"It sounds like she is sad": Introducing a Biosensing Prototype that Transforms Emotions into Real-time Music and Facilitates Social Interaction

Xi Lu
Indiana University Bloomington
Bloomington, IN, USA
xlu2@iu.edu

Xiaohang Liu
Indiana University Bloomington
Bloomington, IN, USA
liu351@iu.edu

Erik Stolterman Bergqvist
Indiana University Bloomington
Bloomington, USA
estolter@indiana.edu

ABSTRACT

This paper introduces a biosensing prototype that transforms emotions into music, helping people recognize and understand their feelings and actions and those of other people. This study presents a series of three experiments with 20 participants in four emotional states: happiness, sadness, anger, and neutral state. Their real-time emotions were captured through a wearable probe *Audiolize Emotion* that detects users' EEG signals, composes data into audio files which are played to users themselves and others. At last, we conducted observations and interviews with participants to explore factors linked with social interaction, users' perceptions of music, and the reflections on the use of audio form for self-expression or communication. We found that *Audiolize Emotion* prototype triggers communication and self-expression in two ways: building curiosity and supporting communication

CHI'19 Extended Abstracts, May 4–9, 2019, Glasgow, Scotland UK

ACM ISBN 978-1-4503-5971-9/19/05.
https://doi.org/10.1145/3290607.3312784

KEYWORDS
Biosensing; wearables; music; social interaction; emotional expression; communication

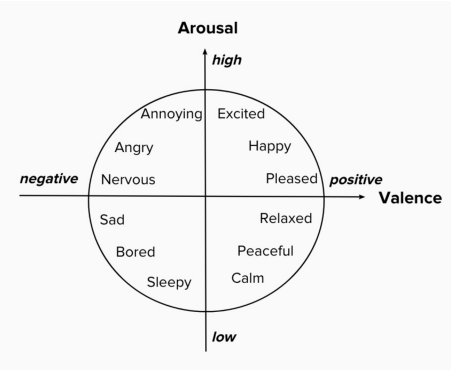

Figure 1: valence-arousal emotion state

by extending expression form. Based on the results, we provide future directions to explore the field of emotion and communication further and plan to apply the knowledge into more fields of VR game and accessibility.

INTRODUCTION

We present a wearable emotional biosensing prototype called *Audiolize Emotion* to propose an innovative way to express emotion and augment current methods of communication, which mostly focuses on speech and visualization in the field of HCI [4]. In this study, we aim to examine the approach which leverages music and biosensing technology together to see whether it could work as an alternative design space of self-expression and communication.

Our fast-paced world leads to less space for expressing emotions and communicating with others. People are exploring multiple ways to communicate with each other in a more efficient and direct way, such as the prevalent use of expression stickers and short videos. Furthermore, verbal communication is limited and sometimes even creates misinterpretations due to language barriers and individual differences caused by culture and/or personality. Hence, there is an urgent need for researchers to explore new communication methods that produce fewer misinterpretations and constraints. In the field of HCI, emotional expressions and nonverbal communications are mainly focused on visualization and tactile sensation, such as body gestures, facial expressions, and touch [12]. However, human beings have a long history of utilizing music to express feelings and opinions while we found fewer studies that explore the possibility of aural interaction for emotional expression and communication. Therefore, through our work, we would like to argue the possibility of leveraging music as one nonverbal way to attend to language barriers and individual differences frequently seen in verbal communications. For our current progress, we have explored people's perceptions and interpretations of this innovative interaction, which transforms emotion into music, to generate insights for the further nonverbal interaction.

We aim to answer these questions in this paper: Whether could people correctly perceive emotional music? How do people interpret the emotional music? Would people accept this kind of nonverbal interaction? Can this design trigger people's social interaction in a positive way? What factors may influence people's use of this biosensing wearables?

RELATED RESEARCH AND RELATED WORKS

Emotion is a subjective feeling of complex state when people are aroused, contributing to both physical and psychological variances that, in turn, influence people [2]. Russell (1980) [14] proposed a circumplex model of emotion which is a structure formed by two dimensions of valence and arousal, as shown in Figure 1. Based on this emotion categorization, we chose four distinct emotions for our test: happy, calm, sad and angry. To detect emotion, Lauwereins (2012) [9] and Maia (2017) [11]

Figure 2: prototype

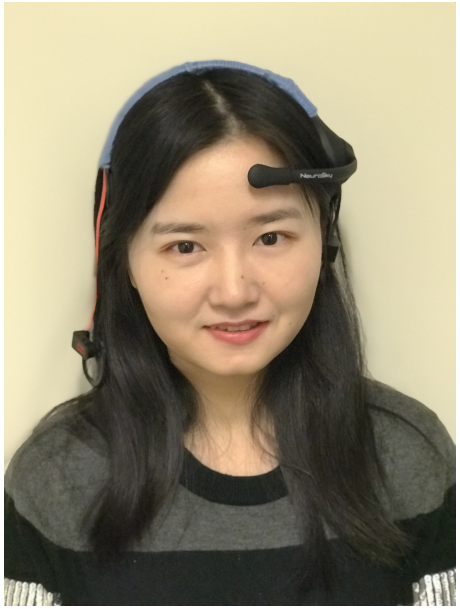

Figure 3: user wearing *Audiolize Emotion*

suggest using psychophysiological sensors, such as EEG(electroencephalogram) which measures brain's electrical activity and EEG is proved to be related with valence and arousal.
Researchers are now exploring multiple ways to represent emotion through biosensors to improve communication. Ashford (2014) designed a LED-screen pendant to visualize emotion by sensing EEG data [1]; Howell (2018) discussed a case study by designing a T-shirt with biosensors to investigate people's perceptions toward emotional visualization [7]. Furthermore, research and design projects indicate a close relationship between music and emotion. Chuang at el (2015) created an interactive music instrument which automatically generated music based on user's emotional states [5]; However, research seldom explores how to audiolize real-time emotion through wearable emotive designs. Therefore, we created a headphone prototype which aims to expand current methods of communicating through a wearable biosensor device to collect EEG signals which represent real-time emotion and transform it into music.

AUDIOLIZE EMOTION PROTOTYPE SYSTEM DESIGN

The *Audiolize Emotion* prototype (Figure 2, 3) consists of three parts: brain signals sensors, a data processing system, and the output of music. We used the existing Neurosky MindWave Mobile device as a sensor to detect faint brainwave signal in this study. When people wear the prototype, the Alpha signals are transferred to the computer via Bluetooth for data processing. Certain types of emotion will be detected, augmented and algorithmically transformed into various audio files through ChucK, which is a music-focused programming tool. Users then listen to the real-time emotional music played through wireless earphones, which connected with the wearable sensors. The value of EEG for 10 sec was taken as one dataset for each type of emotion, to avoid the errors caused by the moment of muscular movements or mental distraction.
We tend to see the prototype not as a final solution, but as one possible way to display our design concept of transforming emotion into music. During different stages of the research, we changed different forms of the systems, hoping to evoke people's reflections on the design of the system, trigger questions and explore alternative design spaces and potential needs.

METHOD OF STUDY

In this study we explored participants' opinions of using the prototype as well as listening to or sharing the emotional music. This study contains three stages which serve different functions.

Stage 1- collect brainwave for creating emotional music: We recruited 4 participants to collect their brainwave in four different emotional conditions: calm, happy, angry, and sad by watching selected YouTube videos which included keywords of "calm", "happy", "angry" or "sad" in the title. We then transformed the brainwave we collected into emotional music by our algorithm.

Stage 2 - explore participants' perceptions on emotional music to gain insights for improving the algorithm: As we already produced different music pieces (15s-20s) based on brainwaves collected under participants' different emotions, we then recruited 8 participants to listen to these pre-made emotional music and identify what emotion this music conveys. After the experiment, we conducted a quantitative analysis by calculating the accuracy to compare participants' interpretations of the emotion with our own data. We found that happy emotional music (Accuracy=6/6) and sad emotional music (Accuracy=6/6) are easier to be identified than calm emotional music (Accuracy=3/7) and angry emotional music (Accuracy=2/6). Then we compared the values to the qualitative analysis of participants' interpretations to generate insights to further revise the algorithm and create new emotional music.

Stage 3 - utilize the prototype as a probe to study participants' interpretations and personal experiences when interacting with the prototype: We decided to use the Wizard of Oz method to conduct the experiment. We recruited 8 participants and asked each participant to watch a video to trigger one specific emotion. After watching the video, we let the participant wear the prototype and played the premade music (20s) of that specific emotion via the Bluetooth earphone. Then, we conducted a semi-structured interview to ask participants a list of questions: *Do you think it's representative of your current emotion? What do you think of your emotional music? Do you like the music or not? What is your idea about this design by which your emotion can create a music piece and you can listen to it or share it? Any suggestions or ideas?*

FINDINGS

Our findings are centered around these two things:

New form arouses curiosity and conversation. There are many ways to explain curiosity as stated by Daniel Berlyne. He described specific exploration in the context of epistemic curiosity: " [3] the brand of arousal that motivates the quest for knowledge and is relieved when knowledge is procured (pg 274)". *Curiosity and imagination shown on the form of the prototype.* When they first saw the *Audiolize Emotion* prototype, all participants showed enthusiasm in touching it and had questions on what would it do. And some suggested that the prototype can be combined with daily objects like hats or glasses. *Curiosity is triggered by the varied form of emotion from mental activity to material sound.* Almost all the participants have shown curiosity and excitement about how their emotional music would sound. As one participant mentioned, *"This is the first time that I could hear my emotion. It's so interesting!"*-P1

Music as an extensive expression form Emotional music works as an indirect but powerful way to express one's opinions when they don't know how to express their emotions verbally. One participant said, *"If I were bothered by someone that I am not so familiar with, I would like to play my emotional music to show instead of directly expressing my unpleasant."*-P2 Another participant mentioned, *"It*

would be quite useful If I were focusing on my own business and others could know that I prefer to be alone by hearing my emotional music."-P3

Furthermore, as this prototype allows participants to freely create music even without any prior musical skills, this innovative interaction increases participants' self-satisfaction by creating their emotional music. Some participants even expressed their willingness to share their own "work" which they are proud of. One said, *"It gives me a sense of pride as if I created something."*-P4

REFLECTION AND DESIGN IMPLICATION

As Janlert, L. E., & Stolterman, E. noted [8] that people tend to understand and interact with artifacts by thinking of it as having characters which can lead to generating expectations. In our case, participants thought this prototype is innovative and creative. Experiences, such as the curiosity, the imagination of what music that will be produced, the pride of creating their own music, and the reflection of hearing their own emotional music, are triggered when wearing the prototype. These experiences actually augment people' s performance as participants know that their different actions could create corresponding music, making doing things more interesting.

Emotions are contagious as it facilitates social interactions by synchronizing brain activities across different people [13]. Therefore, our finding, which suggests that music can be an alternative and even more powerful way to express one' s emotion rather than words in some situations, indicates that our prototype could facilitate social interactions as well. Specifically, for people who are not good at or unable to articulate their emotions, our prototype could greatly benefit them.

Based on above reflections, our research findings suggest some opportunities where this design could be applied to: *Embedded into a VR game.* As the background music of video games can increase players' immersion [10], therefore, we propose to apply our design to VR game to create players' own real-time emotional music based on their mental activity to make players more immersed into the game, augmenting their game performance. *Care for people with autism.* It is sometimes difficult for people to communicate with people who have autism. In fact, people with autism don't lack emotions but have trouble identifying them [6]. Therefore, we propose our design could be utilized to help people with autism communicate with others by sharing their emotional music.

CONCLUSION

Our design contributes to the HCI community by presenting the possibility of leveraging music, something which HCI researchers seldom focus on, as one innovative way of expressing emotions to facilitate social interactions and augment performance. To achieve the goal, we designed and built an interactive prototype which transforms emotions into real-time music by detecting EEG signals. Through analyzing user's reflections by using both qualitative and quantitative methods, we found that music expression triggers curiosity and communication, also works well by breaking through the

ACKNOWLEDGE

We appreciate Dr. Robert Goldstone for his advice on the knowledge of EEG signals and Andrew J Hunsucker for his advice on paper writing.

language barrier as an extensive expression form. We believe that a wide range of applications, such as VR and accessibility, can be enabled by applying our *Audiolize Emotion* concept. To eliminate the hesitation of wearing the design in a more casual social setting, we plan to iterate on the appearance of the prototype by trying different texture to make it become ideally suited for the daily wear. Furthermore, we will iterate on the algorithm to create more pleasing music which may further encourage users' willingness to share their own emotional music.

REFERENCES

[1] Rain Ashford. 2014. Responsive and Emotive Wearables: Devices, Bodies, Data and Communication. In *Proceedings of the 2014 ACM International Symposium on Wearable Computers: Adjunct Program (ISWC '14 Adjunct)*. ACM, New York, NY, USA, 99–104. https://doi.org/10.1145/2641248.2642731

[2] A Ashtaputre-Sisode. 1992. Emotions and Brain Waves. *The International Journal of Indian Psychology* 3, 2 (1992), 14.

[3] D.E. Berlyne. 1960. *Conflict, arousal, and curiosity*. McGraw-Hill Book Company, New York, NY, USA.

[4] Daniel Boyarski and Richard Buchanan. 1994. Computers and communication design: Exploring the rhetoric of HCI. *Interactions* 1, 2 (1994), 25–35.

[5] Galen Chuang, Shelley Wang, Sara Burns, and Orit Shaer. 2015. EmotiSphere: From Emotion to Music. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '15)*. ACM, New York, NY, USA, 599–602. https://doi.org/10.1145/2677199.2688809

[6] Sebastian Gaigg. 2019. People with autism don't lack emotions but often have difficulty identifying them. https://theconversation.com/people-with-autism-dont-lack-emotions-but-often-have-difficulty-identifying-them-25225.

[7] Noura Howell, Laura Devendorf, Tomás Alfonso Vega Gálvez, Rundong Tian, and Kimiko Ryokai. 2018. Tensions of Data-Driven Reflection: A Case Study of Real-Time Emotional Biosensing. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 431, 13 pages. https://doi.org/10.1145/3173574.3174005

[8] Lars-Erik Janlert and Erik Stolterman. 2017. *Things that keep us busy the elements of interaction*. The MIT Press, Cambridge, MA, USA.

[9] Rudy Lauwereins. 2012. Biomedical Electronics Serving As Physical Environmental and Emotional Watchdogs. In *Proceedings of the 49th Annual Design Automation Conference (DAC '12)*. ACM, New York, NY, USA, 1–5. https://doi.org/10.1145/2228360.2228362

[10] Laura Levy. 2015. *The effects of background music on video game play performance, behavior and experience in extraverts and introverts*. Ph.D. Dissertation. Georgia Institute of Technology, Atlanta, GA.

[11] Camila Loiola Brito Maia and Elizabeth S. Furtado. 2017. ReTUXE: A Framework for User's Emotional Evaluation Based on Psychophysiological Measures. In *Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems (IHC 2017)*. ACM, New York, NY, USA, Article 64, 4 pages. https://doi.org/10.1145/3160504.3160577

[12] Albert Mehrabian. 2008. Communication without words. *Communication theory* (2008), 193–200.

[13] Lauri Nummenmaa, Enrico Glerean, Mikko Viinikainen, Iiro P. Jääskeläinen, Riitta Hari, and Mikko Sams. 2012. Emotions promote social interaction by synchronizing brain activity across individuals. *Proceedings of the National Academy of Sciences* (2012). https://doi.org/10.1073/pnas.1206095109 arXiv:https://www.pnas.org/content/early/2012/05/22/1206095109.full.pdf

[14] Yi-Hsuan Yang and Homer H. Chen. 2012. Machine Recognition of Music Emotion: A Review. *ACM Trans. Intell. Syst. Technol.* 3, 3, Article 40 (May 2012), 30 pages. https://doi.org/10.1145/2168752.2168754