documentary value, meaning that the original recording is not edited in any way in order to present the sonic material in its original form. Soundscape can also be a compositional style, it can contain processed and unprocessed sounds but I can’t be abstract. The relationship to the original sounds has to be kept in order for the piece to be considered as soundscape. (Westerkamp, 1999)

Overview of sound synthesis

There are number of methods that can be used when synthesizing sounds in digital domain. I am going to focus on general aspect of sound synthesis and describe granular synthesis in a bigger detail due to the area of interest of this work.

Sound synthesis is one of the key elements in contemporary music, especially in the ambient genre that puts focus on long evolving textures that are hard or impossible to create using only acoustic instruments. Thanks to the computers we are able to create and modify waveforms in the digital domain and translate them to physical impulses with digital-audio converters and speakers. There is variety of methods available to create sounds digitally. Sample playback or wavetable description of single wave cycles are most simple ways to produce signals in most cases wave shapes like a sine, square, triangle or saw are used as building blocks. In more complex models signals can modify each other like in a frequency modulation or an amplitude modulation where one wave modifies a frequency or amplitude of a second one. Signals can be added together to create more reach and complex sounds (Collins, 2010). The common synthesis scenario in addition to creation of bare signal also applies the use of filters or ADSR ramps. ADSR helps shaping a sound and it can give it for a feeling of “growth” when long attach is used, sustain parameter when set to the maximum makes the sound play endlessly and high amount of decay can make sound gradually dissolve into silence. The filtering capabilities of synthesizers are also essential in creating unique and interesting tones, while it is beyond the scope of this work to explore the theory behind different type of filters it is still worth mentioning that they are an important factor when one wants to emphasize or mute certain frequencies of desired sound. When it comes to ambient music it is often observed that synthesizers used for that music usually have a high sustain and a high release parameter values which make sounds last long and gradually fade out, that is supposed to make them less striking for the listener. Low-pass and band-pass filters also can be helpful to make a sound closer to ambient music. Complex synthesizers allow applying multiple routing in the synthesizer circuit which means that ADSR ramps can be added not only to the output's amplitude but they can also be applied to other parameters like filters or built in effects which can produce more motion in the sound.

In the next paragraph I explain concepts behind granular synthesis. It is interesting to see how well this method is going to be useful when creating ambient like background textures, I describe this method and its sound results in chapter 3 of this work.

Sound grains and granular synthesis

With the development of the acoustics is has been observed that the sound can be described as a wave traveling through the air. After further research different ways of measuring and transcribing sound appeared. There are many approaches to present a sound in visual form; it can be represented in the time domain, for example the change of the amplitude over the chosen amount of time units (milliseconds, seconds, minutes, etc).

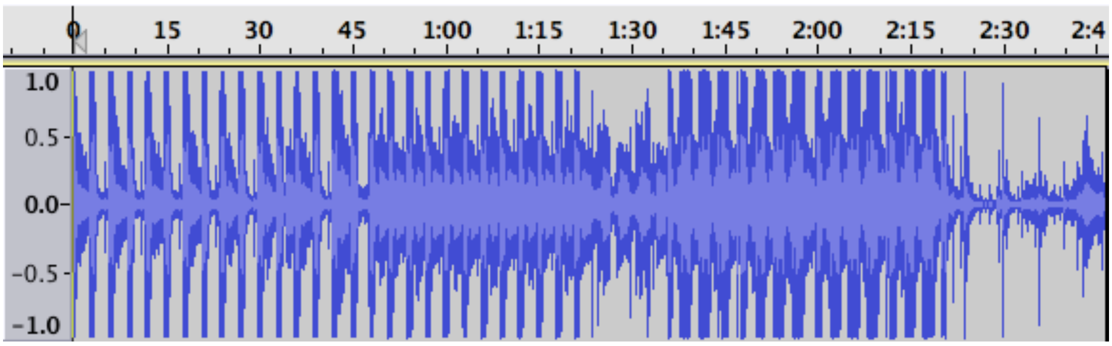

Figure 7 - visual representation of a waveform (x-axis - time, y-axis - amplitude)

Another method is to present sound wave's properties in a single basic time unit. That way one axis of the graph previously used by time scale can be used for something else, like frequency:

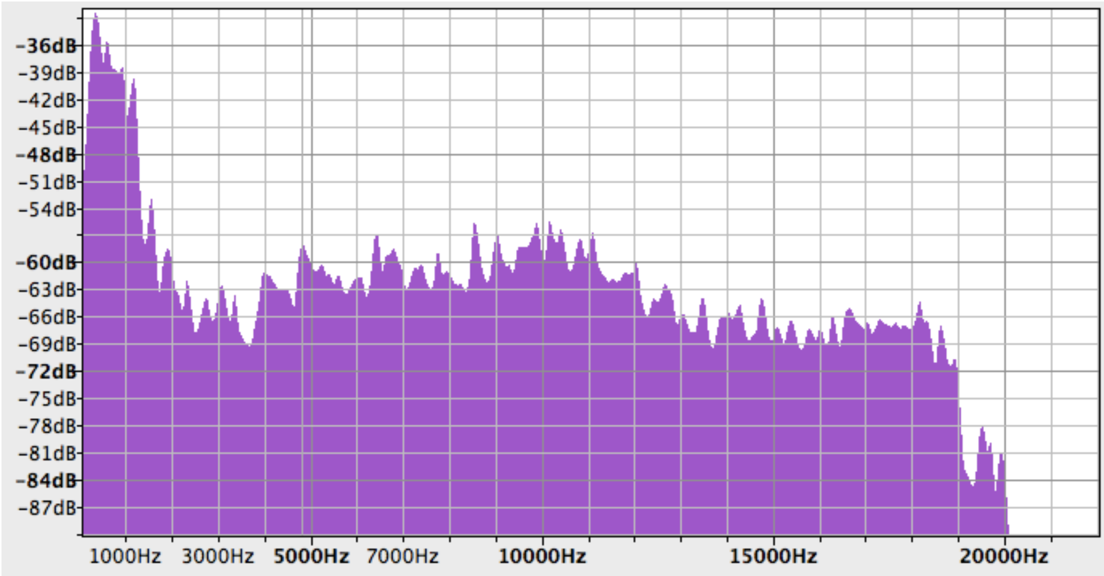

Figure 8 - visual representation of a waveform (x-axis - frequency, y-axis - amplitude)

Those two graphs represent two views on the same problem of representing sound wave in the visual form and can be described as complementary to each other because each of the basic time units in graph one can be represented it the way it is shown in graph two.

Those two examples are also interesting because they represent two ways of looking at the same problem. From the macro scale like amplitude of the whole musical piece to micro scale which is a representation of single time unit that the whole musical piece is built from. Between those extremes there is a wide spectrum of divisions we can apply to the music. For example whole piece can be divided into stylistic parts like chorus or verse, these can be broken down to motives or phrases, that are built from notes representing rhythms and harmonies that can be divided in the sets of pitches on different frequencies. This example shows that we can look at the sound on a timescale of our choice. It is also important to ask if we can go infinitely deep dividing a timescale or is there any elemental particle that is a fundament of any sound.

According to Dennis Gabor the sound can be broken down to the elemental particles described as grains. His work in this field is very significant because he took an attempt to merge frequency and time scale in sound. In other words he combined two examples of sound representation mentioned earlier into single meaningful graph (Roads, 2001).

His approach can be observed in a graph called a spectrogram that on one axis represents a time scale and on the second axis shows frequency. The amount of grains and their density represent the change of frequencies over time.

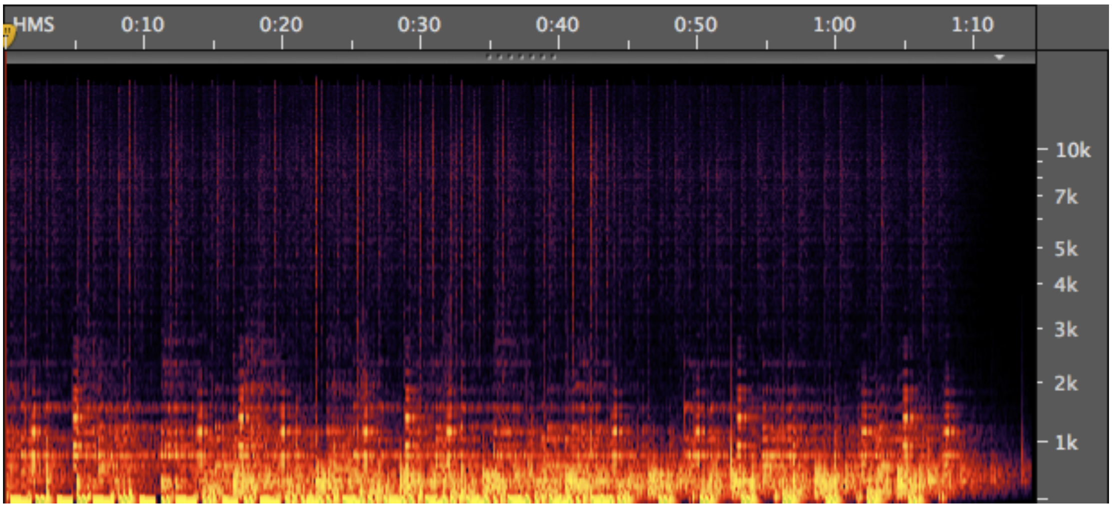

Figure 9 - waveform's spectrogram (x-axis - time, y-axis - frequency)

Gabor was also working on other sound related projects; one of his inventions was a machine that allowed to time manipulate a sound without changing its pitch using analog techniques. He constructed a mechanism that contained of a magnetic tape and a head both spinning with different speeds. When the head was spinning faster than tape it would sample tape's sound in the way that parts of sonic material would be duplicated and overlapped. That would create an effect perceived by listener as a time stretch (Roads, 2001).

Techniques used by Gabor and his discoveries in the sound elemental particles allowed further research in sound manipulation on the micro scale. It opened a door for a new ways of synthesis, especially granular synthesis.

Another important person in the world of micro sounds is Iannis Xenakis, who claims to be inventor of granular synthesis techniques. During 1950s' he experimented by working with tapes and splitting sounds into fragments that he also called “grains”. The difference between Xenakis and Gabor is that Gabor’s grains are elemental sound particles holding single frequency and single amplitude in a single time frame. Xenakis would use grains more as short sound fragments that could change frequency or amplitude over time, he would combine them in order to create clouds or swarms resulting in complex sound textures (Roads, 2001).

Another composer interested in a micro time scale during the 1950’s was Karlheinz Stockhausen, who took an attempt to compose a musical piece with signals like sine waves, impulses or noises. He also researched a connection between rhythm and the pitch. He clamed that when one increases the rhythm’s tempo to the particular level the rhythmic pattern becomes a continuous structure where one cannot hear the rhythm anymore. That resulted in the statement from his ‘. . . How time passes . . . . ‘ essay where he states that pitch and rhythm are part of the same phenomenon.

Post Second World War mathematical findings by Dennis Gabor let the world look closer at the fabric of sound. Discovery that the sonic structures can be built from elemental particles containing a frequency and an amplitude in a single timeframe inspired changes in the way we perceive music. Many composers instead of using classical music notation approach started to compose sounds on the micro time scale by using tone generators or sound grains they would combine into clouds of elemental sounds forming sonic textures that have never been heard before. This also led to a discovery of granular synthesis techniques that through the time were mastered and later applied in the digital domain. With the current technology it is possible to transform music by altering its elemental structure, getting a chance to look on sound from novel approaches (Roads, 2001).

Time stretch software

After describing theoretical background behind granular approach to the sound I think it is important to mention software based solutions making use of such an approach. With the development of personal computers and the Internet many users got a chance to develop sound applications and make them available worldwide. One of the most remarkable software in the context of this work is “Paul's Extreme Sound Stretch” software.[9]

This piece of software allows user to manipulate the length of audio files. Its implementation is very impressive because it can slow down the sound from couple of times, so the 4 minutes tunes can last for about an hour or it can stretch it in a really extreme way changing its length up to couple of literately trillion years. Five different built-in algorithms can achieve this, user is also allowed to “freeze” particular playback window and let it play endlessly.

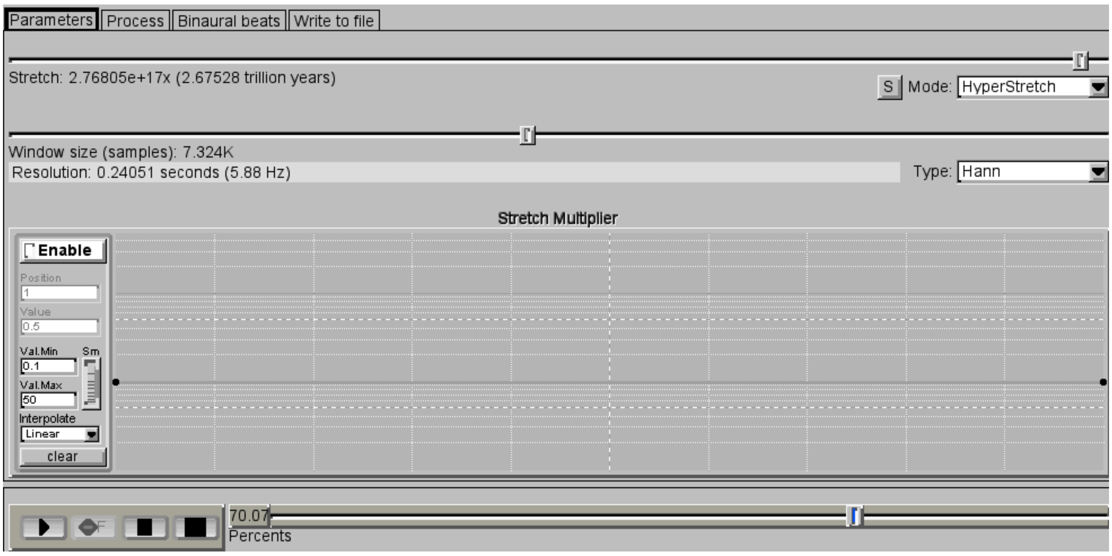

Figure 10 - Paul’s Extreme Sound Stretch interface

Besides the time manipulation abilities the software has also some built in tools like a band-pass filter, pitch shifter, frequency shifter, compressor etc.

This software is broadly used to manipulate songs that already exist, the results are available to listen to on video hosting website youtube, where we can hear transformations of wide variety of songs from film soundtracks to pop songs.

It is worth mentioning that time stretching algorithms are essential part of contemporary DAWs (Digital Audio Workstations) like Apple Logic, Steinberg Cubase or Ableton Live. Samples in the loop based music in most cases have to be

[9] http://hypermammut.sourceforge.net/paulstretch/

in sync in order to produce a coherent musical structure, that is why it is important to have an ability to freely manipulate the length of the sound files in order to match their tempo with the overall tempo of the track. For example Ableton Live besides algorithms responsible for warping drum beats or tonal structures has an algorithm called texture, where user can specify the length of the sound grains used for time manipulation.

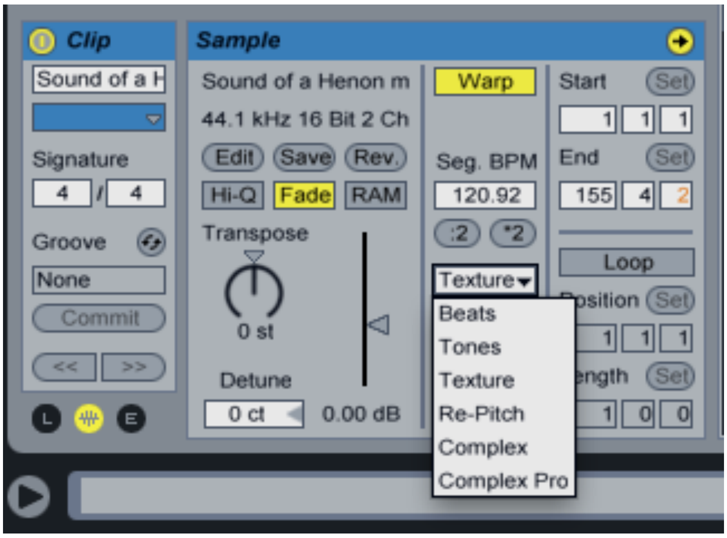

Figure 11 - Ableton's time stretch algorithms menu

Alvin Lucier's sound transformation

One of the most significant examples of works and compositions influenced by electroacoustic music and its means is piece called "I'm sitting in a room" by an American composer Alvin Lucier. His approach resembled some of the techniques common for experimental compositions at that time. Lucier used his voice, a tape recorder and a room as a source of reverberation. In his peace he read a text aloud and record it on the tape. Then he played back the recording and record it once again with the reverberation of a room we was located in. The acoustic properties of a space changed some of the frequencies of the sound. With each repetition of this process the sound changed more and more to finally melt into a sonic texture.

This experiment is very interesting because of a fact that Lucier used a physical room as an effect processor instead of traditional reverberation circuit. It is also significant to mention that only transforming a prerecorded sound created the composition. Lucier proved that transformation of sound has such a big potential that it can be used not only to add new acoustic properties to the original source but also it is efficient enough to build whole pieces (Burns, 2002).

Sound object and formalization describing sound perceptually

The twentieth century, especially post second world war period, completely changed the notion of music. Not only it brought novel approaches applied to the theory and composition of classical music, it also introduced new ways of performing and creating the sound itself. With the development of electric and mechanical devices recording and manipulation of sound became possible. One of the first people who discovered hidden potential in those machines was Pierre Schaeffer, an engineer hired by the French national radio. Due to his technical background and passion towards music Schaffer started using studio equipment to experiment with sound. He produced radio broadcasts where he used his novel ideas to create sound effects, which in next years resulted in composition of music later called "Musique concrete" (*concrete music*). The palette of his tools contained single groove gramophone sound fragments that allowed endless looping; sound recorded on magnetic tapes that were transformed by changing their speed of playback, reversing etc. Additionally this new music was enhanced with effects, edited field recordings or electrically generated tones (Dack, 1994).

Electroacoustic music, like Musique concrete, redefined the theory of the sound perception. Pierre Schaeffer not only was a composer but also a philosopher. He formulated his thoughts influenced by Edmund Husserl's phenomenology. Schaeffer described the new perception of sound. The natural human experience connects the source of the sound with the possible emitter like: splash with water, the noise of the engine with the car etc. With the development of the audio devices it became possible to separate sounds from their natural emitters by storing them initially on gramophone discs. Even though the splash of water would be played back with the gramophone it is natural for a human to still connect it to a waterfall or a river. Electroacoustic music goes one step further and blurs the notion of natural sound emitters associated by human mind, because of the use of transformation techniques mentioned before. A sound separated from its original source is described, by Pierre Schaeffer, as a sound object. An activity of listening to the sounds without seeing their cause is called an "acousmatic listening". This idea is closely connected with a "reduced listening". This concept, also developed by Schaeffer, describes the way of listening where a listener should focus on sounds themselves without considering their origin or cause. Reduced listening seams as an accurate way of describing ambient music experience, mainly because ambient is mostly a digital form of music that puts much focus on a sound texture. Since the electroacoustic sounds can go far beyond the range that could be described by music notation it became necessary to develop a new system that could categorize all the possible areas of sound transformation outcomes (Kane, 2007).

TARTYP - formalized way to describe sounds

Tonal music can be described in wide variety of ways using different tools like Schenkerian analysis; analysis of chords, tones, motives and many other ways. Electroacoustic sounds, due to their complex nature, require taxonomy that takes into the consideration all the possible forms that a sound could be transformed to. Having that in mind it seams most reasonable to mention Schaffer's TARTYP (*Tableau Récapitulatif de la Typologie)* taxonomic system. It was designed to describe complex concrete sound objects.

This system takes into the consideration the fact that analyzed sound objects can go beyond single tones created by conventional instruments, in fact TARTYP in theory can describe all the possible sounds. It uses two axes that represent two most important factors. The vertical axis represents the sounds' mass that can be described as pitch. On one side it indicates information about stable single pitch (*violin*), than moves towards more complex set of pitches (*chords, piano clusters*) and ends on unpredictable notion of pitch that is mostly connected with transformed or concrete sounds (Dack, 2001). On the horizontal axis the duration of the sounds is represented, the further they are form the center the longer they get. "This is either continuous (*'held sounds' to the left)* such as a sustained note on a wind or string instrument, or iterative (*'iterative sounds' to* *the right*) where the sound energy is maintained in close, repeated bursts (*a tremolo, for example*)" (Dack, 2001). Two last columns of each side of a diagram represent the "execution" of the sound; if the sound object has an "execution" it means, "it gives the impression of the way in which it could have been created" (Dack, 2001). It is logical to assume that the more the sound is transformed and altered the more of its "execution" is being lost.

Pierre Schaeffer was definitely an influential person in the world of music and sound experiments, his works and works of artists associated with the city of Cologne like Kalheinz Stockhausen were definitely one of the most important influences for further development of electronic music as such. On the other hand Schaeffer not only invented creative ways of producing and transforming sounds. He was also a philosopher who provided a solid background for understanding and describing sounds that are beyond the notion of classical instrument based music. Thanks to the inventions such as TARTYP we are able to describe tonal and atonal sounds in order to systematize them or compare with each other. From a radio engineer Schaeffer became a visionary who's ideas, initially developed for electroacoustic music, are still up to date and are usable in the contemporary world.

Summary

After the research described in this chapter it is clear to see that the topic of sound generation using different approaches, like generative algorithms or synthesis is as broad as the term of ambient music. I defined methods that can be useful when one wants to generate music with computer or a smartphone. I also described the field of background music with the biggest emphasis on ambient. I gathered definitions of music and proposed how they can be described, I also define three most important factors that make the sound ambient: the focus on texture, the aim to create an atmosphere and being the part of a background instead of taking listeners attention. While one might say that this way of perception is too vague and it doesn't describe the sound itself, I believe that ambient should be treated as a phenomenon of a background sonic influence instead of a stiff definition holding the parameters of the sound.

In the end of a chapter I presented Pierre Schaeffer and his concept TARTYP with some examples of how it describes sound objects.

Methods for creating sound textures from waveforms

After analyzing the topic of ambient music and sound generation now I focus on finding proper tools to answer a question from the problem formulation. I describe methods for generating background sound textures from given waveforms and their application in my setup. I describe the way I created background sounds using these methods. I use those methods to create sounds used during the test phase of this project.

Application of time stretching

The first technique that seems natural to use when creating long evolving background textures out of existing waveforms is time stretching method. What makes this approach useful is definitely the fact that time stretching of the sound makes it much longer therefore the attack of all sounds gets increased which makes it closer to typical ambient sound. When the waveform gets stretched its texture gets more audible which is also one of the key elements of the ambient and background sounds. It is worth recalling the example of Jurassic Park theme slowed 1000% because it captures the idea of transforming sound into an ambient texture very well. It is a musical composition available online[10] where time stretching technique is used to transform the sound. The original movie theme played by an orchestra ends up as almost one hour coherent etheric texture that is enjoyable to listen to. One might say that it is a universal way of creating ambient textures that is applicable to any waveform. It is important to point out that the example of Jurassic Park slowed down 1000% times creates such a coherent background sound because the original source, the orchestra, mainly consists of instrumental melodies with the reduced rhythmic layer of drums or percussion. There are no snare drum hits that would interrupt long phrases of for example violins, this results in much more clear sound when stretched. The process gets much more complex if one wants to use this technique to transform more extreme types of music like metal or drum'n'bass.

[10] http://soundcloud.com/birdfeeder/jurassic-park-theme-1000-slower

Due to the high level and intensity of drums related to those genres but also the use of distortion on metal guitars or drum'n'bass leads the sound even when stretched is still reach in sharp distorted signal with highly compressed drums. Even though this type of transformation definitely creates some type of texture, its properties are very different from the ones defined by the background ambient texture.

Time stretching is a technique that is definitely useful when one wants to emphasize sound textures in transformed sounds. It works best used with waveforms containing tonal acoustic instruments that do not contain rhythm layers. Even though the results of the transformations can be very different and may or may not always work to create ambient sound it is important to see that this technique has a potential to be used at least as a part of a set of tools when transforming a sound. Therefore I use this technique to create background sounds, I think it is important so measure on which kind of samples it works best and how it works compared to other methods.

Application of reverberation

Alvin Lucier's "I'm sitting in a room" experiment was very influential for me when thinking about transformation of sound. Even though it wasn't his aim while making his recording to see if "one can create ambient sound texture from any waveform", he in fact, on purpose or not, developed an early, formalized analogue approach to transforming sounds into textures. What makes his experiment even closer to ambient like type of sounds is the use of reverberation, very popular effect amongst ambient composers. Lucier's experiment shows that the iterative use of reverb effect, in the long run, leads to the emphasis of the certain frequencies and the cancelation of others. It is questionable if his particular approach produces efficient results in the context of ambient sounds. On the other hand Lucier's experiment proves that an iterative use of sound effects with a certain settings can result in useful transformations that may result in textures that are satisfying from an ambient background sound point of view.

My method

After experimenting with previously described methods and evaluating them by my own ears I noticed that they can produce satisfying results with certain sound sources, like for example time stretching working better with orchestra like type of sounds than heavy metal. This fact made me look for my own method that would make use of two previously described approaches but on the other hand that would be more universal. My aim was to make use of each of the method's advantages to create an approach that could be applied to biggest number of sounds; would produce results that would fulfill main concepts of ambient sound outlined in the background chapter and also be satisfactory for myself as a listener.

The environment and application of methods

In this section I explain the practical application of the previously described methods. For the testing reasons I had to create or use software that would allow me to apply time stretching algorithms or add audio effects to audio samples. I decided to make use of already developed tools and combine them to reflect the guidelines mentioned in the previous paragraphs.

Method 1 – Time Stretch

When it comes to application of a time stretch it seamed most reasonable to use Paul's Extreme Sound Stretch software mainly because of its ability to expand the sound as many number of times as I wanted. It is also free to use and its source code is publicly available. This software allowed me to import any sound I wanted and try different settings. My aim was to set up the settings in a way so the structure and most characteristic part of sounds became unrecognizable, for example the attack had to be expanded, the overall length had to be long enough to emphasize sound's texture like words from a spoken word samples would loose their meaning and become layers of sounds. I decided to slow down each sample 44 times; this amount seamed enough to blur the original sound of a sample without making it extremely long. In this method I used default settings of the software, mode was set to stretch and the type was set to Hann.

Method 2 – Reverberation

When creating Method 2 my aim wasn't to recreate Alvin Lucier's experiment the way it was originally done, I used a guideline form his work and used reverberation as an effective tool to transform sounds. I fallowed Lucier's approach and also applied a reverb effect on already reverberated sound. On the other hand I didn't want to model Lucier's room physical properties in order to get the same results as he got. I used the reverberation effect to remove noisy frequencies from the sound samples in order to get an effect closer to the definition of ambient. Reverberation also made the sound's decay longer therefore I judged it as more background like than the original. In order to apply this method in the digital domain I used Ableton Live DAW software, although it could be any other audio production environment that supports the use of audio effects. I chose Ableton Live because of my experience with this application and also the fact that this software supports the use of the "send tracks" that allow putting signal in the finite and infinite loops. I used the original length of the sample without any form of time manipulation to make the second method very different from the first one.

I have created two send tracks in Ableton Live both with the Ableton's native reverb effect.

Figure 12 - reverb effect settings

In order to generate a background sound I applied hi cut feature, which is a high-pass filter, that eliminated all unwanted frequencies that during the initial setup trail and error phase made me judge the sound as less ambient like. To remove the original signal the dry/wet knob is turned 100% up. The decay time emphasizes the textural features of the sound and it was set up at a level of 2.89s. The second reverberation with the same settings was applied to the second send bus channel. Afterwards I created finite feedback loop between each of sends and inside each of them. The original sound sample was initially routed through 100% wet reverb effect to completely remove the original properties of the sound and make its properties more ambient like.

Figure 13 - screenshot of reverberation matrix

Method 3 – My approach

As described before my aim was to create a solution that would combine what I found most useful in the two methods described before. I decided to stretch the samples I was working with and apply some of the filtering for the best results. For the biggest flexibility once again I used Ableton Live, in this approach I use much more effects than in the "reverberation method". I started with decreasing the project tempo to the lowest possible number 20BPM (beats per minute), afterwards I applied "texture" time stretching algorithm with the grain size of 25ms and expanded each of the samples up to eight times. That resulted in the time stretched samples I could add effects on later during the process.

Since I am looking for a solution that can be applied to any kind of a waveform for the initial test I used complex samples time stretched of metal and rap music, the common use of compressed loud drums in such genres led me to applying an equalizer as a fist effect. My aim was to remove high frequencies mostly connected with percussion cymbals in order to make the sound more homogeneous. I made the equalizer cut off the frequencies around 5.57kHz and 11.5kHz.

Figure 14 - screenshot of EQ settings

Having method 2 in my mind I decided to use also a reverb effect to add some of the decay to the samples. The decay time was set to 1.92 second and the dry/wet parameter was set to 63%. The last effect applied to this method is a resonator. It is broadly used in electronic music especially deep techno and similar genres. The effect emphasizes selected frequencies of the sound, which may result in a characteristic metallic sound. Though Ableton Live has a built in resonator effect, I choose to use Native Instruments Reaktor and a Resonatter ensemble available from the database of Reaktor's users files[11].

Figure 15 - screenshot of resonatter effect

11 http://www.native-instruments.com/index.php?id=userlibrary&L=1&type=0&ulbr=1&plview=detail&patchid=4102

The use of this effect is essential for method 3 because it adds frequencies that are perceived as a harmonized sound; therefore I got a feeling that the sound gets more musical and more ambient like.

I used properties of ambient music outlined in the background chapter as a guideline to judge the results of the methods I evaluated. I also followed my experience with listening to ambient music and personal taste to tweak each of the parameters of the sound. When running initial internal tests I used many different sound types: classical music, drum'n'bass, metal, rap, sine, square, triangle wave, etc. The parameters of each of methods were tweaked and changed to be most useful for a variety of sounds. The methods designed in this chapter should be verified and judged with test evaluation in order to see which one works best with different sound inputs.

Testing

I define three methods, suitable in my opinion, for creating ambient background textures from a given waveform. I evaluate them using the definition of ambient sound, described in the background chapter, and my own judgment. To evaluate my own research it seams logical to prepare a testing session where my ideas are going to be confronted with common listening sense of participants. Therefore I propose a test where listeners are judging sounds created with proposed methods.

Pretest setup

In the initial phase of testing scenario I decided to create a survey that would indicate if my assumptions are correct. In case the results would indicate that the created samples do not fit the definition of background sound I would have a chance to verify my methods before running the final test.

Using Pierre Schaeffer's TARTYP guideline I chose three sounds representing different sound description values. I chose:

- sample from a metal song "Siberian Kiss" by a band called Glassjaw (Glassjaw, 2007) containing guitar distortion, loud drums and screams
- saw wave
- a guitar pluck sound

I applied three methods to each of the sounds, getting nine transformations in the end. In order to measure the results I created a scale from 1 to 5 that would indicate how well does each of the sounds represent the ambient background texture (1 – meaning not background at all; 5 – meaning very background ambient sound). I created questionnaires where initially I ask if a participant knows what the concept of the background sound is, next he's asked to rate 9 sounds. I managed to run a pretest with 20 participants.

The test was run in the Medialogy department of Aalborg University Copenhagen and contained mostly of Medialogy students and people related with the education. I created simple HTML document containing sound samples in the wav format. The test was run on the laptop with headphones connected. Each participant was asked if he or she was familiar with the concept of background music, if the answer was negative I gave the participant a brief overview of the topic. Next the participant got a questionnaire and was supposed to sit in front of the computer and put on the headphones. The participants had no time limits when doing the test and could navigate freely through all of the sounds, they could also listen to them as many times as it was necessary in their opinion (see Appendix – pre-test questionnaire, see attached CD - questionnaire document).

Pretest results

In this section I present the analysis of the results collected from the pretest survey. (For the full listing of participants and their answers see Appendix – pre-test results table).

Table 1 presents the names of sounds used in the questionnaire in the order they were presented to the participants; the fields describe source files and the methods used to transform the samples (see attached CD - pre-test sound samples).

Sound Name	Source Name	Method Name
Sound 1	Glassjaw	time stretch
Sound 2	Glassjaw	reverberation
Sound 3	Glassjaw	my method
Sound 4	Guitar pluck	time stretch
Sound 5	Guitar pluck	reverberation
Sound 6	Guitar pluck	my method
Sound 7	Saw wave	time stretch
Sound 8	Saw wave	reverberation
Sound 9	Saw wave	my method

Table 1 - order of the sounds used in the pretest

Since the answers of participants contained rating on scale 1 to 5 it seams most reasonable to present them as an average score with additional information about standard deviation to indicate the possible spread of most extreme scores.

Figure 16 shows the most important, in my opinion, result: the average score of each method. It is clear to see that "reverberation" and "my method" have similar scores much higher then than "time stretch" based one. It may be argued which one got higher rating because "my method" has lower standard deviation value, meaning that answers of the participants had smaller spread, indicating that they were a little more constant than in the "reverberation method".

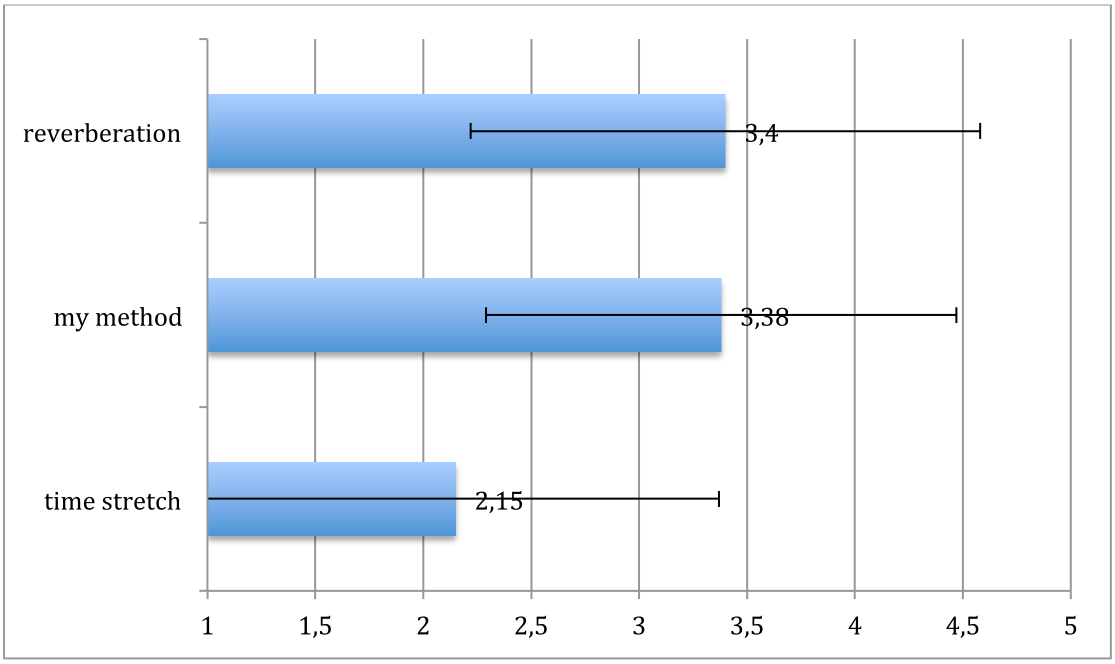

Figure 16 - average of method in the pretest group

It is also important to see what scores did each of the sound get separately. Figure 17 represents numeric values of average rating of the sounds, with information about the source file and the method used for transformation. It is clear to see that the "time stretch method" is occupying last positions of the chart. One might notice that that the same source file "Saw wave" ended up on the first and the last place depending on the method used for transforming the sound, that might indicate that the method used to transform a sound has much higher influence on the average score than the sound source.

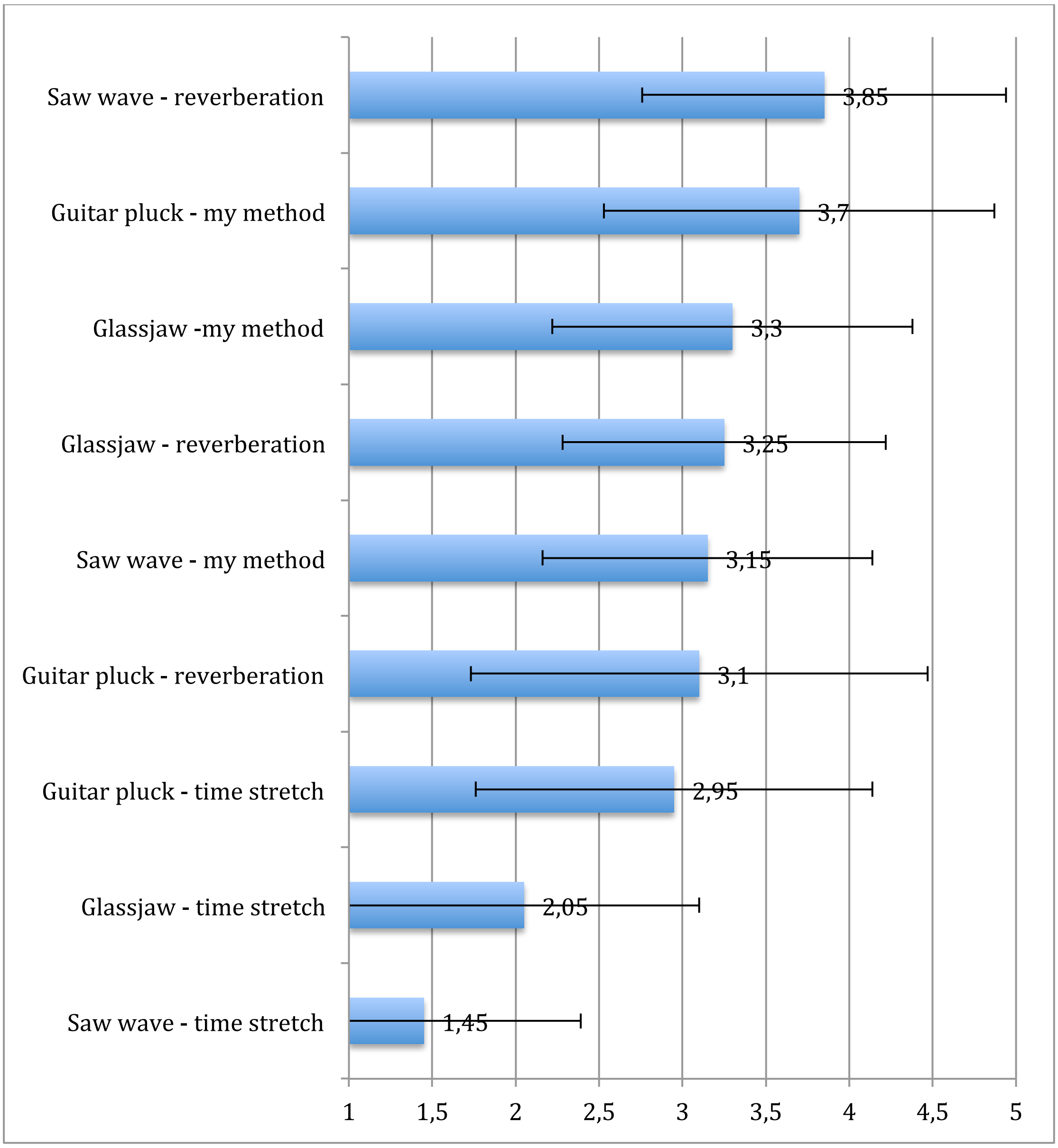

Figure 17 - average of sounds in the pretest group

The result of the pretest shows that "time stretch method", considering the spread of the last two answers getting to the rating of 1, in some cases may not be considered as ones producing background sound textures. However "Guitar pluck" sample was rated on average 2,95 with standard deviation value of 1,19 meaning that there are some sounds that could be transformed into background texture with this method. The results also show that "reverberation" and "my method" were rated above 3 on average that could be considered as a partly successful while every rating above 1 indicates a certain extent of success in creating background sound texture. I decided to keep all the methods for the final test, to verify my assumptions, “time stretch” is also an important part of “my method” and it seams important so see how it is going to be rated separately and also as a part of a more complex approach.

Test setup

The participants of the pretest were mostly people connected with new media and technology, therefore they may have different understanding of ambient background sounds that a common listener. In order to reach more people from different areas than only Medialogy department I developed an online survey. It contained HTML form element and a PHP script that saved results directly into the .csv file. The java script based validation mechanism guaranteed that only submissions with all answers were accepted, the user could only submit the answers once within the browser session. For the cross browser sound listening experience I used Flash based audio element niftyplayer[12] because of its simplicity and the fact that it is free and open source.

The survey started with the title and a short description of the problem area: “Ambient background texture can be described as a sonic wallpaper. It's supposed to provide a listener a sound background experience for the environment he's in.” Next I instructed the user about the fact that he or she is supposed to rate the sounds on given scale. “On scale 1-5 please rate how well, you think, each of the sounds represent ambient background textures: (**1- the least**; **5 –the most**)” (see Appendix – test survey questionnaire).

For the better statistical analysis of the test results I used 2 sounds representing 5 different category types: sine wave, bowed string, environmental sound, speech and singing. Each of the sounds was transformed using three methods described previously, in the end giving thirty sound samples lasting ten seconds each. The user had full control over the order of the sounds, the number of repetitions and the volume they were played back.

12 http://www.varal.org/media/niftyplayer/

The links to the survey were posted on music related online forums and were also sent out using facebook[13]. This way it was more likely to gather participants representing different backgrounds and different experience with music.

Table 2 shows the order of the sounds in the survey and the information about the method used to transform it (see attached CD - test sound samples).

13 http://www.facebook.com

Name	Source Name	Method Name
Sound 1	Cello 1	time stretch
Sound 2	Cello 1	reverberation
Sound 3	Cello 1	my method
Sound 4	Cello 2	time stretch
Sound 5	Cello 2	reverberation
Sound 6	Cello 2	my method
Sound 7	Environmental break	time stretch
Sound 8	Environmental break	reverberation
Sound 9	Environmental break	my method
Sound 10	Environmental water	time stretch
Sound 11	Environmental water	reverberation
Sound 12	Environmental water	my method
Sound 13	Galas 1	time stretch
Sound 14	Galas 1	reverberation
Sound 15	Galas 1	my method
Sound 16	Galas 2	time stretch
Sound 17	Galas 2	reverberation
Sound 18	Galas 2	my method
Sound 19	Sine wave 300Hz	time stretch
Sound 20	Sine wave 300Hz	reverberation
Sound 21	Sine wave 300Hz	my method
Sound 22	Speech 1	time stretch
Sound 23	Speech 1	reverberation
Sound 24	Speech 1	my method
Sound 25	Speech 2	time stretch
Sound 26	Speech 2	reverberation
Sound 27	Speech 2	my method
Sound 28	Sine wave 3000Hz	time stretch
Sound 29	Sine wave 3000Hz	reverberation
Sound 30	Sine wave 3000Hz	my method

Table 2 - order of the sounds in the test

The source of the samples used for transformation contained of:

- Cello 1 – bowed cello playing two notes after each other repeatedly
- Cello 2 – bowed cello playing single note continuously
- Environmental break – field recording of bending and breaking and organic material and breaking glass
- Environmental water – field recording of bubbling water
- Galas 1 – sample from Diamanda Galás' performance – singing and vibrato
- Galas 2 - sample from Diamanda Galás' performance – staccato scatting
- Sine wave 300Hz – stable 300Hz sine wave sample
- Speech 1 – recoding of a voice saying "No" repetitively
- Speech 2 – voice sample from Ernest Hemmingway's "Old man and the see" audiobook
- Sine wave 3000Hz – stable 3000Hz sine wave sample

Test results

The test result contains of answers of **62** participants submitted worldwide.

72.5% or respondents answered that they have heard about the concept of ambient background music before.

Due to a couple of answers consisting of mainly ratings of 1 and 2, I excluded them from the results because of a suspicion they may have been biased or some of the participants didn't fill out the answers properly (see Appendix – test results part 2 for the list of excluded participants and their answers).

Figure 18 shows the average rating of each method with standard deviations:

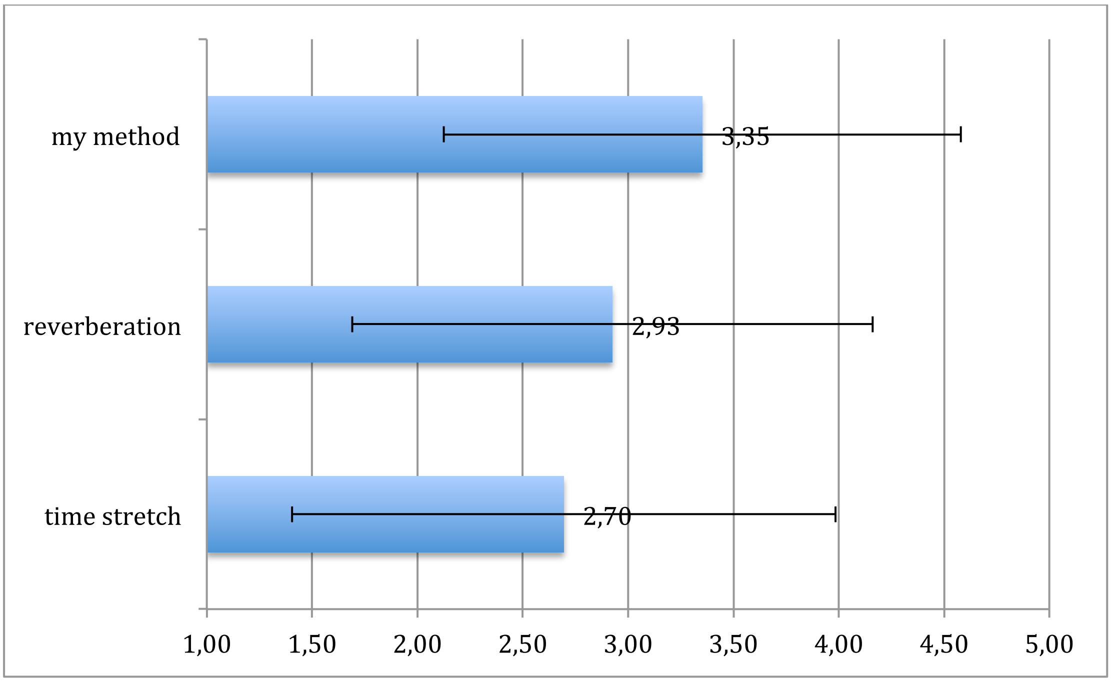

Figure 18 - average of rating of methods

When looking on the average results of methods it is clear to see that only one that exceeded the average rating of 3 is "my metod", with possible error value of 1,23. This result is similar to the one from the pretest. "Reverberation" was rated 0.7 below rating of 3, which is a lower score than one form the pretest. "Time stretch" method is got the lowest rating as previously, however during the final test this method got was rated 2,7 which is higher than during the first test. Looking on the pretest and a final test results it is reasonable to assume that "my method" can be considered as one creating most background texture like sounds.

Figure 19 shows the scores of separate sounds:

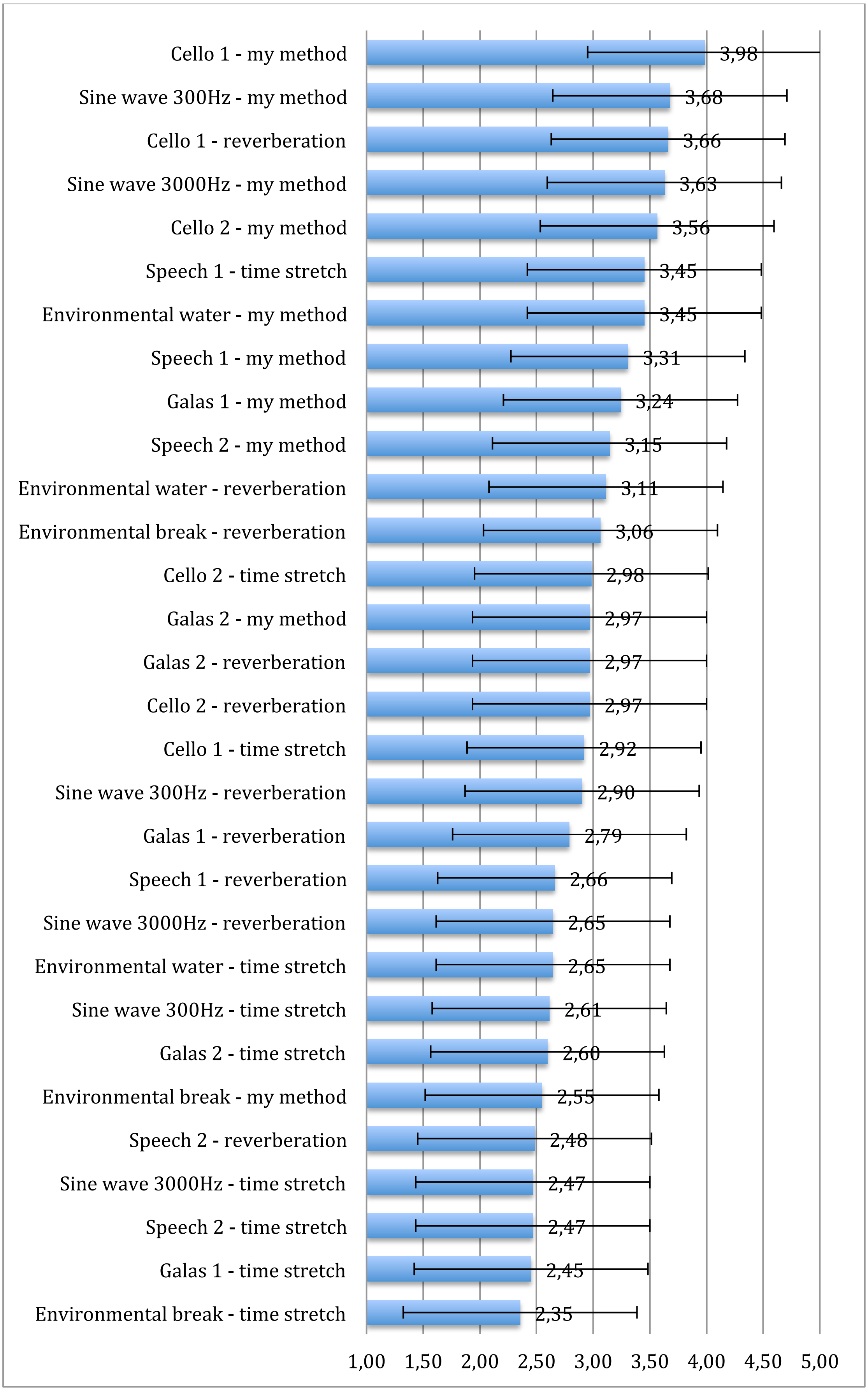

Figure 19 - average rating of each sound

It is worth emphasizing that out of ten top rated sounds, eight were created using “my method”. Twelve of sounds were rated above 3 and the one with the lowest rating got 2.35 on average. As in the pretest sounds created using “my method” and “reverberation” were rated higher than ones created using a “time stretch” technique, four of them occupy last places on the chart. In the final test “reverberation” got lower rating than in the pretest.

Does the knowledge of ambient change the rating?

When analyzing the sounds’ ratings it is interesting to see if the fact that a test subject is familiar with ambient background music does change his or her preference, therefore I divided the answers into two groups, people familiar with the concept of an ambient background sound and people who haven’t heard about it before.

Figure 20 presents the average rating of methods submitted by people who are familiar with ambient:

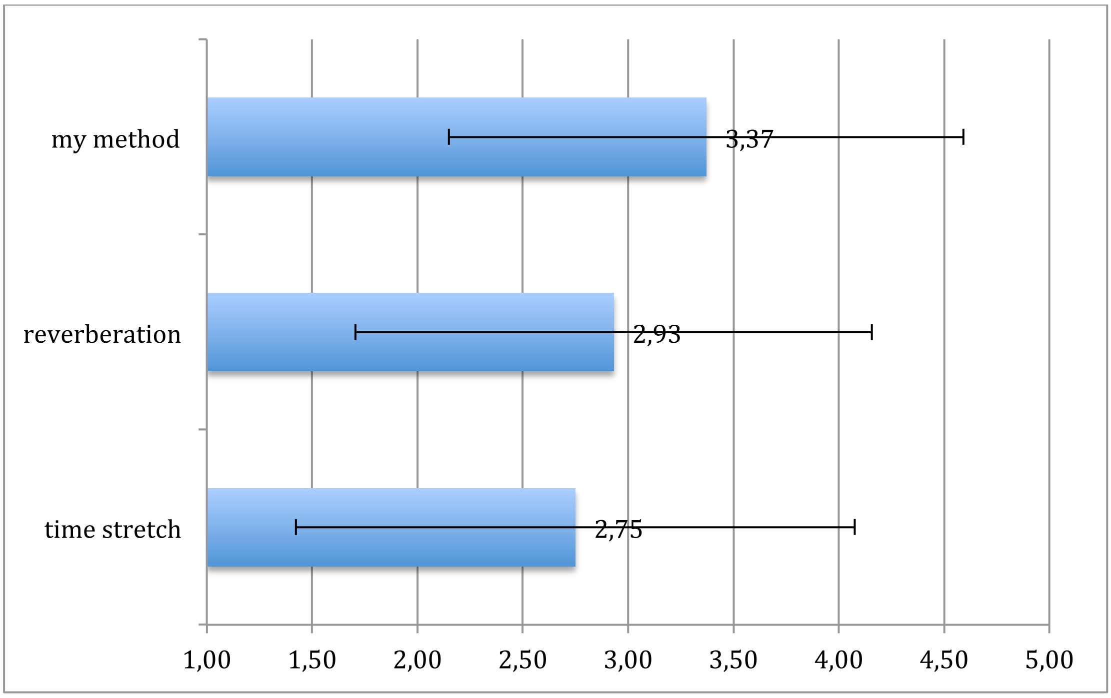

Figure 20 - average of methods amongst participants who knew what ambient is

Figure 21 presents answers from people who haven't heard about ambient music before:

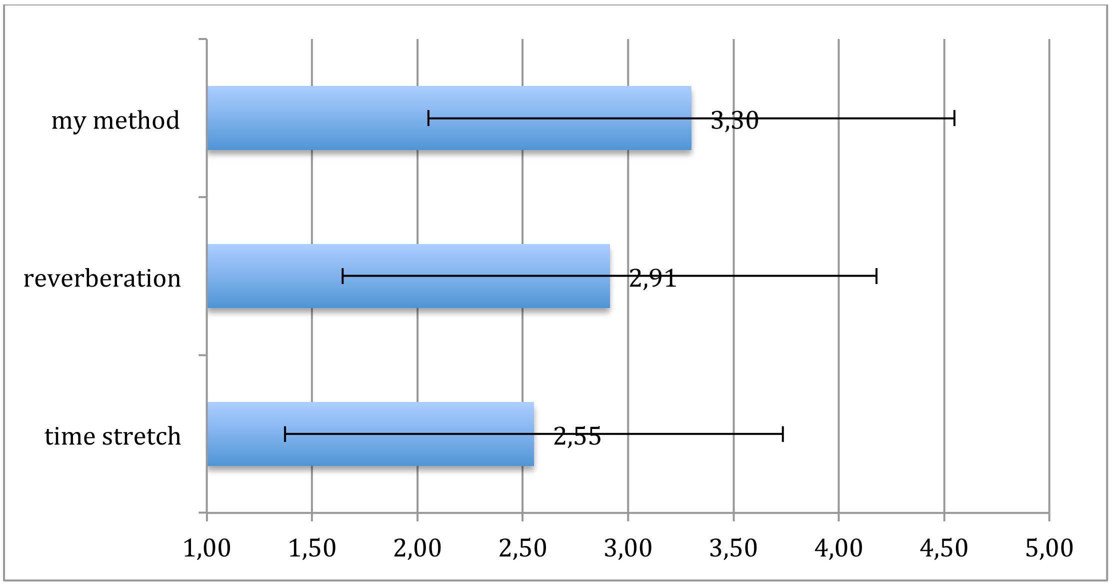

Figure 21 - average rating about people who don't know what ambient is

It is clear to see that people who know the concept of ambient background music give sounds higher ratings on average than people who did hear this kind of sound for the first time in their life. That is a reasonable observation, it seams natural that people familiar with the subject may have put some effort in researching this kind of music before. Therefore it is natural for them to be more welcome and tolerant for any kind of a background sound and that may be a reason why they rated the sounds higher. On the other hand it is worth mentioning that the biggest difference between the answers of two groups wasn't bigger than 0.2 of a point, therefore it is reasonable to think that this difference doesn't affect the answers too much. One can conclude that people familiar with ambient music tend to rate the sounds from the test only slightly higher than others.

Discussion

The test results from the previous chapter definitely indicate which method, out of three proposed, works best in the testing environment. It is important to mention that "my method" was rated evenly high as the "reverberation" in the pretest but was rated highest during the final test. On average it scored over 3 in the analysis of all answers from participants but also got highest rating from people that are and are not familiar with ambient music. The lower rating of "reverberation" and "time stretch" method may indicate that they work best only with certain type of sounds, for example samples of a Cello 1 and Cello 2 transformed with reverberation and time stretching were all rated 2.7 and above.

It may be argued that this kind of testing, when subject needs to have headphones on, requires more control than an online survey can give. One of the reasons to think about it this way is the fact that there is no way to check if the participant really uses the headphones or for example laptop speakers. In the worse case scenario someone might just click on some random answers and twist results a lot. Since the survey was sent out using the facebook website the surveys were addressed to the trusted people, the link was also posted on some music related online forums, that would mean that people following the link to the survey would be interested in music therefore I assume that the risk of the abuse of the survey is quite minimal.

The second possible weakness of this kind of rating of sounds is that possibly some of the users may have confused the rating of how much they thought something was related to ambient music and they would judge sounds based on their musical preference. I clearly defined the objective of the survey by asking: "On scale 1-5 please rate how well, you think, each of the sounds represent ambient background textures: (1- the least; 5 –the most)". It would be interesting to see how much personal preference of the participant affects the rating of how ambient the sound is, but if the test subject does it unconsciously there is nothing that can be done about that. One of the solutions to see how much the personal preference affects the judgment of a sound could be adding additional question to each sound. I could possibly ask: on scale 1 – 5 please rate how much you personally like the sound. Afterwards I could measure the relationship between the personal taste and the judgment of background texture. It this context is seams also important to ask users if they like ambient music. One can also argue that the feeling of a background sound is connected with personal preferences because, if somebody finds the sound annoying or disturbing it instantly becomes a foreground instead of background and occupies one's attention. Despite the proposed way of measuring the connection between the preference and the judgment of background sound it may have been helpful to add an information like: "please remember that the question how well the sounds represent background textures does not mean how much you like the sound".

The results presented in the previous chapter clearly show that majority of participants rated "my method" the highest, that indicates that out of three presented methods this one produces results that are closest to the ambient background textures. Is this method suitable for all sounds? The survey results show that almost all sound were rated 3 or higher except for a sound called "Environmental break" getting a rating of 2.55, whereas the same sound transformed with "reverberation" method scored 3.06. Another example is a sample "Speech 1" where "time stretch" method was rated higher than other methods applied to this sound. That may indicate that with current setup it may be sometimes necessary to adjust a method to the sound in order to create the most background like textures. It is questionable if a result of an average rating of a single method is enough to state that this method could be applied to all sounds, the last examples show that there may be some exceptions to the rule.

Conclusion & future work

In this section I answer the problem question formulated in the Introduction: "Can one create ambient background sound texture from any waveform?" I also sum up the results of my research and talk about future perspectives related with the project.

The test and discussion chapters provide a methodology and results of my research on creating ambient background textures. Basing on the results of the test I show that out of three proposed methods the participants rated "my method" the highest. This method was created by the means of the previous two ones and is supposed to address the biggest number of sound files.

The fact that one of the methods was chosen to be better than others doesn't mean it produces satisfactory results a priori. In order to see if it does so, I need to answer the question how high the method should have been rated to suspect it is successful. When one thinks about the scale of the rating values given by the user: 1 – not ambient at all; 5- very ambient like, every answer above 1 seems as partly successful, meaning better than rating "not ambient at all". The result of "my method", scoring more than 3 on the average may lead to the conclusion that the method is showing a tendency to become successful after additional adjustments. This also shows that "my method" still has some areas where it may be considered as unsuccessful and that needs further testing.

Therefore I answer that my research shows that using the method I propose one can partly turn most of given waveforms from the test setup to the ambient background textures. The majority of sounds created with this method were rated above 3 on scale 1 -5 during the test I conducted; therefore I state they partly meet the success criteria of becoming an ambient sound texture. I think that the total success criteria for the sound to become an ambient background texture would be a rating of 5 on an average on scale I prose. Even though my method was not rated 5 on average it clearly shows a tendency to be rated 3 and above.

As the future work if seams logical to define what sounds got the lowest ratings, define their properties and tweak the parameters used for transforming them into a background texture. It is also possible to include additional effects that would possibly make the method more applicable to wide variety of sounds, so they would get higher average ratings. It is also important to notice that test was run using the samples that were only 10 seconds long, which meant that the participants put more focus on the perception of the texture rather than letting the sound float as the background of the space they were located. Therefore I think that it is worth conducting one more test in the future. It is going to be meaningful to create a music piece, an EP or an album using the methods described in the previous chapters. It will be interesting to give an album to test participants and run a qualitative test, where they would state their opinions about how the sound affected them in the longer perspective.

From the technical point of view it also seams natural to create a tool for transforming audio samples to ambient textures that could be run inside music production environment or as a standalone application, for this reason it would make much sense to package the chain of effects I used in Ableton Live into a Native Instruments Reaktor ensable. This software lets the users run sound patches they way they want, it gives the creator the possibility to add knobs, sliders and other control parameters if it is necessary and the runtime is free to download. During the pretest and test period of the project I got a number of positive feedback and interest about how the sounds were done, that is why I think that there is going to be an interest in a tool for transforming waveforms developed as, for example, an ensable for Native Instruments Reaktor.

I may not state that there I propose a unified method of transforming any given waveform into an ambient background texture that would meet total success criteria, but I can clearly state that combination of time stretching and filtering gives results rated higher on average than application of time stretch or reverberation separately. My research shows also that in some cases those separate methods mentioned before actually work better than their combination.

Even though the methods I proposed in this project did only partly succeed in creating ambient background sound textures from a given waveform; I think I researched an interesting field of alternative generation of sound. My work shows that there is a potential in the, at least, one method outlined in this thesis. I my opinion sound textures that were created during this project can be used in many interesting ways and create sonic backgrounds not only for the listening pleasure but also for movies or computer games.

It was my pleasure to work and build on top of great concept of ambient music developed by Brian Eno.

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Appendix

Appendix contains the questionnaires and full test results

Pre-test questionnaire

Are you familiar with the concept of ambient music? (YES/NO) ___________

On scale 1-5 please rate how well, you think, the sounds represent ambient background textures: (1- the least; 5 –the most)

Sound 1: _________

Sound 2: _________

Sound 3: _________

Sound 4: _________

Sound5: _________

Sound6: _________

Sound7: _________

Sound8: _________

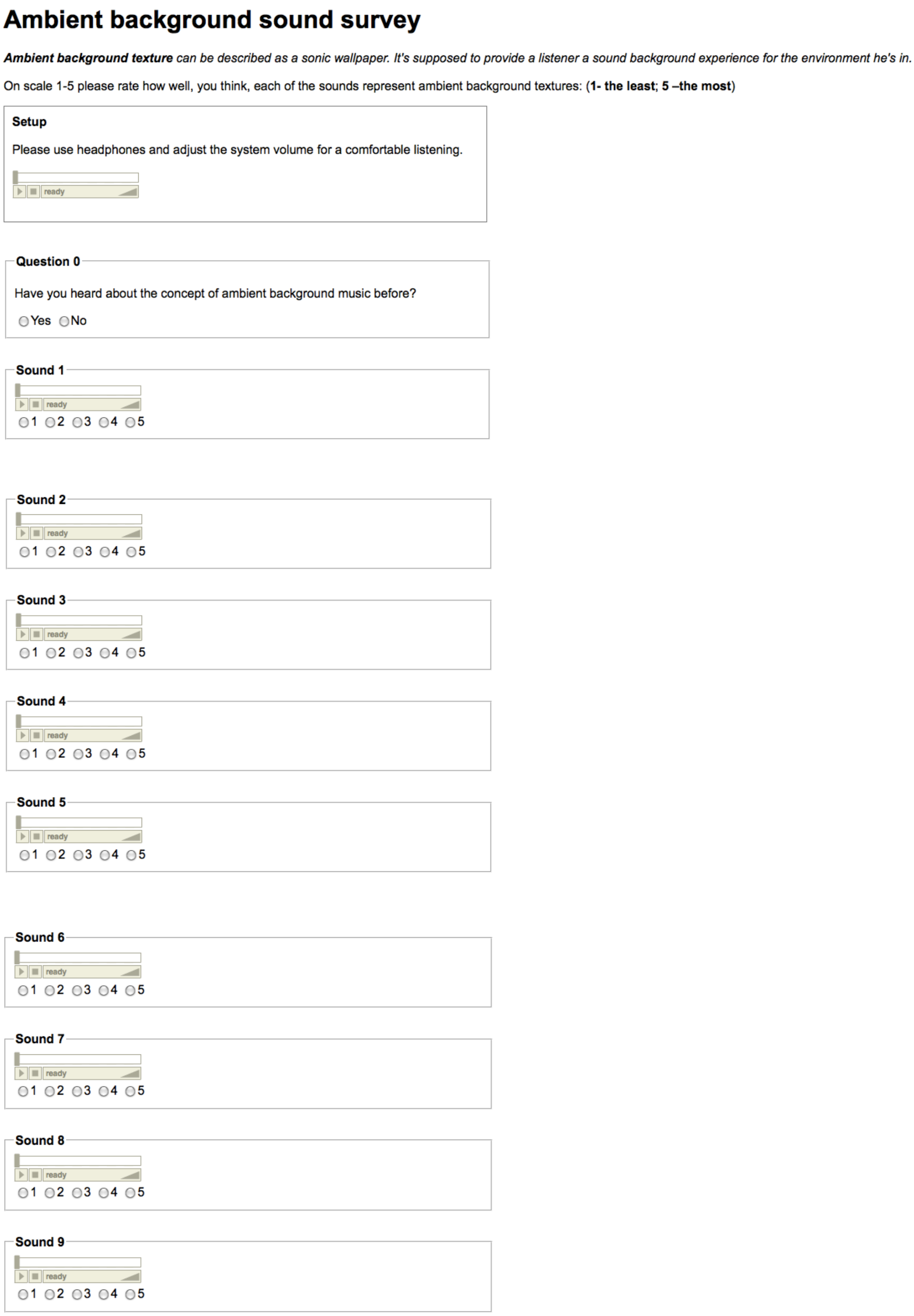
Sound9: _________

Pre-test results table

		time stretch			reverberation			my method		
	Answer1	s1	s4	s7	s2	s5	s8	s3	s6	s9
Participant 1	yes	2	4	1	2	4	4	3	5	4
Participant 2	yes	1	4	1	3	2	3	3	3	2
Participant 3	yes	3	2	1	4	2	4	5	3	3
Participant 4	yes	4	2	1	3	1	2	5	3	3
Participant 5	yes	2	4	1	2	3	3	4	5	4
Participant 6	yes	4	3	1	2	4	5	2	3	3
Participant 7	yes	1	2	1	4	1	3	4	4	4
Participant 8	yes	1	2	3	3	3	4	2	4	3
Participant 9	yes	2	4	3	5	5	5	4	5	4
Participant 10	yes	1	3	1	2	4	2	2	3	2
Participant 11	no	1	2	1	3	1	3	2	2	2
Participant 12	yes	1	4	1	2	3	2	2	2	2
Participant 13	yes	2	3	1	4	5	5	4	4	3
Participant 14	yes	3	2	1	4	3	4	2	2	2
Participant 15	yes	2	1	3	4	3	4	3	5	5
Participant 16	yes	2	3	1	3	4	5	3	4	4
Participant 17	yes	2	1	1	3	2	4	4	5	3
Participant 18	yes	1	5	1	3	5	5	4	5	2
Participant 19	yes	4	5	4	5	5	5	5	5	5
Participant 20	?	2	3	1	4	2	5	3	2	3
Sound avarage		**2,05**	**2,95**	**1,45**	**3,25**	**3,10**	**3,85**	**3,30**	**3,70**	**3,15**
Standard deviation		1,05	1,19	0,94	0,97	1,37	1,09	1,08	1,17	0,99
Method avarage		**2,15**			**3,40**			**3,38**		
Methode deviation		1,22			1,18			1,09		

Test survey questionnaire

Image presents the screenshot of an online test survey (9 out of 30 questions)



Ambient background sound survey

Ambient background texture *can be described as a sonic wallpaper. It's supposed to provide a listener a sound background experience for the environment he's in.*

On scale 1-5 please rate how well, you think, each of the sounds represent ambient background textures: (**1- the least**; **5 –the most**)

Setup

Please use headphones and adjust the system volume for a comfortable listening.

ready

Question 0

Have you heard about the concept of ambient background music before?

○Yes ○No

Sound 1

ready

○1 ○2 ○3 ○4 ○5

Sound 2

ready

○1 ○2 ○3 ○4 ○5

Sound 3

ready

○1 ○2 ○3 ○4 ○5

Sound 4

ready

○1 ○2 ○3 ○4 ○5

Sound 5

ready

○1 ○2 ○3 ○4 ○5

Sound 6

ready

○1 ○2 ○3 ○4 ○5

Sound 7

ready

○1 ○2 ○3 ○4 ○5

Sound 8

ready

○1 ○2 ○3 ○4 ○5

Sound 9

ready

○1 ○2 ○3 ○4 ○5

Test results table

		time stretch										reverberation										my method									
	Answer1	s1	s4	s7	s10	s13	s16	s19	s22	s25	s28	s2	s5	s8	s11	s14	s17	s20	s23	s26	s29	s3	s6	s9	s12	s15	s18	s21	s24	s27	s30
Participant 1	yes	3	4	2	1	2	1	3	3	2	2	5	5	2	2	2	2	4	3	2	4	4	4	2	3	2	2	5	3	3	4
Participant 2	no	2	3	2	3	1	4	1	4	1	1	4	3	3	2	2	4	1	4	4	1	5	3	2	2	3	2	4	5	4	5
Participant 3	no	3	3	1	2	1	2	5	4	2	2	4	4	4	3	1	3	4	3	3	1	5	4	2	4	2	3	5	5	3	1
Participant 4	yes	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Participant 5	yes	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Participant 6	yes	4	2	5	5	5	4	2	5	3	3	3	3	5	4	3	5	2	3	2	3	4	2	3	4	3	2	4	3	2	2
Participant 7	yes	3	2	3	3	2	3	3	3	4	4	4	2	3	4	3	3	5	4	4	4	5	2	3	2	3	2	3	4	5	5
Participant 8	yes	4	1	1	1	1	1	2	3	1	1	5	1	1	1	1	2	3	1	1	2	5	3	3	2	1	2	4	1	1	3
Participant 9	yes	5	5	5	4	4	1	3	3	2	2	2	2	2	2	3	1	2	2	1	4	2	2	3	2	2	2	2	2	1	5
Participant 10	yes	3	3	2	2	4	2	5	3	2	2	4	3	2	3	2	2	5	2	1	2	5	4	3	5	3	3	1	4	2	3
Participant 11	no	3	3	3	2	1	1	3	2	1	1	4	3	2	1	1	1	3	2	2	1	5	5	1	4	2	1	5	4	4	5
Participant 12	yes	3	4	5	4	4	1	2	2	2	2	3	4	2	4	3	1	2	1	1	2	4	2	2	2	2	1	4	2	3	2
Participant 13	yes	2	3	4	3	1	1	4	4	3	3	3	3	3	3	4	3	3	4	2	4	4	3	2	3	2	2	5	1	2	3
Participant 14	no	2	2	2	2	2	2	2	4	2	2	4	3	3	3	3	3	2	2	3	1	3	4	4	3	3	4	5	3	2	3
Participant 15	yes	4	2	2	3	3	3	4	4	4	4	2	3	3	2	4	4	4	3	3	3	4	3	3	3	5	4	5	4	4	4
Participant 16	yes	3	3	2	2	2	3	2	4	3	3	4	4	3	3	3	4	3	1	2	3	4	5	4	4	4	4	4	3	3	4
Participant 17	yes	4	3	2	2	4	4	1	2	2	2	4	2	5	3	5	5	2	4	4	3	3	3	2	4	3	3	1	2	4	2
Participant 18	yes	5	3	2	3	2	3	4	5	4	4	4	4	2	3	3	3	4	3	3	3	4	3	3	4	3	3	3	4	5	3
Participant 19	yes	2	4	1	1	5	5	1	5	5	5	2	4	4	4	4	3	5	2	1	4	4	2	2	1	4	1	2	5	5	5
Participant 20	yes	2	2	1	1	1	1	1	3	1	1	3	1	2	2	1	2	1	2	1	1	3	2	1	2	2	1	4	2	1	5
Participant 21	yes	3	3	1	5	4	1	1	1	1	1	4	2	5	3	4	5	2	5	5	4	5	4	3	5	5	5	4	3	2	5
Participant 22	yes	1	2	1	1	3	3	1	3	3	3	5	4	4	4	5	5	3	5	2	4	3	5	2	3	4	3	4	2	3	5
Participant 23	yes	1	5	3	3	3	2	2	5	2	2	3	5	2	3	1	3	2	2	2	2	4	5	2	4	4	5	5	4	5	1
Participant 24	yes	5	5	4	5	5	5	5	5	5	5	3	4	4	3	4	4	5	4	2	5	5	5	4	5	4	5	5	4	4	5
Participant 25	yes	4	5	3	3	1	2	2	4	2	2	4	4	2	2	1	2	3	1	2	1	5	3	3	5	5	2	4	5	4	3
Participant 26	yes	3	3	2	3	1	2	2	4	2	2	4	4	5	5	4	5	3	3	4	4	5	5	2	5	5	5	5	5	4	5
Participant 27	no	3	3	4	5	2	2	1	5	3	3	2	2	3	4	3	3	1	2	3	3	4	4	3	4	3	4	4	3	4	4
Participant 28	yes	3	3	2	2	1	1	2	4	1	1	5	3	4	3	3	2	2	4	2	1	4	4	1	3	3	1	5	4	2	2
Participant 29	no	2	3	4	2	3	3	1	4	4	4	3	1	3	2	4	4	2	1	2	3	2	4	1	1	3	3	3	3	4	3
Participant 30	no	4	2	1	2	2	1	4	3	1	1	5	4	5	4	3	5	4	1	2	1	4	5	3	4	4	4	1	1	2	5
Participant 31	yes	3	2	1	5	5	2	1	5	4	4	4	3	5	5	5	3	1	3	3	2	5	4	4	3	5	3	4	4	5	5
Participant 32	no	2	1	1	1	1	2	2	4	1	1	3	2	2	2	3	1	1	2	2	2	4	3	3	3	3	3	3	3	3	5
Participant 33	no	3	3	4	2	2	2	5	4	2	2	5	4	5	4	3	5	5	4	3	2	4	5	4	5	5	4	5	4	3	5

		time stretch										reverberation										my method									
	Answer1	s1	s4	s7	s10	s13	s16	s19	s22	s25	s28	s2	s5	s8	s11	s14	s17	s20	s23	s26	s29	s3	s6	s9	s12	s15	s18	s21	s24	s27	s30
Participant 35	yes	4	3	4	2	5	5	1	4	2	2	5	2	4	5	4	4	2	3	4	5	5	4	4	4	3	3	2	3	4	2
Participant 36	yes	3	3	1	2	3	3	2	4	4	4	4	2	3	3	1	2	2	1	2	3	4	2	4	5	4	1	2	5	3	3
Participant 37	yes	3	3	1	3	4	4	1	4	3	3	4	3	4	3	4	3	2	3	3	1	2	3	2	4	4	4	4	4	3	1
Participant 38	yes	4	3	2	2	1	1	2	3	1	1	4	4	1	3	1	1	2	1	1	3	5	5	2	3	2	3	3	2	2	4
Participant 39	yes	2	2	2	3	2	2	1	1	3	3	3	3	2	3	2	3	2	2	3	3	3	4	4	5	4	4	4	5	5	4
Participant 40	no	2	3	3	2	1	3	3	3	3	3	5	2	2	2	3	4	3	5	4	2	5	3	1	2	4	4	4	4	3	2
Participant 41	yes	2	2	1	3	2	3	1	2	3	3	3	2	2	2	2	2	2	2	1	2	4	3	2	3	3	4	3	3	2	3
Participant 42	yes	4	2	1	2	2	3	2	5	3	3	5	2	2	2	1	1	2	1	2	3	4	5	3	3	2	4	4	3	2	3
Participant 43	yes	4	2	2	2	1	2	1	3	2	2	4	2	3	2	2	3	1	2	2	2	4	2	3	2	2	2	3	2	2	3
Participant 44	yes	3	4	1	2	1	1	5	5	1	1	5	4	5	5	4	2	5	5	4	2	5	5	1	3	4	2	5	5	3	5
Participant 45	yes	2	2	1	1	1	1	5	2	1	1	2	2	2	2	2	3	2	4	1	1	3	2	1	3	2	3	4	3	3	1
Participant 46	no	2	2	4	2	3	2	1	2	3	3	4	2	3	3	2	3	1	2	3	1	2	4	2	4	3	2	1	1	3	4
Participant 48	no	2	2	1	1	1	1	2	2	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	3	1	1	4
Participant 49	no	2	5	4	5	4	5	1	1	1	1	4	1	3	4	3	2	1	1	1	3	5	2	4	4	4	4	5	1	2	3
Participant 50	yes	2	3	1	4	1	4	4	5	3	3	3	4	2	3	2	3	3	4	3	3	2	4	2	5	4	3	2	4	2	4
Participant 51	no	2	4	2	3	1	4	5	4	3	3	4	4	4	5	3	5	5	4	4	2	3	4	4	4	4	4	3	4	3	3
Participant 52	yes	1	2	3	1	3	2	2	3	3	3	3	2	4	2	4	3	3	4	3	2	4	3	2	4	3	2	3	2	4	5
Participant 53	yes	3	4	2	3	2	3	4	3	3	3	3	2	2	3	2	2	4	2	3	2	3	3	2	4	4	2	4	3	4	4
Participant 54	yes	2	3	3	3	3	3	3	3	2	2	4	3	3	4	4	3	3	2	2	3	3	2	3	3	4	3	4	3	3	4
Participant 55	no	3	3	2	2	3	4	4	5	3	3	4	3	4	4	5	3	4	3	2	4	4	2	4	4	4	5	5	4	3	5
Participant 56	yes	4	5	4	5	4	4	5	5	3	3	3	5	4	4	2	2	5	1	2	4	5	5	4	5	3	3	5	3	5	4
Participant 57	yes	2	2	1	2	1	2	3	2	2	2	3	3	1	3	1	1	3	2	2	2	4	3	1	3	2	1	4	3	2	3
Participant 58	no	2	2	2	4	4	4	4	4	3	3	4	4	5	5	5	5	5	4	4	4	5	3	2	5	4	5	1	5	3	5
Participant 59	yes	4	4	2	2	2	3	2	3	3	3	4	4	3	3	2	2	3	2	2	3	5	5	3	4	2	4	3	4	4	4
Participant 60	yes	1	4	1	1	1	1	3	3	1	1	3	3	2	3	2	3	2	3	2	1	2	4	1	3	2	1	5	4	1	3
Participant 61	yes	1	1	1	1	1	2	1	2	1	1	3	2	3	3	2	3	4	1	1	1	5	5	1	1	4	3	4	4	3	1
Participant 62	no	3	3	5	4	5	3	1	2	2	2	4	4	4	2	4	4	2	4	2	3	4	2	2	2	4	2	2	2	3	4
Participant 63	yes	4	1	1	1	1	2	1	2	3	3	2	2	1	2	1	2	2	2	2	3	5	4	2	3	2	3	3	3	3	3
Participant 64	yes	4	4	2	3	1	4	5	3	2	2	3	1	1	4	1	1	4	1	4	4	4	5	1	4	1	3	5	3	5	4
Average sound		**2,92**	**2,98**	**2,35**	**2,65**	**2,45**	**2,60**	**2,61**	**3,45**	**2,47**	**2,47**	**3,66**	**2,97**	**3,06**	**3,11**	**2,79**	**2,97**	**2,90**	**2,66**	**2,48**	**2,65**	**3,98**	**3,56**	**2,55**	**3,45**	**3,24**	**2,97**	**3,68**	**3,31**	**3,15**	**3,63**
Std. Dev. Sound		1,09	1,11	1,34	1,29	1,44	1,29	1,49	1,17	1,16	1,16	0,96	1,14	1,27	1,09	1,31	1,29	1,31	1,31	1,13	1,2	1,03	1,15	1,11	1,17	1,11	1,25	1,24	1,21	1,19	1,26
Average method		**2,70**										**2,93**										**3,35**									
Std. Dev. Method		1,29										1,24										1,23									
Do you know ambient	72,58%																														

excluded participants	Answer1	s1	s4	s7	s10	s13	s16	s19	s22	s25	s28	s2	s5	s8	s11	s14	s17	s20	s23	s26	s29	s3	s6	s9	s12	s15	s18	s21	s24	s27	s30
Participant 34	yes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	2
Participant 47	yes	1	1	1	1	2	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	2	1	2	2	1	2	1	1