Dillon Bastan 2021

This is my documentation for the prototype Vibroacoustic device I created for this project phase. Here I will share my intentions behind and background of the project, what it is, a bit about the process, my brief research into the subject of Vibroacoustics and Vibroacoustic Therapy (VAT), and how the prototype was developed and functions.

My interest in creating this prototype stems from my interest to help others and give back with the skills I have been learning over recent years. Since I have spent quite a bit of time learning about working with sound and light, particularly for interactive applications, I have been investigating how to use sound and light as therapeutic methods. Before this project, I was looking into therapies using light, particularly with Visual and Audiovisual Entrainment (AVE) of brainwaves. As my investigation turned more to sound, I came upon the concepts of Vibroacoustics and in particular VAT. VAT was a recently developed therapy by Olav Skille in the 1980s using low sinusoidal tones to vibrate a patient's body during a therapy session. Often the patient lay on a bed that had embedded speakers playing the tones. It was common that VAT sessions combined the physical vibrations of the sine tones with the auditory listening of music as well during the session. Below is an image that shows a sort of flowchart about VAT elements:

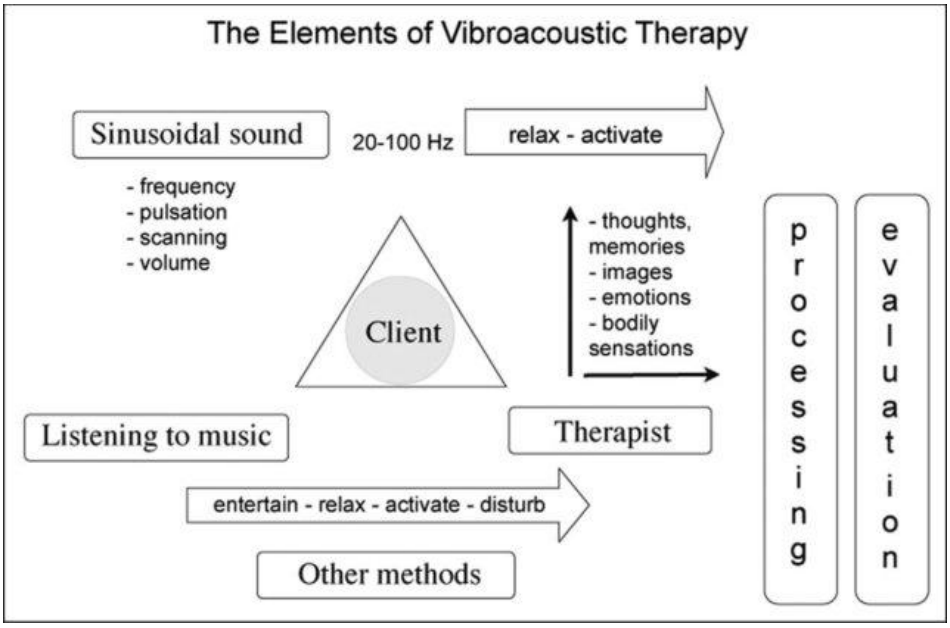

Image from Esa Ala-Ruona and Marko Punkanen in Music and Medicine 4(3):128-135. 2012.

There are various studies on the benefits of VAT both observed and hypothesized. It has shown to be effective for increasing circulation, pain relief, and increasing mobility[1]. Also, there is potential evidence for treating Cerebral Palsy[2]. In fact there are actually quite a large amount of

[1] Bartel, Chen, Alain & Ross (July 2017). "Vibroacoustic Stimulation and Brain Oscillation: From Basic Research to Clinical Application". Music & Medicine. 9 (3): 156.

[2] Institute of Special Education Studies, Faculty of Education, Palacky University Olomouc, Žižkovo nám. 5, 77900 Olomouc, Czech Republic

other disorders and issues that VAT could potentially treat that are a bit beyond the scope of this documentation. One article in particular hypothesizes some incredible potentials of VAT[3]:

- “low-frequency, sinusoidal sound causes resonance (oscillation) in our body and this seems to be the main effective aspect of VAT. Every object has its natural frequency and when the forcing function’s (in this case VAT) frequency matches the natural frequency of an object (eg, thigh muscle), it will begin to resonate.”
- “Resonance in our body will increase the circulation of blood and enhance our metabolism.”
- “It will also release tension in muscles and resonate with affected body parts.”
- “One additional aspect related to the relaxation response is the possible activation of oxytocin production”
- “A state of deep relaxation is the most common subjective experience reported by clients and patients after the VAT.”
- “there could be beneficial uses of VAT resulting from the stimulation of the Pacinian corpuscles, which are large mechanoreceptors located in the subcutaneous and connective tissues surrounding visceral organs and joints. Pacinian corpuscles are sensitive to pressure and can react to VAT stimulation from 60 Hz upward. When the Pacinian corpuscle is stimulated, it sends neurological nonpain messages to the brain that appear to inhibit the pain impulse. Nonpain messages can be understood here through the gate control theory of pain.”
- “According to the gate control theory of pain by pioneers Melzack and Wall, A-bnerve fibers, which transmit information from vibration receptors (Pacinian corpuscles and Meissner corpuscles) and touch receptors in the skin, stimulate inhibitory inter-neurons in the spinal cord that in turn act to reduce the amount of pain signal transmitted by A-qand C fibers from the skin to second-order neurons that cross the midline of the spinal cord and then ascend to the brain.
- “Cellular cleansing mechanisms of sound vibration—the Jindrak postulate theorizes about the possible mechanical cleaning effect of vibration in our body and brain. According to Jindrak and Jindrak, vibration can assist in removing some of the molecules, which are waste products resulting from activity in the nerve cells, through a diffusion process.”

As you can see from this article alone there are some exciting possibilities for the field of VAT. And from what I’ve found in my research, though there are some studies into VAT, it still is a very recent field with a lot of exploration still needed. I became interested in this topic and quite quickly thought of the idea for my prototype: a suit or system that vibrated the body directly on many points using independent channels for each vibration source or speaker. My reasoning and interest to try and make this device went something along these lines: As far as I could find, the VAT sessions were done on beds, chairs, or using vests with a sparse amount of speakers vibrating the medium. And to my understanding, the surfaces just vibrated at a certain frequency during the session depending on the intended purpose. So I was curious to create a device that

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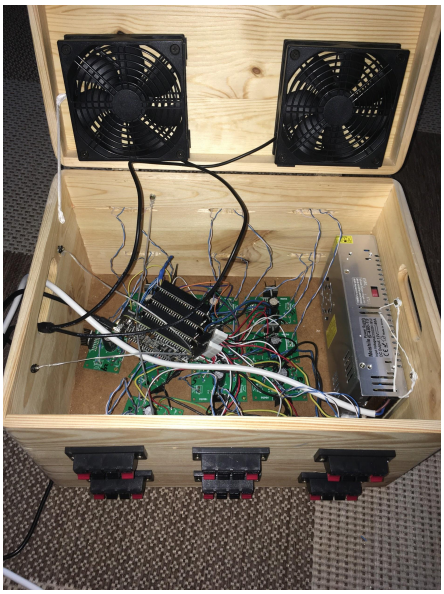
[3] Punkanen, Marko & Ala-Ruona, Esa. (2012). Contemporary Vibroacoustic Therapy Perspectives on Clinical Practice, Research, and Training. Music and Medicine. 4. 128-135.

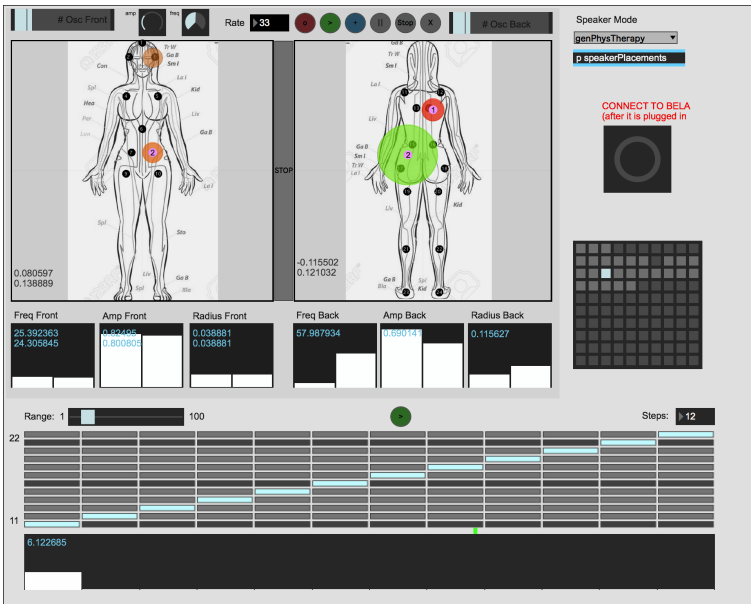
directly and immersively vibrated on the body on all sides using a cushion such as foam between the speaker source and the body. I also wanted to have each speaker be an independent audio channel so that I could “move sound” throughout the body similar to a massage or physical therapy session. In subsequent research I found other speaker and vibration suits that have been made in the past either for art, therapy, entertainment, or technical purposes. However, none quite did what I was attempting and for the same reasons. Of course I have no professional education or training in the appropriate fields to seriously pursue the subject alone, so my intention was to just create a prototype and go from there. Afterwards I hoped to use the prototype to collaborate with individuals who were knowledgeable and active in the appropriate fields to conduct experiments, gather data and design further improvements of the system. Personally, I was and still am open to different possibilities of this device. I was interested and excited about any positive outcome of the device that could help people, whether just as an entertaining or inspiring experience or a legitimate therapeutic device. To me an inspiring experience can help someone just as much as physically addressing an illness or issue.

Now I will go into more details about the device itself and how it was intended to function. As noted before, I wanted to “move sound” throughout a person’s body by using many speaker sources, all of which were independent channels. The way this would happen is by outputting sinusoidal tones out of the speakers and automating their tunings and volumes from a software or a programmed sequence. By using this automation, I could make it feel like a sound is moving through the body, similarly to the hand of a physical therapist moving. However, the experience would of course be much different as vibration from a speaker has a much different effect on the body than a hand (and those differences would be one thing the device could explore). To balance my available budget (which came from a previous project) while still covering a decent area of the body with speakers, I settled on using 24 speakers and channels for the prototype. The mechanism’s prototype I divided into a few sections: the actual suit or system of speakers that attach to the body, an amplifier capable of amplifying 24 independent channels, a computer or microcontroller capable of outputting 24 independent channels, and a software to create and run sequences of automations for the vibrations. I will below describe each element of the prototype.

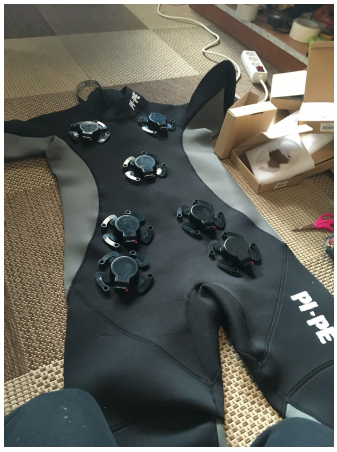


A fair amount of time was first spent researching ways to output and amplify 24 independent channels without spending something like $10,000 or more. In the end my method wasn’t exactly cheap, but certainly saved a ton of money in comparison! I decided to use the Bela microcontroller with shields that expanded the audio outputs until I reached 24 channels. I coded the sine waves on the Bela itself using the C++ RT audio framework, and then I opened it up to receive OSC messages to control the sine waves from an external software. For the amplification, there were many options to build or buy cheap amplifiers. Though it would’ve been cheaper to order the parts independently

and build my own amplifiers, I took a slightly safer, yet still affordable, route and bought a bunch of DIY 2 channel amplifiers that included all of the parts. I constructed the twelve 2 channel amplifiers and put them together in a box with the bela, a power supply (480w with up to 20w per channel!), and some fans. The outside of the box was aligned with connectors for the 24 speakers as well as a usb connection to control or reprogram the sine tones.



The software for the prototype had a few versions, all of which more or less used Max/MSP and outputted OSC messages to the Bela. The interface of the software featured a front and backside image of a body. On top of the body image I placed small black circles to represent where the speakers would be for a particular arrangement. For example, speakers could be set up on the body according to meridians, glands, muscle groups, etc depending on the background and intention of the health practitioner I would work with. For the prototype, I consulted with a physical therapist about a general placement of the 24 speakers to target major muscle groups which you can see in the image here. Also you will notice in the image that there are colored circles of different sizes on top of the body as well. Each of these colored circles represent a sine oscillator. The color and opacity of the circle represents the tuning and amplitude of the oscillator, while the size is the size of the area it targets. If a small black circle (representing a speaker) is underneath a colored circle (a sine oscillator) then that particular sine oscillator is sent out of the corresponding speaker it is on top of. Therefore, in this software you visually place sound vibrations on the body, and then create sequences to automate the movement and parameters of the sound sources. Additionally, this interface can be controlled from an iPad or mobile devices. This allows for two ways of controlling the vibrations: (1) using pre programmed sequences designed on the software or (2) moving the sound sources with your fingers for a real-time or “live” and responsive therapy session on the mobile device similar to a massage session.



Now I will discuss how the suit was created. Originally I had hoped to create a series of straps with the speakers placed on them for different parts of the body so that the prototype could work for many different body types. Unfortunately, designing such a system is an entire field of study itself and beyond my capabilities. Therefore, for the prototype I submitted to buying a wetsuit that fit one body type firmly, and attached all of the speakers to that. The speakers were not

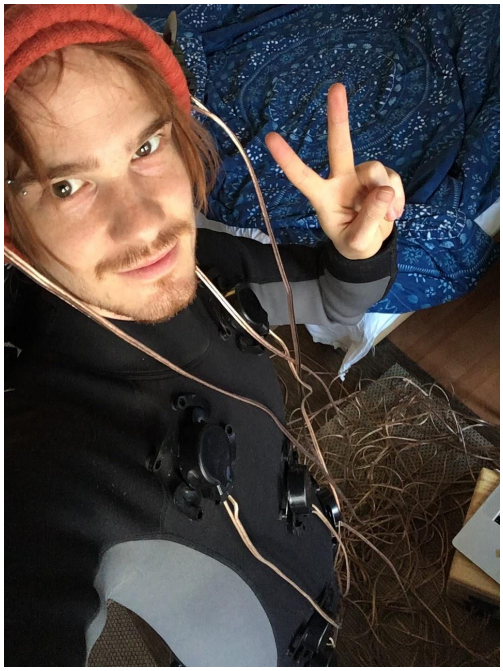
traditional cone speakers, but audio exciter or surface transducers, this way I could directly vibrate the surface (body) they were attached to. So to summarize, the speakers attached to a wet suit worn by a patient, the speakers connected to the 24 channel amplifier containing the Bela microcontroller (that outputs sine tones to the speakers), and the bela was connected to an external software to control it with the additional option of controlling that software with an iPad. Additional attachments were also used to vibrate the head and feet.

Now I will discuss my results, issues, concerns, and future intentions. This device was certainly a prototype and it was my goal just to have it function somewhat correctly and start exploring some possibilities. I would say I succeeded to a degree. The system is functional and I have had several test runs, but of course not without flaws. Personally it was a very fascinating feeling to have dynamic vibrational patterns and sources from so many parts of my body simultaneously. To feel the full energy of the system was exhilarating yet a little scary! I still need to work with health practitioners to develop advanced sequences to alleviate or target certain conditions based on a particular medicinal culture, so I cannot comment on that aspect of the device at this time. The wetsuit is very hot and not ideal for the system despite its convenience in making the system with it. Additionally, it is quite heavy with all 24 speakers attached to it. So because of these reasons it is not the most comfortable experience and leaves me resistant to keep testing the system, especially when its intended purpose is to relax the user. The wet suit has other issues as well: in some parts of my body it doesn't fit skin tight to and so the vibration in those areas is not strong enough. It also doesn't work very well with the adhesives that attach the speakers to it. Of course a proper version of this device won't use something like a wetsuit. Other issues include some minor signal flow issues in the process of controlling and outputting the sine tones. Though they are minimal and irregular, the system definitely would need some fine tuning before further use. So the suit itself would need to be reengineered, but also I would need to use different types of speakers. The biggest problem with the prototype is that the user must be on their knees or hands and knees. This is because the speakers are placed all over the body, including the bottoms of the feet, and these speakers cannot have pressure put onto them or they won't function. This leaves just the hands and front of the shins to rest on. However, there does exist audio exciter speakers that look and feel just like a piece of cushioned fabric in which you can place your weight onto. I would in the future need to use such a type of speaker, however buying 24 of them was far outside my budget. Using such a speaker would allow the user to lay down, and probably would make the weight of the suit much lighter. Even better would be waterproof speakers so that the user could lay in a sensory deprivation chamber, but that's in the world of fantasies right now! The amplifier itself would need to be thoroughly reengineered. Right now it is very bulky, and a Frankenstein of a system. However, with the correct engineering it could become compact, easier to attach the speakers (with one multi-pin attachment instead of 24 speaker wires) and consume far less power than the current 480w!

That leads me into my safety concerns of the device of which I had several. One was of course the power and appropriately separating the circuitry from the body. On this point I am not 100% confident that I did this, although I did consult with several electrical engineering peers who assured me my system was safe, especially because the final connection of the speakers

was mechanical and traveling through foam before touching the skin. Another concern was vibrating over the heart. Several cardiologists assured me that it was almost certainly safe in the system I had. However, there are studies and stories of those who have received a pressure at the heart area at the perfectly wrong moment of the heartbeat cycle that caused ventricular fibrillation leading to death. Though it seemed unlikely my device could cause such a result, I left the speaker above the heart area unplugged to avoid such a horrific event. My final concern was damage to the nerves or muscles from vibration. This is still in a hazy area for me, because on one hand many of these studies were about healing with vibration, so it is shown that this activity has and could have many positive results on the body. However, there are studies in construction workers of damage to the nerves from using heavy power tools daily for decades. Although I have no official source or position to confirm this, from my research there seems to be a level of intensity and prolonged exposure that differentiated a harmful bodily vibration from a therapeutic one. Therefore, it was my intention to keep the intensity of the device to the comfort level of the patient and conduct testing with a professional to understand the possible benefits and side effects of the therapy.

As for the future, I hope to work closely with a health practitioner, or even better a small team of multidisciplinaries with relevant backgrounds to conduct legitimate research and refine the overall system with. Once having a system that runs more smoothly and fits more body types, I would like to conduct initial research to gather data and experiences from as many people as possible. Depending on the results, I would use that data and experience to pursue funding, possibilities, and reach a wider audience with the device. It could be that the device holds no meaningful physical therapy uses, yet it still could hold many other uses whether as a unique art installation or sound experience, a bodily multichannel audio listening device, or a sexual pleasure device. As mentioned, for me I am open to different possibilities and ways of helping and inspiring people with the device. Thank you for your attention!



Project github:
https://github.com/ndivuyo/BodyVAT-Prototype