Measuring Autonomic Responses to Musical Tones

A Biofeedback Analysis of Individual Sound Resonance

Lisa Graham

Mount Royal University Research Ethics Board Approval #104513

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Introduction

The relationship between sound and human physiology has been explored across cultures and throughout history, from traditional healing practices to modern medical applications. While contemporary medicine has established clear therapeutic uses for sound in specific contexts (such as using shock wave lithotripsy for kidney stones (Dai et al., 2019)), there remains a significant gap in our understanding of how similar sound interventions can be used to treat or prevent individual health issues. Furthermore, many traditional and newer sound interventions may use anecdotal evidence or lack scientific backing to support its efficacy (*Your Home Note | Brainwave Assessment*, n.d.). This research aims to develop empirical frameworks to measure, analyze, and apply personalized tonal and musical responses in therapeutic contexts.

Key research questions include:

- Can physiological responses to specific frequencies be reliably measured and quantified? If so, how?
- Is there a correlation between subjective experiences of resonant frequencies (“home notes”) and measurable biological markers?

This research addresses several critical gaps in current understanding. While traditional sound therapy practices often rely on subjective experience, there is a pressing need for empirical validation of these approaches. Similarly, while medical applications of sound are well-established in specific contexts (Dai et al., 2019), the potential for personalized frequency-based interventions remains largely unexplored.

This research has the potential to have significant impacts on society in many ways including:

- Customized, non-invasive care for some health challenges
- Reduced burden on health care systems
- Expansion of community health programs
- Self-directed preventative care

Background and Related Work

Cellular and Frequency Interactions

Anthony Holland's research suggests impressive potential in using personalized frequencies at a cellular level to influence biological function such as in the treatment of cancer (Bare, 2023; Holland & Bare, 2023). Although cellular-level study is important and can be helpful for extremely specific applications, this research focuses on the macro scale. Personalized frequencies at the macro scale may be more accessible for individuals to take charge of their well-being and for practitioners with limited

access to equipment or training to have an impact on individuals and communities (such as community health programs).

Resonant Frequency Research

Existing studies on human resonant frequencies identify a variety of ranges including 9-10Hz (RANDALL et al., 1997) and 5-10Hz (Brownjohn & Zheng, 2001), both of which are present when examining subharmonics of the frequency range of the Western chromatic scale at A=440Hz. These previous works do not consider the frequencies in a nuanced enough way to relate them to the subharmonics of this scale.

Medical and Therapeutic Sound Applications

Current medical research demonstrates established sound-based interventions, particularly in shock wave lithotripsy (SWL) (Dai et al., 2019) for breaking up kidney stones, provides an empirical precedent for frequency-specific therapeutic approaches. These applications establish methodological frameworks for investigating frequency's physiological impacts. From the current research perspective, these established frameworks can be used as a guideline for sound-based interventions in other areas.

Economic Implications

The aging baby boomer generation poses significant healthcare challenges with projections indicating limited resources to support this large population (Proffitt, 2020). To combat this, Knickman and Snell emphasize the need for more accessible community care for aging populations (Knickman & Snell, 2002).

Non-invasive sound treatment methods offer potential economic relief by:

- Reducing or eliminating hospital stay duration depending on treatment plan thereby minimizing care facility burdens
- Becoming more effectively used in preventative community health programs
- Providing targeted, efficient patient care both in hospitals and community health programs

Personalized sound therapies could significantly decrease healthcare costs through more precise, less invasive interventions.

Traditional Practices and Scientific Validation

Traditional and current sound healing practices offer valuable observational insights into individual tonal responses. However, these practices largely lack rigorous scientific validation—a critical gap this research aims to address.

Methods

The primary aim of this research is to validate the concept of individual tonal preference through physiological measurement. Objectives of this aim include to:

- Design and implement biofeedback measurement protocols
    - To start, exploring through galvanic skin response and heart rate variability as they are easily available and affordable sensor options

- Collect and analyze physiological data from 10-20 participants in a pilot study. If results look promising, continue collecting and analyzing data from minimum 40 participants
- Correlate subjective reports with physiological measurements

The study will explore whether there is a measurable physiological heart rate variability or galvanic skin response when listening to a series of twelve pre-recorded tones based on the Western chromatic scale at 440Hz. This study uses the currently existing Brainwave Assessment System (*Your Home Note | Brainwave Assessment*, n.d.), which primarily uses client input to determine the home note or personal resonant frequency.

Hardware and Software

Prior to recruitment for the study, the sensors and software were prepared.

Hardware

The primary driver for the sensor setup was the Raspberry Pi 5. An earlier version of the Raspberry Pi was available to use; however, it was not robust enough for this project, so the new version was purchased. The Raspberry Pi 5 supported Bluetooth connection, which was necessary for one of the sensors, and had sufficient USB ports for peripherals. It also supported up to date versions of Python, which will be discussed in the software section.

Sensors

The criteria when evaluating the galvanic skin response and heart rate variability sensors were based on a balance of performance and cost.

The Polar H10 off-the-shelf sensor was selected for heart rate variability (HRV) due to its ease of use, sensor reading quality, and Bluetooth connection. This sensor is known for its comfort and allows participants full freedom of movement while wearing. The sensor is placed just below the chest on an elasticized band as shown in Figure 1:

Figure 1: Polar H10 Heart Rate Variability Sensor

For galvanic skin response (GSR), the Grove GSR sensor from Seeed Studio (Figure 2) was selected for easy integration with the Raspberry Pi 5 via the Grove Base Hat (Figure 3):

Figure 2: Grove GSR Sensor (Amazon.com, n.d.; Seeed Studio, n.d.; Tobii, 2023)

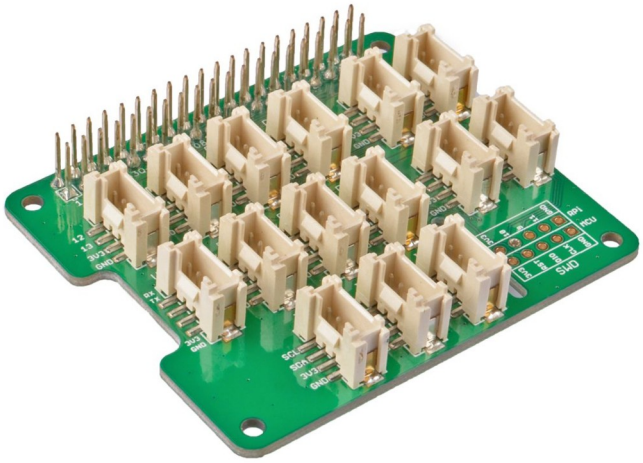

Figure 3: Grove Base Hat

Software

The Raspberry Pi 5 was installed with Debian GNU/Linux 12 (bookworm). This system was used for development and collection of data.

A simple Python program was created to collect information from the two sensors as well as record the note of the track being played. ChatGPT was used to expedite the coding process by creating the

foundation of the program. The code was then tweaked to eliminate bugs and modify the interface as needed to suit the researcher. Figure 4 illustrates the graphical interface of the program.

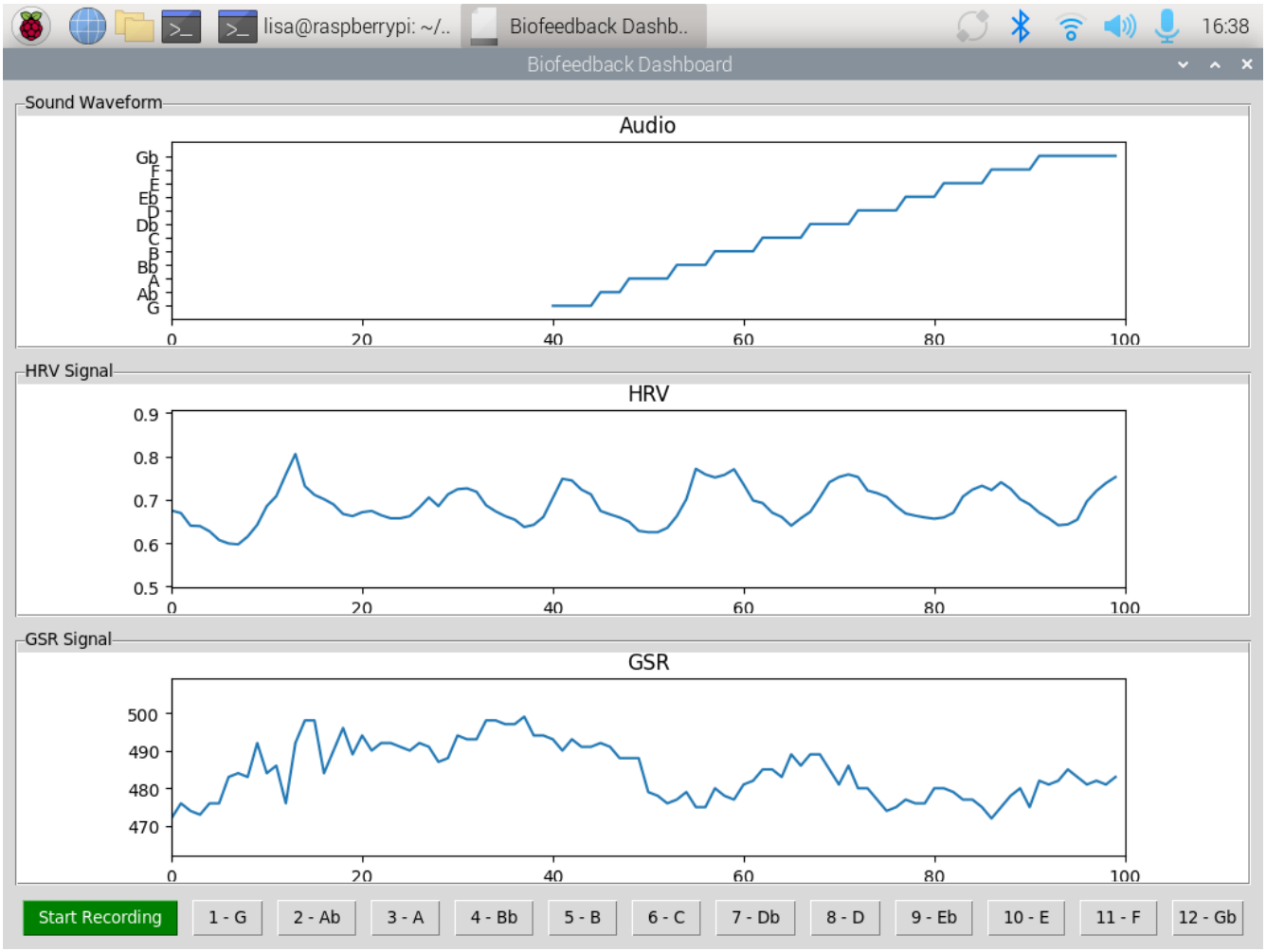

Figure 4: Software Interface

All three graphs were synchronized to show the last 100 seconds of incoming data from the sensors and audio. Data was sampled twice per second. Buttons were included at the bottom of the screen to start recording data (Figure 5) and to trigger audio tracks to play (Figure 6).

Figure 5: Two States of the Start/Stop Recording Button

Figure 6: Recording Button with Buttons to Trigger Playing Each Track

The start/stop button was included to prevent extensive data from being gathered as the sensors were set up and audio volume levels checked for each participant. Once these checks were complete, the researcher would start recording the data.

Once the sensors were no longer needed, the researcher would stop the recording, which triggered the collected data to be written to a CSV file for future analysis. Recorded fields included timestamp, reading for GSR sensor, reading for HRV sensor, and active audio track (nothing if no track was being played).

The complete study setup before participant arrival is pictured in Figure 7. Not shown is a yoga mat if the participant chooses to lay down.

Figure 7: Study Setup

Study Protocol

The study consisted of four parts:

1. Recruitment
2. Consent form and intake interview
3. Data collection
4. Debrief interview

Each part will be explored in more detail in the following sections.

1. Recruitment

Participants were recruited using a variety of methods including:

- Social media – Instagram posts on existing platforms (harmonicspiritstudio, lisagrahammusic, yycwax)
- Posters – Mount Royal University campus and Microspace common kitchen
- In person – announcements in classes and workshops including class taught at Mount Royal University, yoga classes, music classes, and other opportunities as they arose
- Existing network – emailed/instant messaged friends and family
- Special interest groups – local Calgary subreddit on Reddit
- Newsletters – including HEAR newsletter

Examples of recruitment materials can be found in Appendix A.

When responding to recruitment ads, participants were asked to provide their location of choice (Mount Royal University or Microspace). From there, a mutually convenient time was scheduled.

2. Consent Form and Intake Interview

On arrival for their session, participants were invited to review and sign the consent form (Appendix B). If participants consented to being audio recorded, the recording was started. Following this, a short intake interview was conducted. This interview was intended to gather demographic information (name, gender, and year of birth), experiences with sound and energy healing, previous experience with personal resonant frequencies, and questions to gauge confidence and anticipated comfort level with the forthcoming study. The intake interview can be found in Appendix C.

3. Data Collection

Following the intake interview, participants were fitted with the sensors and a set of headphones. The researcher started the program to ensure sensor data was being recorded. Once this was verified, participants were given a set of headphones and asked to find a comfortable volume using the first track of the brainwave assessment process.

Once the sensors and headphones were set up, participants were invited to sit in a chair or lay on a yoga mat – wherever they felt most comfortable. As the participant settled, the researcher started the sensor recording. Before starting the breathing exercise, the researcher briefly outlined the next two steps of the process – the exercise and listening to the sounds. From here, participants were guided through a short breathing exercise (Appendix D) to focus their attention before moving through the Brainwave Assessment System protocol.

As the breathing exercise came to a close, the researcher explained the brainwave assessment process and immediately proceeded with the assessment as the participant was ready. During this process, the

participant listened to twelve pre-recorded tracks revisiting any tracks they connected with at the end. By the end of this stage, the participant intuitively identified their personal resonant frequency.

Once the participant was satisfied with their selection, they were invited to take a few moments to breathe and return to the current space. The researcher stopped the sensor recording and participants removed their sensors in their own time.

4. Debrief Interview

Immediately following the session, participants were asked a series of questions reflecting on their experience. These included confidence and comfort level questions from the intake interview and were intended to get a before and after view of the participants' expectations and experiences. Participants were also invited to provide any additional feedback or insights on the study and their experience in an open-ended question to close the interview. The full debrief interview script can be found in Appendix E.

Additional Factors

All participants were asked to provide an emergency contact or complete a Distress Management Protocol form (Appendix F) in case of distress from the tones used in the study. In addition to this, a distress protocol (Appendix G) was created to support the researcher in case of an adverse event.

To conclude, the researcher's overall script for the study is included in Appendix H.

Results and Discussion

To date, eight participants have been recruited (2 female, 6 male) aged 33 to 64.

Intake Interview Results

Experience with Sound or Energy Healing

None of the participants had experience with sound or energy healing. Two participants had heard of the concept of a home note, soul note, or personal resonant frequency. One participant was unsure what it was and the other associated it with feelings of peace and resonating with self.

Meditation Practice

Half of the participants did not have a meditation or meditation-like practice. The other half mentioned prayer, yoga, lofi beats, and sounds such as rainfall and ocean as part of their meditation practice.

Logic vs Intuition

When asked how much they agreed with the statement 'In general, I feel like I am a logical person,' all participants agreed (3 participants) or strongly agreed (5 participants) with the statement. There was

slightly less agreement when participants were asked about the statement ‘In general, I feel like I am an intuitive person.’ Four participants strongly agreed and four participants agreed although two of these participants rated a 3.5/5 on the scale (between neither agree nor disagree and agree on the provided scale).

Anticipated Comfort and Confidence Levels

Before setting participants up with sensors, they were asked to evaluate their comfort level with intuition and sensors as well as their confidence in identifying their personal resonant frequency in each way.

Comfort

In terms of comfort, six participants felt comfortable using their intuition while the other two were unsure or not fully comfortable. All participants felt comfortable using both sensors to identify their personal resonant frequency.

Confidence

In terms of confidence, two participants were mostly confident or confident, four were uncertain, and two had no confidence they would be able to intuitively identify their personal resonant frequency. The expected confidence in the sensors was higher with six out of eight confident and two out of eight uncertain.

Debrief Interview Results

The debrief interview focused on comfort and confidence post-experience. They were also provided an opportunity to reflect on their experience and share any thoughts.

Actual Comfort and Confidence Levels

Comfort

In terms of comfort, most participants (seven of eight) felt comfortable using their intuition, which is slightly more than those who expected to feel comfortable before the experience. Most participants felt comfortable using the sensors although two participants reported the galvanic skin response sensors as feeling tight and being distracting as the session progressed.

Confidence

Participants varied in their confidence levels post-session. Confidence in intuition varied from very confident to not at all confident. Three participants had a fairly high confidence level, two were moderately confident, one had very low confidence, and two were uncertain. Participants who provided additional comments highlighted uncertainty between two tones, uncertainty in what they were looking for, and difficulty picking one as challenges.

Confidence in the sensors also varied. Three participants had a fairly high confidence level, three were moderately confident, one was not confident, and one was uncertain. One participant highlighted particular confidence in the heart rate variability sensor. Others expressed curiosity as to the results. In conversations after the study, some participants followed up asking if they picked the ‘right’ note intuitively.

Data

The steps in data analysis for each participant were as follows:

1. Clean the data
    - All entries without an associated note (meaning a track was being played) were removed
2. Calculate the average value, standard deviation, and coefficient of variance for each note for each of the sensors
3. Calculate the average value, standard deviation, and coefficient of variance for the first twelve notes played (original set of all notes).
4. Compare the average sensor value to the sensor values for each note played to see if there is a match.

The following section explores the process for one participant in the study as an example.

Sample Calculation

Step 1: Clean the Data

Figure 8 shows a screenshot of part of the CSV file prior to cleaning. Note how some rows do not have a note in the far right column. This represents times at which no sound was playing.

1	timestamp	gsr	hrv	audio
974	1749716607.0318	443	0.993	G
975	1749716607.61014	440	0.993	G
976	1749716608.1882	447	0.986	G
977	1749716608.76327	440	0.968	G
978	1749716609.34123	445	0.968	G
979	1749716609.94573	442	0.974	G
980	1749716610.51988	443	0.974	G
981	1749716611.09268	454	0.964	
982	1749716611.6653	439	0.967	
983	1749716612.23844	443	0.967	
984	1749716612.81135	450	0.974	
985	1749716613.38425	437	0.974	
986	1749716613.95715	449	0.962	
987	1749716614.53013	445	0.962	Ab
988	1749716615.1352	441	0.972	Ab
989	1749716615.70955	447	0.989	Ab
990	1749716616.2812	439	0.989	Ab
991	1749716616.85541	437	1.019	Ab

Figure 8: Partial Raw Data From Participant Recording

Figure 9 shows a screenshot of part of the CSV file after cleaning the data. Note how there are no longer gaps between the notes. This step is completed to make the calculations in the next step easier.

	A	B	C	D
1	timestamp	gsr	hrv	audio
47	1749716607.0318	443	0.993	G
48	1749716607.61014	440	0.993	G
49	1749716608.1882	447	0.986	G
50	1749716608.76327	440	0.968	G
51	1749716609.34123	445	0.968	G
52	1749716609.94573	442	0.974	G
53	1749716610.51988	443	0.974	G
54	1749716614.53013	445	0.962	Ab
55	1749716615.1352	441	0.972	Ab
56	1749716615.70955	447	0.989	Ab
57	1749716616.2812	439	0.989	Ab
58	1749716616.85541	437	1.019	Ab
59	1749716617.42541	450	1.019	Ab

Figure 9: Cleaned Participant Data

Step 2: Calculate Statistics for Each Note

In this step, a new worksheet was created to collect the statistics for each sensor. As shown in Figure 10, the spreadsheet was set up to document each note in different columns (all twelve of the original notes played followed by any the participant wanted to repeat). The mean, standard deviation, and coefficient of variance were calculated for all data points for the particular note being played for each sensor (galvanic skin response on the top followed by heart rate variability).

		G	Ab	A	Bb	B
GSR	Mean	444.5384615	445.02	446.02	445.1875	445.66
	Standard Deviation	5.889377405	5.779944213	5.877976884	5.302172377	6.3000
	Coefficient of Variance	0.013248297	0.012988055	0.013178729	0.011909976	0.0141
		G	Ab	A	Bb	B
HRV	Mean	0.983269231	0.95574	0.9523	0.935854167	0.9640
	Standard Deviation	0.028464023	0.03660702	0.027351268	0.034669252	0.030
	Coefficient of Variance	0.028948351	0.038302278	0.028721272	0.037045571	0.0315

Figure 10: Calculating Mean, Standard Deviation, and Coefficient of Variance Note by Note for Each Sensor

A simple bar chart was created based on the mean values and notes to get a very basic visual representation of changes in the sensor rating. This is shown in Figure 11.

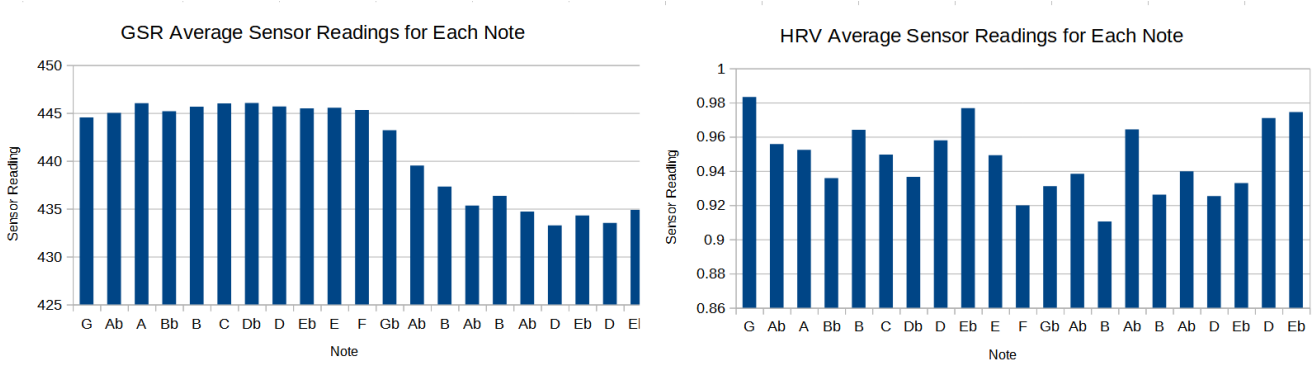

Figure 11: Sample Bar Chart Representation of Sensor Readings for Each Note for GSR and HRV Sensors

The galvanic skin response readings were quite consistent across all twelve notes originally played for the participant, so the researcher decided to see whether there was any statistical significance across this subset of data.

Step 3: Calculate Statistics on Original Twelve Note Set

The next calculations are based on all data in the original set of twelve notes (G through Gb). The mean, standard deviation, and coefficient of variance were calculated for all sensor values recorded for the first twelve notes. Figure 12 shows the results of the calculation:

		First Twelve Notes
GSR	Mean	445.27357032457
	Standard Deviation	5.8116166964313
	Coefficient of Variance	0.0130517890208
		First Twelve Notes
HRV	Mean	0.9509289026275
	Standard Deviation	0.0416339036633
	Coefficient of Variance	0.0437823517071

Figure 12: Mean, Standard Deviation, and Coefficient of Variance for First Twelve Notes

Since the coefficient of variance is well under 1, the data is not statistically significant, leading the researcher to believe the sensor data does not help one determine one's personal resonant frequency.

Step 4: Compare Mean of First Twelve Notes to Individual Note Means

Interpreting the data by comparing the mean of the first twelve notes to the means of individual notes leads to something interesting. In this case, the mean HRV for all twelve notes combined is 0.9509. This is very similar to the mean of C for HRV (0.9496). The percentage difference of the mean HRV for all twelve notes compared with the mean of C is 0.140%.

The mean GSR of all twelve notes is 445.2736 and HRV is 0.9509. This is very similar to the mean of F for GSR (445.3043). Calculating the percentage difference of the mean GSR for all twelve notes compared with the mean of F is 0.007%. This becomes very interesting as the data for all participants is compared.

A Summary of All Participants

For all participants, it was interesting to note that there was some fluctuation in the simple bar chart between the initial set of twelve notes and the notes that were revisited for the galvanic skin response sensor. How it varied differed from participant to participant, but all participants exhibited this behaviour. Figures 13 through 16 showcase the mean GSR values for four of the participants in the study.

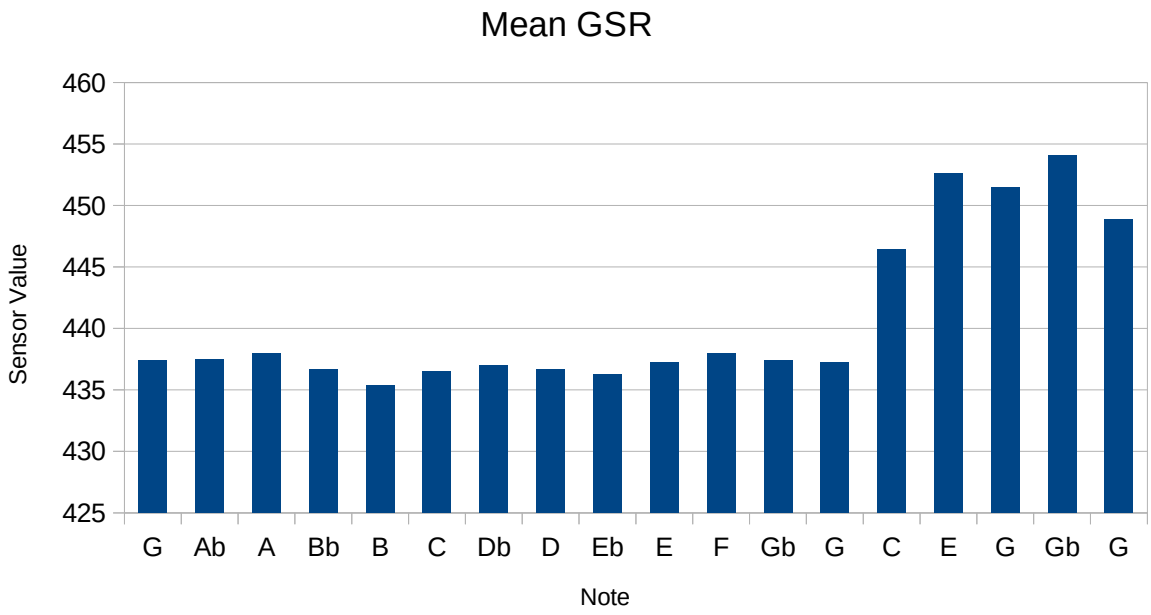

Figure 13: Mean GSR Graph for Participant 1

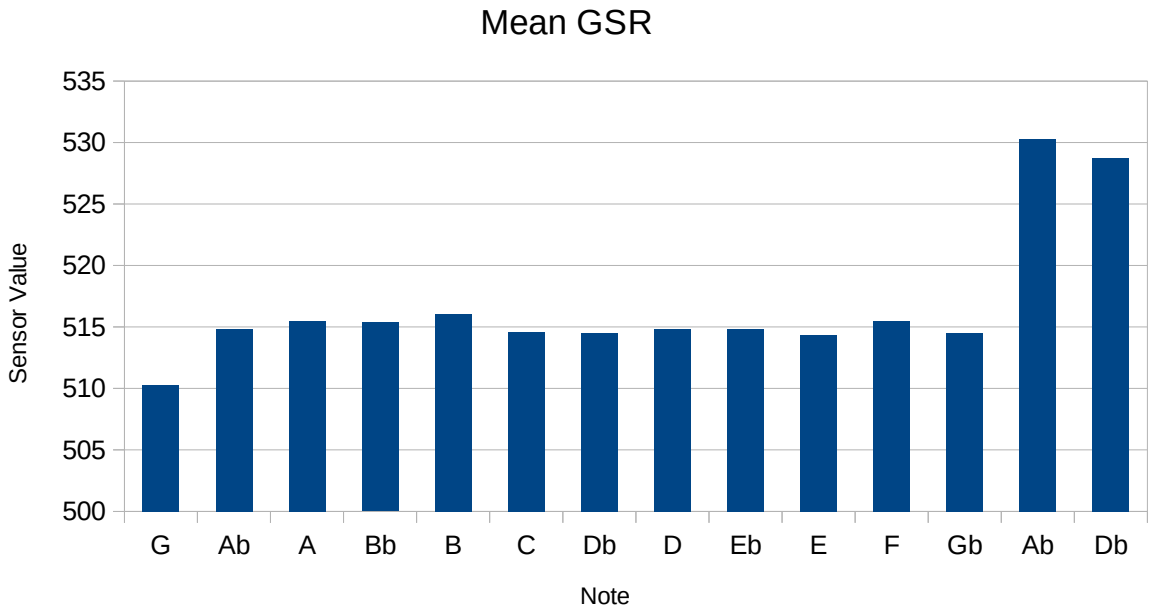

Figure 14: Mean GSR Graph for Participant 3

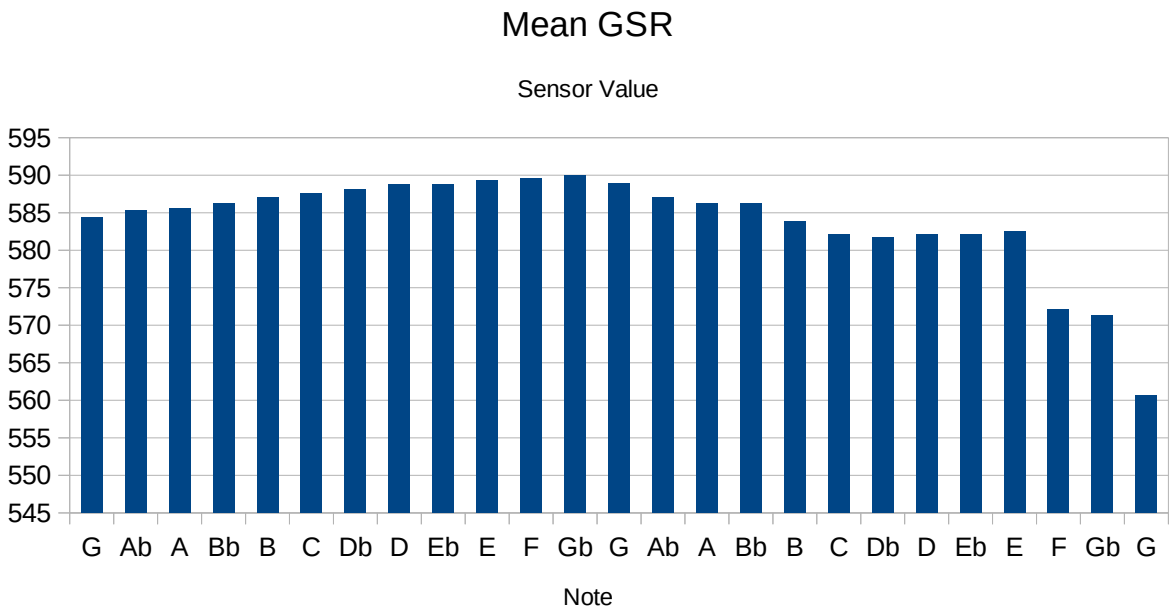

Figure 15: Mean GSR Graph for Participant 5

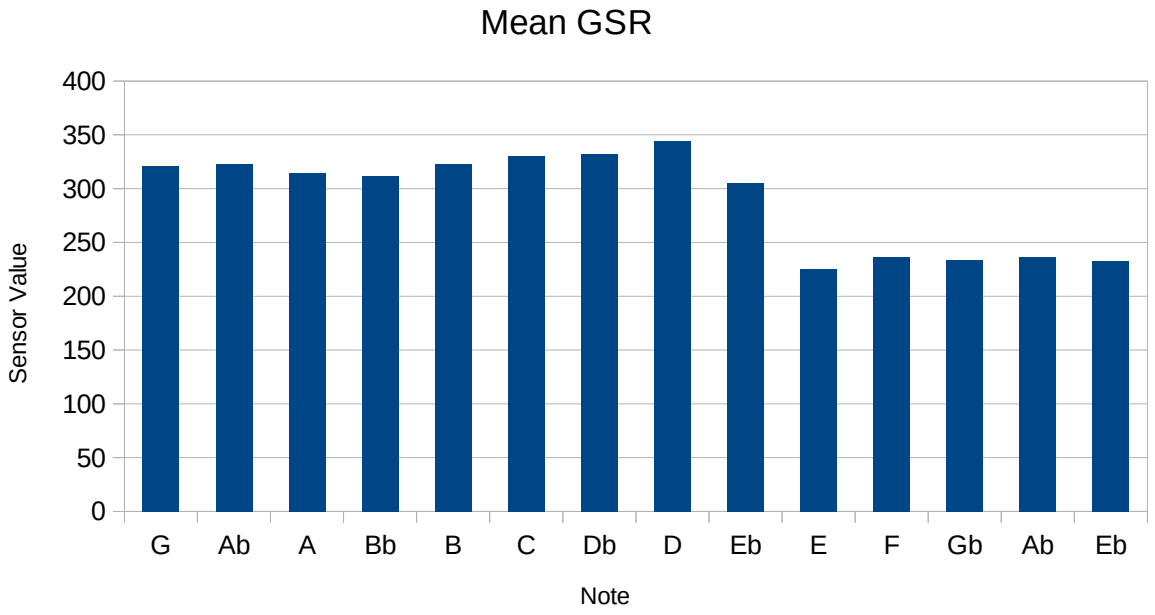

Figure 16: Mean GSR Graph for Participant 7

When calculating the standard deviation and coefficient of variance, there was no statistical significance to the individual notes for each participant. As the graphs did not seem to show a significant difference from note to note for each participant, the mean, standard deviation, and coefficient of variance were calculated on the first set of twelve notes as a collective. The coefficient of variance showed there was no statistical significant among this data, leading the researcher to believe this perhaps was not a valid way in which to determine one's personal resonant frequency. These trends were observed across all participants in the study.

However, in investigating further, the average of the sensor data for the galvanic skin response was remarkably similar to one value in the averages of each note's data. This could potentially suggest that the average of the participant's data for the first twelve notes could be used to determine the participant's personal resonant frequency. That said, the intuitively identified personal resonant frequency did not necessarily match with this data. Three intuitively identified personal resonant frequencies were within a half step and one was an exact match. With only half of the participants following this pattern, additional data will be required to see if this trend continues. Table 1 outlines the calculations and compares the personal resonant frequency determined by the GSR sensor versus the intuitively identified value.

Table 1: Comparing Average Mean (First Twelve Notes) to Closest Matching Note from GSR to Intuitively Identified Note

Participant Number	Mean of First Twelve Notes	Closest Matching Mean from Individual Notes	Percent Difference (%)	Corresponding Note	Participant's Intuitively Identified Note
1	436.98	436.97	0.002	Db	G
2	445.31	445.3	0.002	F	D
3	514.59	514.59	0	C	Db
4	358.88	358.48	0.112	C	B
5	587.56	587.61	0.009	C	G
6	501.98	501.68	0.06	Db	D
7	299.95	305.18	1.729	Eb	Eb
8	572.43	572.5	0.012	B	G

These results did not transfer as well for the HRV sensor. The percentage differences were higher and comparing the corresponding notes to the participant's intuitively identified notes had larger disparity in most cases. Table 2 shows the same calculations for the HRV sensor data (note the HRV sensor was not working for Participant 1, so there is no data):

Table 2: Comparing Average Mean (First Twelve Notes) to Closest Matching Note from HRV to Intuitively Identified Note

Participant Number	Mean of First Twelve Notes	Closest Matching Mean from Individual Notes	Percent Difference (%)	Corresponding Note	Participant's Intuitively Identified Note
1	No Data				G
2	0.951	0.952	0.105	A	D
3	1.138	1.137	0.088	C	Db
4	0.838	0.838	0	A	B
5	1.027	1.025	0.195	F	G
6	0.98	0.981	0.102	Gb	D
7	0.84	0.84	0	Ab	Eb
8	1.613	1.508	6.729	D	G

It's also interesting to note the differences in identified notes for GSR and HRV sensors compared with the participant's intuitively identified note. Table 3 brings this information together for easy comparison:

Table 3: Comparing Intuition, GSR, and HRV Personal Resonant Frequencies

Intuitively Identified Note	GSR Identified Note	HRV Identified Note
G	Db	
D	F	A
Db	C	C
B	C	A
G	C	F
D	Db	Gb
Eb	Eb	Ab
G	B	D

With the values drastically different for the most part, it is difficult to make any definitive conclusions; however, additional data will be helpful to determine whether there are patterns in the data.

Conclusions

With the current small sample size, it's difficult to draw any conclusions. However, there may be a trend in exploring the averages of each note and comparing those to the average of the entire data set for each person using the galvanic skin response data. Further study is needed to see if the values match for a larger sample size or if the data is coincidental.

Future Work

Note this work is ongoing and data collection will continue until 20 people have participated in the study. At that point, the researcher will determine whether there is sufficient promise indicated in the work to continue data collection.

Other possible opportunities for future work include:

- Exploring the use of medical and consumer grade EEGs
- Expanding the study beyond a pilot

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Appendix A: Recruitment Materials

Templates were created for various recruitment methods:

Verbal Recruitment Script

The following script will be used to verbally recruit participants.

Some examples of recruitment opportunities include:

- University classes taught at MRU
- Yoga classes
- Music classes
- Crafting workshops at YYC Beeswax
- Sound healing sessions
- Others as they arise

In all cases, the audience will know who I am and this script will be used as part of an organic conversation.

I'm working on a research study about how sound affects our bodies, and I'm looking for participants. Would you be interested in hearing more about it?

[If yes, continue]

Great! I’m studying how different sounds might impact physical responses like heart rate and skin conductivity. I’m curious to find out if there is a way to determine personal resonance (or your ‘home’ note) using these physical responses.

As a participant, you would:
- Spend about 90 minutes with me
- Wear simple, non-invasive sensors on your fingers/chest
- Listen to different sound frequencies
- Share your experiences in brief interviews before and after

The sensors are completely safe and measure heart rate and conductivity of your skin - nothing painful or invasive. No musical experience or special knowledge is needed.

The study takes place at Mount Royal University or Microspace based on your preference, and we can schedule a time that works for you.

Does this sound like something you might be interested in participating in?

[Answer any questions they have]

If you'd like to participate or have more questions, please email me at lgraham1@mtroyal.ca or take one of these information sheets [mini version of the recruitment poster] with all the details.

Thank you for your time!

Email Recruitment

Subject Line: Sound Frequency Study Participants Needed

Seeking Participants for Sound & Biometrics Research

What you'll do:

- Experience different sound frequencies while wearing non-invasive biometric sensors
- Complete brief interviews before and after
- Total time commitment: ~90 minutes

Requirements:

- Over 18
- Interest in health/wellness research
- No prior experience needed

Location: Mount Royal University or Microspace (3130 114 AV SE)

Contact Lisa Graham (lgraham1@mtroyal.ca) with questions or to participate.

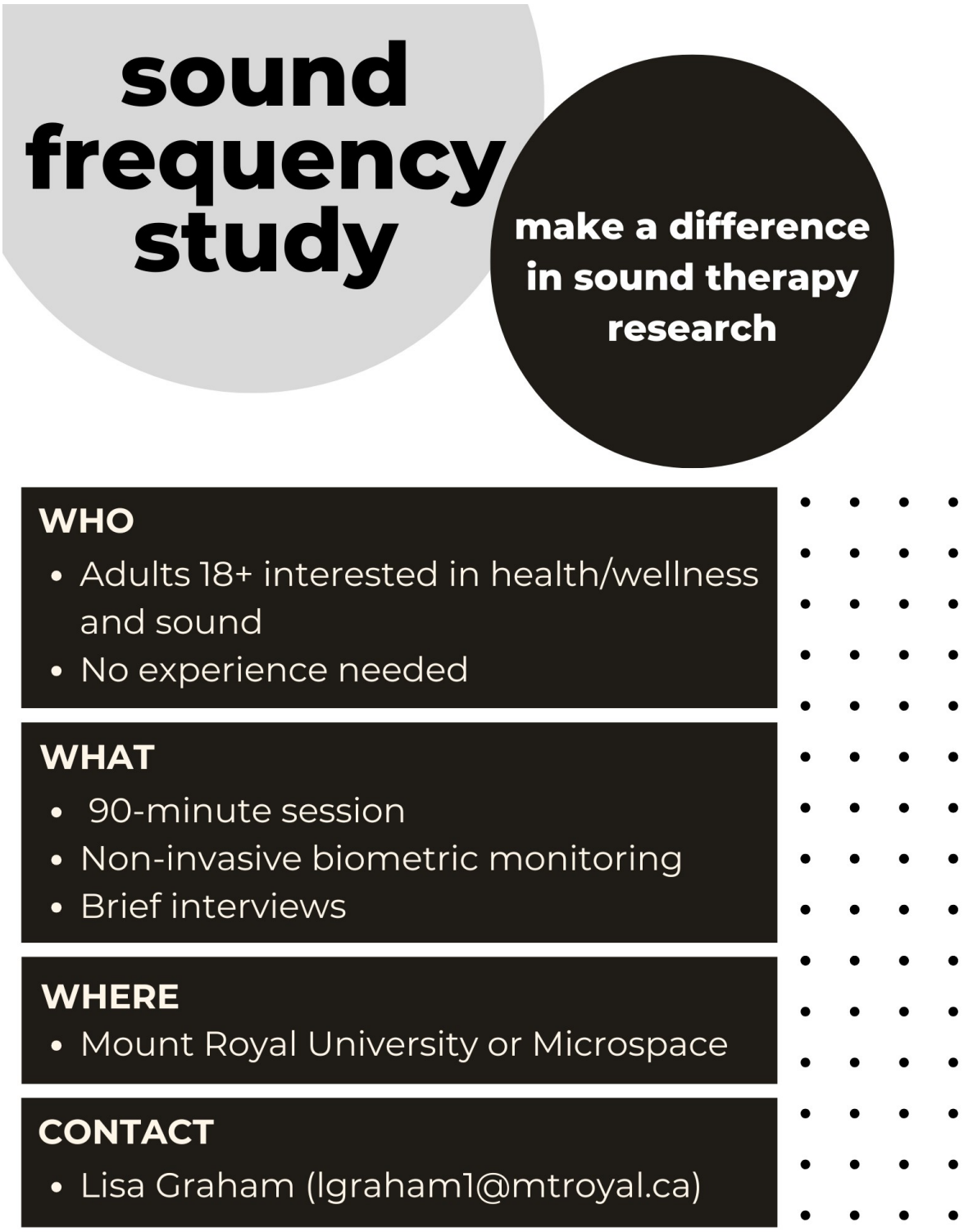
Classified Ad

RESEARCH PARTICIPANTS NEEDED Sound Frequency Study at MRU/Microspace

- 90-minute session
- Non-invasive biometric monitoring
- Must be 18+
- No experience required

Contact: lgraham1@mtroyal.ca

Poster


sound frequency study
make a difference in sound therapy research
WHO
• Adults 18+ interested in health/wellness and sound
• No experience needed
WHAT
• 90-minute session
• Non-invasive biometric monitoring
• Brief interviews
WHERE
• Mount Royal University or Microspace
CONTACT
• Lisa Graham (lgraham1@mtroyal.ca)

Appendix B: Consent Form

CONSENT FORM

Project Title: Measuring Autonomic Responses to Musical Tones: A Biofeedback Analysis of Individual Sound Resonance

Investigators: Lisa Graham, Mathematics and Computing, Faculty of Science and Technology

Contact Information: 403-440-6633, lgraham1@mtroyal.ca

You are being invited to participate in a research project, as described above and in this consent form. Please note this consent form serves to provide an overview of what the research in question is about and what your participation would entail; it is only one part of the consent process. Read this consent form carefully. You should understand the accompanying information. If you have any questions, please ask for help. You will receive a copy of this form.

Summary of the Study:

We are studying how different sound frequencies affect the human body. While some sound treatments are already used in medicine (like breaking up kidney stones), we don't fully understand how different sounds might help with health and healing. Our study will measure how your body responds to different musical tones using simple sensors that track things like heart rate and skin response.

Eligibility Criteria

- Adults over 18 years of age
- Open to non-invasive biometric monitoring
- Available for a 90 minute session
- No experience required

Location of Study

- ☐ Mount Royal University (please note there is paid parking that will not be reimbursed)

- ☐ Microspace (3130 114 AV SE Calgary, Alberta T2Z 3V6; free parking available)

Sensor Details and Placement

- Polar H10 Heart Rate Variability Sensor
    - The sensor is on an elasticised band that will be placed just below your chest muscles with the band wrapping around your torso
    - The sensor will monitor variations in your heart rate

Photo courtesy https://m.media-amazon.com/images/S/aplus-media-library-service-media/a00129ba-cf22-407b-a746-d20841eb75ae.__CR0,0,1940,600_PT0_SX970_V1___.jpg

- Grove Galvanic Skin Response Sensor
    - The sensor is contained in two elasticised bands
    - Bands will be placed on either the tips of the finger or between the first and second knuckle of the index and middle finger of the non-dominant hand depending on participant's anatomy
    - The sensor will monitor changes in sweat gland activity (electrical conductance of your skin)
    - The image below shows an example of the setup (actual sensors are slightly different)

Photo courtesy https://connect.tobii.com/s/article/where-to-place-gsr-electrodes?language=en_US

<u>Participant's Involvement/ What would my involvement entail?</u>

Your participation in this study will consist of one 90-minute session comprised of three parts:

1. Intake interview

    1. Short interview on previous experiences and anticipated confidence and comfort level coming into the study
2. Data collection
    1. Connect sensors
    2. Breathing exercise
    3. Brainwave assessment
    4. Debrief and closing
    5. Sensor removal
3. Debrief interview
    1. Short debrief reflecting on your experience

Collection of Personal Information/ What sort of personal information would be collected and how?

Your name and email will be collected in this consent form. This information will be used to contact you regarding the study. The emails will not be shared and will only be used for follow up communication. The consent forms containing your name and email will be stored separately from the rest of the research.

Your name, gender, and year of birth will be collected in the intake interview. Your gender and date of birth will be used to categorize the data in the data analysis phase of the study.

The interviews and data collection will be audio recorded. This will be used to supplement the researcher's notes on the session. Raw audio will not be used in any publications.

Your comments may be quoted in published works. If this is the case, a pseudonym will be used.

The data collected in this study will be accessed by only the principal investigator. All data will be securely stored in password protected digital devices or locked filing cabinets. Digital data will be stored on physical hard drives and local devices at Mount Royal University. The data will not be stored in a cloud

system. Backups will be done on external hard drives and secured in a locked filing cabinet at Microspace.

All identifiable data such as names and emails will be retained for 7 years following the completion of the study. At this time, digital data will be deleted from the hard drive on which it is stored. Any physical artefacts including consent forms will be securely shredded using the secure shredding box available in the faculty office. Anonymized data may be retained indefinitely for future research unless participants opt out.

_____ (initial): I give consent to be audio recorded during interviews and data collection.

_____ (initial): I give consent to be quoted under a pseudonym. I understand quotes may be paraphrased or combined with quotes from other participants to protect anonymity.

The data generated by this study may be used for future research.

_____ (initial): I give consent for the data I contribute to this study, once anonymized, to be used for future research

Subject to the exceptions noted on this consent form, efforts will be made by the institution and the researchers to keep the information confidential. Such efforts include coding of data.

FOIP Notification

The personal information that you provide to Mount Royal University is collected under the authority of the Post-Secondary Learning Act and the Alberta Freedom of Information and Protection of Privacy (FOIP) Act – Section 33(c). The information will be used for the purpose of conducting the research project. Collected personal information is protected from unauthorized access, collection, use, and disclosure in accordance with the FOIP Act and can be reviewed or

corrected, where appropriate, on request. Questions regarding the collection of personal information can be directed to: Lisa Graham, Math and Computing, Faculty of Science and Technology, Mount Royal University 4825 Mount Royal Gate SW Calgary, AB T3E 6K6. 403-440-6633, lgraham1@mtroyal.ca

Study Risks or Benefits for Participants/What are the risks or benefits involved in my participation?

Risks

Participants may experience skin irritation or a rash due to placement of the sensors against the skin. This is anticipated to be rare although higher risk for those with sensitive skin.

If a rash develops, we will immediately stop the study and provide lotion. We recommend reaching out to a doctor if the rash persists or gets worse after leaving.

Some participants may be triggered by certain tones used in this study. This is anticipated to be extremely rare. To help ensure your well being, you will be asked to provide an emergency contact during the intake interview along with any known auditory triggers and coping mechanisms you currently use.

We **strongly recommend** that you provide an emergency contact in case you experience significant distress during the study. If you choose not to provide one, an alternative distress management plan can be developed with you.

In case of distress, we will immediately stop the study. You will be supported in using your identified coping mechanisms. If you do not have any, you will be guided through a simple breathing exercise. If an emergency contact has been provided, they may be called to support you as you complete your participation in the study.

_____ (initial): I understand that providing an emergency contact is optional and give consent for the research to contact my emergency contact in the case of a triggering event.

If you feel distressed during the study or afterward, please reach out to the Calgary Distress Centre (available 24/7) at 403-266-4375.

Benefits

As a participant in this study, you may benefit from this work by gaining:

- A better understanding of yourself by identifying your personal resonant frequency
- Potential benefit from using the customized tracks for each brainwave state based on your personal resonant frequency (for personal use only)

_____ (initial): I understand this is a research study. The results are not a medical diagnosis, nor does it validate any current treatments I am undergoing. The researchers are not providing me with medical advice or treatment plans.

_____ (initial): I understand the customized tracks are provided for personal use only. Sharing and distributing the tracks is prohibited.

Voluntary Participation and Withdrawal of Consent:

You are under no obligation to participate in this research study.
You are free to withdraw before the data has been analyzed (anticipated to start July 1, 2025. If you participate after this data, data will be integrated within 1 week of your participation) without prejudice to pre-existing entitlements. You will not suffer any disadvantage or reprisal for withdrawing. If you withdraw after this time, we will be unable to remove your anonymized data from aggregate findings.

If you wish to withdraw from the study, please email the principal investigator at lgraham1@mtroyal.ca. Once your email has been received, your consent forms along with any other physical or digital artefacts generated from this study will be securely destroyed.

You will be given, in a timely manner throughout the course of the research project, information that is relevant to your decision to continue or withdraw from participation.

What will happen to the results of this research project?

Preliminary results from this research project will be presented in early July to fulfill course requirements of the Advanced Sound Healing certificate through Globe Institute. After this time, we plan to publish this work in a peer-reviewed journal, Sound Healing Research Foundation, and other publications as opportunities arise.

Compensation:

To thank you for your participation in this project, you will receive a set of four tracks, one for each brainwave state, tuned to your personal resonant frequency. These tracks are for your personal use only and should not be distributed or shared.

Who should I contact if I have concerns regarding ethical issues related to this research project?

If you have any questions concerning your rights as a possible participant in this research, please contact the Research Ethics Officer, at Mount Royal University, 403-440-8470, hreb@mtroyal.ca.

Signature (written consent):

Your signature on this form indicates that you:

- Are voluntarily consenting to participate in this research project,
- understand to your satisfaction the information regarding your participation in the research project and your agreement to participate,
- have not yet commenced participation in the research project – your participation will only begin once you have provided your consent, and
- have been given adequate time and opportunity to:
    - consider the information provided,
    - pose any questions you may have, and

- discuss and consider whether you will participate.

If you have further questions concerning matters related to this research, please contact Lisa Graham, Mathematics and Computing, Faculty of Science and Technology, 403-440-6633, lgraham1@mtroyal.ca.

Best Contact Email: _____

_____	_____	_____
Participant's Name	Signature	Date
_____	_____	_____
Principal Investigator or Delegate's Name	Signature	Date

The Human Research Ethics Board of Mount Royal University has approved this research study.

A copy of this consent form has been provided to you for your records and reference.

Appendix C: Intake Interview Script

Intake Questionnaire

Name

Gender

Year of birth

NOTE: Emergency contact information will be used in case the participant is triggered at all during the session. Participants will be notified that the emergency contact will be contacted if any trigger response occurs.

Emergency Contact

Name

Phone

If no emergency contact is provided, work with the participant to identify a distress management plan

Please complete the Distress Management Plan (No Emergency Contact) form before continuing.

Previous Experience in Sound and Energy Healing

NOTES: These questions are to gauge previous experiences. May include sound baths, reiki, shamanic healing practices, etc

Do you have previous experience with sound or energy healing? Y/N

If so, which modalities?

Are you familiar with home note/soul note/personal resonant frequency? Y/N

If yes,

1. Have you ever determined your home note/soul note/personal resonant frequency? Y/N
2. How would you describe the home note/soul note/personal resonant frequency?

Do you have an existing meditation or meditation-like practice? **NOTE: This question is used to see if there is a difference in the overall assessment experience for meditators of varying experience.**

NOTES: These questions are to gauge attitudes on intuitive practices vs scientific methods

In general, I feel like I am a logical person.

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

In general, I feel like I am an intuitive person.

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

Prior to Participation

NOTE: These questions are to gauge participant comfort and confidence in the ability of themselves or the biometric sensors to identify their personal resonant frequency prior to the assessment. Although the sensors may be useful, if the participant does not think the process will be comfortable, usage of these sensors in practice may not be viable.

Comfort with Intuition and Sensors

Based on what you expect this experience to be, do you think you will be comfortable intuitively identifying your personal resonant frequency?

Based on what you expect this experience to be, do you think you will be comfortable using the galvanic skin response sensor to identify your personal resonant frequency?

Based on what you expect this experience to be, do you think you will be comfortable using the heart rate variability sensor to identify your personal resonant frequency?

Confidence in Intuition and Sensors

Do you think you will be confident you have identified your personal resonant frequency?

Do you think you will be confident that the biometric sensors will be able to identify your personal resonant frequency?

Known Triggers

You will be listening to a series of tones played on crystal bowls. Do you have any known auditory triggers that may come up as we proceed with this study? Y/N

If so, are there any coping mechanisms we can help with if a situation like this arises? This is important for us to know in case we need to support you through a trigger response.

As acknowledged in the consent form, the researcher will reach out to your emergency contact if a triggering event occurs.

Appendix D: Breathing Exercise Script

- Settle into a comfortable position. We will be here for a while, so be sure to adjust yourself as much as you need as we get started.
- If at any time you feel uncomfortable with this guided breathing exercise, you may return to any breathing exercise you are comfortable with keeping your focus on the breath.
- If it’s comfortable for you, close your eyes.
- Begin to draw the attention to any physical sensations you are experiencing. If the sensors feel uncomfortable, please tell me and we can adjust them.
- Notice how your breath feels as it enters and exits your body.
- Begin to lengthen the inhales and exhales as you sink further into relaxation.
- For the next few moments, we will be exploring the edges of our breath. We naturally pause at the top and bottom of the breath. In this exercise, we will explore continuous motion in the breath. When you inhale, try to find the edge of the inhale and immediately start an exhale. As your exhale draws toward completion, immediately start the inhale. You will notice this exercise requires complete focus. If you begin to think about other things, you are no longer present with your breath. Simply restart the exercise.
- Allow the participant to do the exercise on their own for some time.
- When you reach the end of your next breathing cycle, you can release the disciplined breathing and return to a natural breathing cycle.

Appendix E: Debrief Interview Script

NOTES: With the above questions or something similar, we want to get the comfort level of participants for each method. Although the sensors may be useful, if the participant is not comfortable with the process, potential use in a practical scenario could be affected.

Comfort with Intuition and Sensors

Based on the experience itself, would you recommend others to intuitively identify their personal resonant frequency?

Based on the experience itself, would you recommend others to identify their personal resonant frequency using the galvanic skin response sensor?

Based on the experience itself, would you recommend others to identify their personal resonant frequency using the heart rate variability sensor?

Confidence with Intuition and Sensors

How confident are you that you have intuitively identified your personal resonant frequency?

How confident are you that the biometric sensors have identified your personal resonant frequency?

Closing Thoughts

Do you have any other thoughts to share based on your experience?

Appendix F: Distress Management Plan Form

For participants who do not provide an emergency contact, complete this form.

Participant Name: _____

Date: _____

Known auditory triggers (if any):

2. Preferred Coping Mechanisms (check all that apply or list below):

☐ Grounding techniques

☐ Breathing exercises

☐ Guided meditation

☐ Stepping outside/leaving the space

☐ Quiet environment

☐ Journaling

☐ Speaking with a mental health professional

☐ Other: _____

3. Researcher-Supported Coping Actions (if distress occurs):

☐ Guided breathing exercise

☐ Private, quiet space for recovery

☐ Participant-led grounding strategy

☐ Option to end session early

☐ Referral to Calgary Distress Centre

☐ Other: _____

4. Support Network (optional):

The participant has identified the following informal or professional support they may choose to access after the study, if needed:

(e.g., therapist, trusted friend, campus wellness centre)

5. Researcher Notes / Special Considerations:

Participant Signature: _____ Date: _____

Researcher Signature: _____ Date: _____

Appendix G: Distress Protocol Script

In case of participant distress:

1. Immediately stop study
2. Guide participant through personal coping mechanisms (if needed) or breathing exercise (box breathing)
3. Ask the participant if they would like to continue. Remind them they are welcome to leave the study at any time.
4. Continue with the study or wrap up the study as chosen by the participant.
    1. Contact emergency contact to ensure the participant has support after leaving.
    2. If no emergency contact is specified, follow distress management protocol defined in intake interview

In a crisis, contact Campus Security (403-440-5900) or 911 if a threat is imminent.

All participants in distress will be referred to the Calgary Distress Centre - 403-266-4357.

Appendix H: Researcher Script

5 minutes - welcome, introduction to study, questions, consent forms

10 minutes - intake interview (see script with notes)

5 minutes - set up sensors/headphones and settle participant

- Set up Polar H10 sensor
    - Moisten electrode area of strap
    - Fasten strap around chest and adjust to fit snugly
    - Attach connector
    - Verify sensor is comfortable
    - Verify sensor is connected and tracking correctly
- Set up GSR sensors
    - Have participant wash their hands with soap and water (no alcohol including hand sanitizer)
    - Moisten electrodes
    - Place electrodes on the tips of the index and middle fingers of the participant's non-dominant hand if possible. If there is difficulty placing the electrodes on the tips of the fingers, move them between the knuckles (middle of the fingers)
    - Verify sensor is comfortable
    - Verify sensor is connected and tracking correctly

10 minutes - breathing exercise - never-ending breath for focus and centering

- Script
    - Settle into a comfortable position. We will be here for a while, so be sure to adjust yourself as much as you need as we get started.
    - If at any time you feel uncomfortable with this guided breathing exercise, you may return to any breathing exercise you are comfortable with keeping your focus on the breath.
    - If it's comfortable for you, close your eyes.
    - Begin to draw the attention to any physical sensations you are experiencing. If the sensors feel uncomfortable, please tell me and we can adjust them.
    - Notice how your breath feels as it enters and exits your body.
    - Begin to lengthen the inhales and exhales as you sink further into relaxation.
    - For the next few moments, we will be exploring the edges of our breath. We naturally pause at the top and bottom of the breath. In this exercise, we will

explore continuous motion in the breath. When you inhale, try to find the edge of the inhale and immediately start an exhale. As your exhale draws toward completion, immediately start the inhale. You will notice this exercise requires complete focus. If you begin to think about other things, you are no longer present with your breath. Simply restart the exercise.

- Allow the participant to do the exercise on their own for some time.
- When you reach the end of your next breathing cycle, you can release the disciplined breathing and return to a natural breathing cycle.

20-30 minutes - brainwave assessment

5 minutes - guidance out of assessment

- Script
    - Great job! The assessment is now complete. Please return your attention to your breathing. You can return to the breathing technique we started with, use another breathing technique you already know, or simply focus on the air moving into and out of your body
    - Allow participant to proceed for a few minutes
    - When you finish your next breathing cycle, release your focus and return to a normal breathing cycle.
    - As you are ready, open your eyes if they are closed

5 minutes - remove all sensors

15 minutes - debrief, exit interview (see script with notes)

5 minutes - thank you for coming, next steps (send out personalized audio tracks)

TOTAL ~90 minutes

Post-Participant Sensor Care

Polar H10

Connector (note: manufacturer recommends never using alcohol, disinfectant, or abrasive material such as steel wool or cleaning chemicals)

- Detach connector from snaps
- Clean connector with soap and water
- Dry

Strap (note: manufacturer recommends never using alcohol, disinfectant, or abrasive material such as steel wool or cleaning chemicals)

- Rise strap under running water, hand wash in lukewarm water (40C) with mild dish soap, or wash in washing machine at 40C (lower temperatures do not remove impurities from electrode material and higher temperatures damage the strap; do not use bleach or fabric softener)
- Hang to dry avoiding direct sunlight

GSR

Wipe down contact points with soap and water and dry thoroughly