Instilling Empathy among Strangers through Biofeedback

Timothy Min, Grace Leslie
timothymin@gatech.edu
Brain Music Lab
Georgia Institute of Technology
Atlanta, Georgia, USA

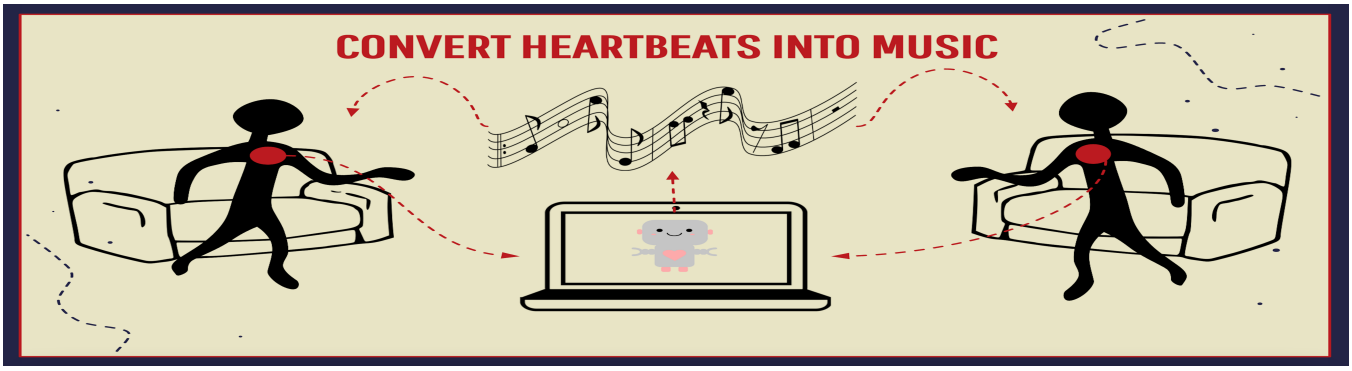

Figure 1: Poster for Empathy for Two installation, 2022.

ABSTRACT

As interfaces and installations controlled by biofeedback continue to grow in popularity, the opportunities for these systems to elicit empathy must be further explored and developed. Past research on empathetic interfaces supports that listening to heartbeats increased the listeners' empathy and emotional perspectives. The first author created an empathetic artistic installation where a musical interface functions using the heart rate of two users. We hypothesized that assigning two users the task of synchronizing heartbeats based on musical biofeedback system will increase the users' levels of empathy towards one another. An informal observational pilot study assessed how the biofeedback-generated musical stimuli induced empathy among strangers, and whether these effects correlated directly to the biofeedback or only the composition design. Observations of behavioral changes and biosignals among participants support the effectiveness of increasing empathy among strangers through such interactions. This installation exhibits design implications for empathetic auditory interfaces, and offers a method to integrate the effects of biofeedback into ensuing virtual designs and installations.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in interaction design**; **Auditory feedback**; **Empirical studies in interaction design**; **Auditory feedback**.

KEYWORDS

Heart Rate, Empathy, Biofeedback, Installation, Heartbeat, Influential, Synchronization, Innovation, Placebo

EmpathiCH '22, April 26, 2022, Virtual Event
2022.

ACM Reference Format:
Timothy Min, Grace Leslie. 2022. Instilling Empathy among Strangers through Biofeedback. In *Empathy-Centric Design At Scale Workshop at CHI 2022*. ACM, New York, NY, USA, 4 pages.

1 INTRODUCTION

Empathy continues to be a prominent reason in our instinctual love for the new and old encounters with people in everyday life. In a room full of strangers, the only immediate commonality of everyone is a beating heart. Without any words or interactions, you still recognize and acknowledge the people around you and their very presence. Everyone that we have met or gotten closer to has stemmed from the very interactions that we have built these relationships upon. For many, it may be the very essence of spending all their lives together growing up. For many in the work field, it could be the numerous meetings and collaborations needed for the companies. Regardless of how intensive or minimal these interactions were, each exchange makes a significant impact in our lives. When it comes to our world today, we truly believe that the solution to many of our problems is or points to empathy. What this world needs today more than oil, more than food, or even more than water, is empathy.

Innovation within technology all seems to head towards virtual reality spaces such as Meta's Metaverse. Inside these new reality mediums, the lack of physical interaction is inevitable, but certain design implications can benefit these spaces through empathy. A setting that overrides the lack of physical interaction could stem from presence and connection. An ideal interactivity utilizes biosignals as the main form of interaction, since accessibility would be open to all without limitation.

2 ISOLATION AND MENTAL HEALTH

The entire world has been isolated from each other like never before. The COVID-19 pandemic enforced everyone to be within their own homes with limited to no interactions with strangers or even family members outside of the immediate household. The recent social isolation directly correlates with poor life satisfaction, work-related stress, and lower overall trust.[1] The revelations in the impacts of isolation emphasize even more how essential an interactive experience of relational human experience remains.[4] This installation design aspires from the necessity for interactions and relational presence whether the communicator is human or artificial intelligence. The hope lies upon employing virtual reality to blur the boundaries of human and machine, and concentrating on instilling empathy through the interchanges.[3] Physical boundaries would no longer be the limitations of our interactions. Whether the communication happens from a different human user or a generated entity, interactions can occur leading to growth in immediate empathy.

3 PREVIOUS RESEARCH

There is evidence that the psychological and physiological mechanisms behind felt and recognized emotions in music will apply to an auditory heartbeat and create changes in the cognitive and affective empathy of listeners. [8] According to Mike Winter's research, mechanisms of empathy validated the effectiveness of auditory stimuli and its capability of enabling increased empathy. If the components of listening to an auditory heartbeat exhibited similar physiological mechanisms of listening to music, then a musical biofeedback system utilizing/implementing the heartbeat would encapsulate both the ideas. Furthermore, studies on the link between music and empathy confirmed its validity and how music perception and cognition affect social cognition. [7] The previous research on empathetic influence of auditory biosignals and music-based empathy supports the notion that an interactive, musical installation controlled by biosignals will increase the levels of empathy of the users.

4 DESIGN IMPLICATIONS FOR INSTALLATION

As the COVID-19 pandemic struck the entire world, the task of optimizing a public installation for multiple users became more toilsome as time progressed. Not only would the design have to incorporate a public, multi-user system, but the installation must also abide by all the rules and precautions enforced because of the pandemic.

The initial idea would be to connect a Ganglion board through OpenBCI, a program specifically made to read biosignals. Through OpenBCI, we can retrieve, EEG (electroencephalogram) data, EMG (Electromyography) data, and ECG (electrocardiogram) data from a user. This ECG data would then be sent to Max/MSP, a visual programming language for music and multimedia, where it would be converted as incoming OSC messages from OpenBCI into number messages which can further be processed to calculate for peaks. The peaks would illustrate the heartbeats from the user accurately and reliably. However, the main issue with this setup persists within its turnaround rates. The setup of ECG recordings requires at least three ECG electrodes to be attached to the chest cavity of the user, and adjustments of the incoming signals and electrode placements require re-calibration and decent time. Also, since sanitation remains vital to this project, every ECG recording would require the disposing and renewing of the electrodes per person. Not only is this method quite expensive but also seems equally detrimental in an ecological standpoint. Due to these reasons, we began looking towards a more analog method.

The analog method refers to the application of pulse sensors. Pulse sensors simply require the user to apply their finger above a given light. The given light allows for the sensors to calculate the heartbeat based on change in blood flow. The two pulse sensors were connected directly to an Arduino ported to a computer. Within the computer, two softwares run simultaneously, Max/MSP and Ableton. Max/MSP receives the data from the Arduino and sends a trigger per heartbeat. These heartbeats begin a list of different algorithms which calculate a heart rate and difference of heart rate between the two users. These differences in beats per minute ultimately control the amplitudes of five layers of harmonies in Ableton. The closer the heart rates are, the more harmonies you will hear. The further the heart rates become, the harmonies begin to die out, until the threshold is passed once more.

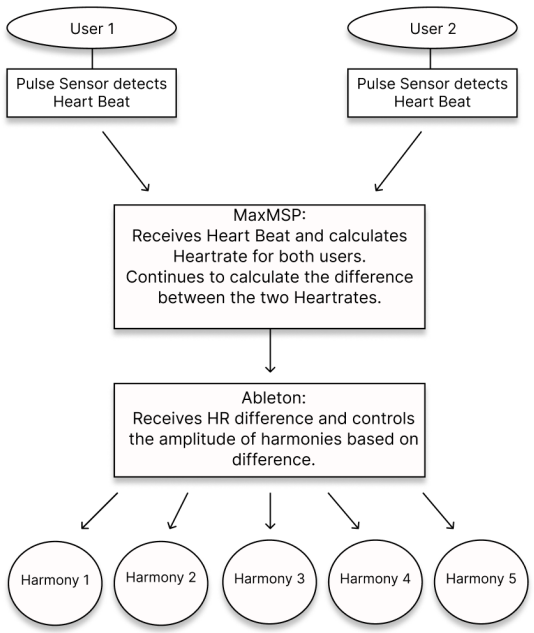

Figure 2: Flow Diagram of Design.

5 MUSICAL CHOICE AND APPLICATION

Musical choice remains as one of the most imperative portions of this installation. As typical as this component may seem, this selection could either advance or deter this entire process. An evaluation of the direct results of empathy guided the process of musical choice. Forms of empathetic measurement describe how a decrease in heartrate led to higher affective empathy, and this may be due

to changes in emotional perspective and increased emotional convergence. These parasympathetic activations signal emotions of relaxation, calm and safety which we ultimately correlated closest with nostalgia. The Oxford dictionary defines nostalgia as "a sentimental longing or wistful affection for the past, typically with a period or place of happy personal associations." Nostalgic music not only exhibits the exact desired emotional status, but it also carries a musical tempo similar to the average human heart rate. Such tempos outside of the average human heart rate could potentially influence the heart rate in confounding manners. In addition, the musical choice should not have nodes of too much excitement or too depressing qualities that could additionally impact the heart rates.

In an informal observational study of 10 listeners (2 women), each participant heard four examples of musical pieces that we felt expressed nostalgia. The four examples are "Squares Suspended" by Andrew York, "Mysterious Barricades" by François Couperin, "Mia and Sebastian's Theme" by Justin Hurwitz, and "Pavane Pour Une Infante Défunte" by Maurice Ravel. Of the four choices, the majority chose "Pavane for a Dead Princess" by Maurice Ravel to have evoked the most nostalgic emotions within them. Within the responses received for this piece, many participants expressed that the piece had a peaceful, happy mood, yet not joyful or excited. To follow up, they also shared how something about the composition seemed rather melancholy but not depressing.

Based on the previous observations, the first author composed a reharmonization of the piece in Ableton Live where the main harmonic structures remain the same for the motif, but the layers of harmonies differ immensely in intended exemplification. A few of the layers focus strictly on the melodic thirds and fifths, while others will almost seem like swaying amplifications of the bass chords.

6 MEASURING DATA AND EMPATHY

The most difficult aspect of tackling empathy as a subject is measurements. No specific neurological or physical body signal could be precisely connected with a level or change of empathy. However, many researchers have developed certain tools of empathy measurement that give insight into whether significant change has occurred that correlates to empathy. The four measurements considered for this installation are user feedback, Interpersonal Reactivity Index, Behavioral Options, and Heart rate.

User feedback and the Interpersonal Reactivity Index (IRI) work in collaboration with each other. Originally, the IRI exists as a questionnaire to measure how empathetic someone is. [2] This task stems from the idea that everyone inherently has different levels of empathy. Implementing a mixture of some random questions in the IRI deters any assumptions of the task of the installation and appends some new user feedback questions for the survey before and after the installations.

In our discussions of potentially new methods of measuring empathy, the Behavioral Option deemed to be a possibly groundbreaking statistical measurement. For example, if a dollar was given to every participant and they are all informed that they could donate that dollar to a charity before the installation. After the installation had taken place, once again, they are reminded that they could donate the dollar to a charity if they so desire. If they had chosen to keep the dollar initially but chose to donate after the installation, this change in willingness may be derived from an increase in empathy due to the installation. Previous research seems to support that an increase in empathy and empathetic concern lead to prosocial behavior. [6] Therefore, witnessing a change of willingness could imply a direct correlation between empathy and disposition.

Finally, heart rate exists significant in all empathy research. Existing studies place heavy emphasis on how a notable decrease in heart rate implies an increase in empathy, and this observation continues to be true among all other empathy research so far. However, one study compared subjects with different levels of affective empathy which resulted in high empathy subjects exhibiting a slight drop and then an increase in heart rate, whereas low-empathy subjects showed a steady decline in heart rate.[5] The given result could suggest different analysis methods for future data analysis of the heart rate data.

7 FINDINGS FROM PUBLIC INSTALLATION

In January 2022, the Empathy for Two installation was opened to the public. While data had not been collected from the participants, some notable observations proved significant to future design implications.

The first finding calls attention to heart rate of the users. Within the numerous pairs utilizing the system, every duo, except for one pair, achieved a perfect synchronization or within 5 beats per minute of each others heart rate. These strangers started the installation at completely different heart rates yet their hearts found a point of unity separate from the music's average tempo. Even though, the exact neurophysiological relationship between the musical biofeedback and empathy may be vague, this discovery seems to prove the efficacy of such systems.

As for the one pair of strangers who couldn't reach within 5 bpm of each other, the reasoning lies within the initial heart rate. Of the two strangers, the initial heart rate difference stood around 25 bpm difference. During the installation, both parties had come closer to each other's heart rates but could never surpass a difference of 10 bpm. Perhaps a significant difference in resting heart rates may never be adequate for unification regardless of scenario.

The second finding refers to a placebo effect. During two of the interactions, one of the sensors had corrupted data from incorrect finger placement and light sensitivity. In order to at least simulate the idea of user-driven change, we manually reconfigured that sensor to a specific false heart rate. In both scenarios, the users audibly witnessed the changes in harmonies and truly believed that their heart beats modulated the composition, when in reality, their biosignals had no effect on the system. Even in this scenario, the users seemed to verbally express an increase in empathy towards the stranger. This finding brings about further discussion on utilizing placebo instead of actual biofeedback as a means of evoking empathy.

The third finding suggests the effectiveness of the Behavioral Method. In the public installations, every participant was given a piece of candy of their choice. Prior to the start of the installation, the participants are given the option of keeping the candy or donating it to a box which would be redistributed to random students.

Not a single participant donated their candy prior to the installation. However, after the installation, they are offered once more the opportunity to donate the candy if they so desired to. Nearly half of all the participants decided to donate their candy after the heart beat synchronization. This observation advocates for measuring empathy through behavioral measures. The fact that almost half of the participants overturned their initial choice supports that this installation had an immediate increase in empathy among the users.

8 DISCUSSION

Though the findings of the public installation are provocative and intriguing, each discovery has a limitation to its current legitimacy. Without being able to collect precise data from the participants, all these findings are strictly observations with no viable statistics to prove otherwise. Further research and reiterations of this installation may help to legitimize the efficacy of musical, biofeedback interfaces as a means of evoking empathy.

If the further studies support the original hypothesis and prove that witnessing the synchronization of heartbeats increases empathy, would a fake musical experience of a prerecorded synchronization affect the participants in the same manner? The discussion of what entices and increases empathy would be extended to discuss whether the actual biofeedback and intervention must occur or simply the persuasion that action and intervention is occurring is enough. In the case that the placebo effect is effective as a means of increasing empathy, this research may hopefully encourage different methods or approaches in therapy or consultation where true biofeedback or association is not necessary. Furthermore, this result would either support or denounce the significance of the musical design because if the biofeedback proves to be insignificant, then an increase in empathy could only be correlated with the musical design. Even within the musical design, a clear anomaly of the entire setup remains if the tempo of the music affected the heart rates of the participants. Even though the points of unity occurred away from the tempo, the influence of tempo on heart rate should not be overlooked. Had the musical choice been something of a higher tempo, it is quite possible that the point of unity may be in an elevated bpm. Furthermore, since measurements of empathy correlate to a decrease in heart rate, the proposed tempo and musical choice may have a greater factor on its capabilities of eliciting empathy than the actual biofeedback setting. Another important aspect of appreciating the beauty of placebo translates into virtual realities. If the placebo effect convinced the participant of communicating with the other user, could it function in the same manner with a non-human entity? Since artificial intelligence continues to grow as a prominent portion of innovation, witnessing AI in empathetic settings in the future would not unanticipated. Perhaps a participant may not possess any empathy towards or with an AI; however, if the participant falsely believes that the other user is human, the interactions demonstrate the same empathetic qualities as the human interactivity.

9 CONCLUSION

The Empathy for Two installation has finally been formulated from end to end. A public installation of this musical, biofeedback interface has been demonstrated and observed with local community participants. The installation seems to advocate for the adequacy of increasing empathy among strangers through observations in behavioral changes and biosignals. The design implications and findings within this installation may prove to be beneficial to future empathetic interfaces whether through human interaction or virtually.

10 ACKNOWLEDGMENTS

Once again, I am beyond thankful and appreciative for all the discussion and conversation I was able to have with my advisor, Dr. Grace Leslie. Our conversations are not only full of wisdom and insight, but also filled with care and optimism. I would not have a sense of direction in any of my work if it was not for her guidance and desire to see her lab students grow in their passions. Next off, I would like to thank Thiago Roque, Alex Cohen, and Mike Winters for their immense contributions to this project. Truly without the three of them, this installation would have never come past the ideation phase. I'd like to also extend my gratitude to the Brain Body Music Lab. Truly, I feel as though I've created bonds with some of the members that I cherish deeply, and hopefully will have the opportunities to continue to build upon them. Finally, I'd like to thank all my fellow Music Technology colleagues for their wonderful responses and advice in research, but ultimately for the joy and laughter. Finally, my gratitude and appreciation stretch to the publications support and staff.

REFERENCES

[1] Ruta Clair, Maya Gordon, Matthew Kroon, and Carolyn Reilly. 2021. The effects of social isolation on well-being and life satisfaction during pandemic. *Humanities and Social Sciences Communications* 8, 1 (Dec. 2021), 28. https://doi.org/10.1057/s41599-021-00710-3

[2] Mark H. Davis. 1983. Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology* 44, 1 (Jan. 1983), 113–126. https://doi.org/10.1037/0022-3514.44.1.113

[3] Andrea L Guzman and Seth C Lewis. 2020. Artificial intelligence and communication: A Human–Machine Communication research agenda. *New Media & Society* 22, 1 (Jan. 2020), 70–86. https://doi.org/10.1177/1461444819858691

[4] Judith V. Jordan. 1997. Relational development through mutual empathy. In *Empathy reconsidered: New directions in psychotherapy.*, Arthur C. Bohart and Leslie S. Greenberg (Eds.). American Psychological Association, Washington, 343–351. https://doi.org/10.1037/10226-015

[5] Albert Mehrabian, Andrew L. Young, and Sharon Sato. 1988. Emotional empathy and associated individual differences. *Current Psychology* 7, 3 (Sept. 1988), 221–240. https://doi.org/10.1007/BF02686670

[6] Daniel Pimentel, Sri Kalyanaraman, Yu-Hao Lee, and Shiva Halan. 2021. Voices of the unsung: The role of social presence and interactivity in building empathy in 360 video. *New Media & Society* 23, 8 (Aug. 2021), 2230–2254. https://doi.org/10.1177/1461444821993124

[7] Zachary Wallmark, Choi Deblieck, and Marco Iacoboni. 2018. Neurophysiological Effects of Trait Empathy in Music Listening. *Frontiers in Behavioral Neuroscience* 12 (April 2018), 66. https://doi.org/10.3389/fnbeh.2018.00066

[8] R. Michael Winters, Bruce N. Walker, and Grace Leslie. 2021. Can You Hear My Heartbeat?: Hearing an Expressive Biosignal Elicits Empathy. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–11. https://doi.org/10.1145/3411764.3445545