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Regulating Drivers' Aggressiveness by Sonifying Emotional Data

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ABSTRACT

There have been efforts within the area of cognitive and behavioral sciences to mitigate drivers' emotion to decrease the associated traffic accidents, injuries, fatalities, and property damage. In this study, we targeted aggressive drivers and try to regulate their emotion through sonifying their emotional data. Results are discussed with an affect regulation model and future research.

1. INTRODUCTION

There is a growing body of evidence that suggests anger is linked to roadway fatalities, injuries, and property damage. It is because difficulties in regulating anger in the driving context could cause maladaptive driving behaviors, such as aggressive driving [6]. However, anger is not an inflexible process. People can change and regulate it at different levels in the emotion generative process. Based on the psychological model of emotion regulation, mitigating negative emotions through cognitive reappraisal could modify overall emotional responses including behavioral and physiological ones. Based on previous research [5], the present paper tries to show that music could be used as a regulatory strategy dependent on the perceived valence and arousal of the musical emotion.

2. MECHANISM

Emotional appraisal [1] is a model designed to discriminate among emotional experiences in terms of their appraisals of their circumstances, especially, effective for discriminating between negative valence emotions [4]. This model includes several orthogonal dimensions of circumstantial appraisal: pleasantness, anticipated effort, attentional activity, certainty, human agency, and situational control [1]. These dimensions are a reflection of mental models people have of their "emotional environments." In particular, anger and sadness were shown to be predicted by appraisals on the *human agency* and *situational control* dimensions, respectively. The human agency dimension is a continuum along which a person appraises the weight of the responsibility and controllability on a scale from "my responsibility/I am in control" to "another person's responsibility/he or she is in control". Anger is characterized by the latter (another persons' responsibility/controllability) consistently. Situational control describes a continuum from human-centered situational control to no human control (e.g., environmental factors, etc.). Sadness was strongly characterized by no human control. On this basis, it is possible that an introduction of stimuli that generate anger or frustration in a person may be mitigated or eliminated by the presentation of stimuli that cause sad appraisals (e.g., sad music) by forcing a *re*appraisal.

To further examine the extent to which music can mediate the driving performance deficits of anger, we designed our experiment to test three hypotheses. In this study, instead of pre-recorded music, we attempt to sonify drivers' physiological data (heart rate and respiratory rate) in real-time. We plan to play their physiological state data in a way that helps aggressive drivers to regulate and decrease their anger. That is, an introduction of sadness with minor key to an angry individual should result in reduced angry state because of the incompatibility of the two appraisals. Assuming that the sad stimuli are not ignored, they should result in a lower other-agency appraisal.

The first hypothesis (H1) is that aggressive drivers presented with "reflective sonification" (e.g., if heart rate increases, sound tempo increases) will show fewer aggressive driving behaviors than the no sonification condition. The second hypothesis (H2) is that aggressive drivers with "regulatory sonification" (e.g., if heart rate increases, sound tempo decreases) will also show fewer aggressive behaviors than the no sonification condition, or even fewer than the reflective sonification group. The third hypothesis (H3) is that the self-rating scores in the other-agency will be significantly lower in the two sonification groups than the no sonification group. The goal of the present study is to see if sonifying drivers' aggression can force cognitive-emotional reappraisal of circumstances.

3. PHYSIOLOGICAL DATA-BASED SONIFICATION DESIGN

The sonification process involved manipulating the stream of data in external software to be scaled to the

MIDI (Musical Instrument Digital Interface) numerical protocol. This MIDI data could then be used by music production software to act as a "player" for the instruments provided within the musical interface.

Pure Data Extended (PD) is the software package that was chosen to process the bio data. Within the file developed in PD, known as a patch, the two lists of data for heart rate and respiration rate were scaled in real-time to fit within the MIDI protocol discussed above. At a rate of 60 Hz the lists were sent a pulse, forcing a line of data through a scaling object with output parameters based on the desired effect or control within Reason, the sequencing and music production software. Inside of the Reason file, there was a single "instrument" that comprised of three layers: a kick drum, bass synth, and flute synth.

The first strategy was to sonify the data in an informative way or we call "reflective sonification". The heart rate data input was scaled to an output between 40 bpm and 240 bpm, the average extremes of human heart rate. This means that as heart rate data were changing, the tempo of the music changed accordingly. The pitch of the instrument was controlled by respiration rate. The respiration rate was scaled to fall between 40 and 80, which represent the notes E2 and G#5. These notes were chosen arbitrarily, as they provided enough pitch range to listeners without becoming too high or too low. This note was then sent through another object within the PD patch that forced the note to fit within the C minor scale, truncating the pitch values if it did not fit, creating a more musical sonic experience.

The second strategy was to sonify the data in an opposite direction, or "regulatory sonification". The goal here is to counteract the user's current state with sonification that represents opposite ends of the data input. For example, heart rate data would control tempo such that as heart rate increases, tempo of the music slows down. Respiration rate would also be reversed, creating lower pitches as the user is breathing faster and vice versa. Another feature of this implementation would be to set a normal level of heart rate, and if the user's heart rate exceeds that level, the sonification is forced into a minor key, calming the user and decreasing arousal. The opposite would also be true, as heart rate moves below the normal level, a major key is chosen, bringing the user to a happier state and increasing arousal.

In conjunction with the methods described above, we also used artistic representation strategies for both cases. The heart rate data controlled the amount of delay effect influencing the flute layer of the instrument in two different manners: 1) as heart rate slowed down, more of the delay effect was introduced, which created a sense of a trance like ambience, representing the meditative state of the subject. As heart rate increased, the delay effect eventually became completely dry and the flute sound was very forward and sharp in the mix.

The respiration data controlled the release of the flute layer of the instrument. As respiration rate decreased, each note of the flute lasted for a longer period of time, creating a droning sensation that pairs nicely with the increased delay effect caused by slow heart rate. As respiration rate increased, the release of the flute became very short and sharp, creating a more percussive tone and a sense of shortness of breath musically.

4. EXPERIMENTAL DESIGN

We will have three groups of drivers: two groups will listen to their physiological data-based sonification, and the remaining group will not listen to any sounds while driving. After completing the consent procedure, participants will be asked to fill out the Aggressive Driving Behavior Questionnaire [2] to delineate between aggressive and non-aggressive drivers. Then, they will respond to human agency and situational control questions [4] and rate their affective states using a Likert scale measuring discrete driving related emotions [3]. To induce anger, participants will write about their personal emotional experiences for 12 minutes and then, will rate their affective states, and human agency and situational control for the second time. Then, they will fall into one of the three groups and drive in a prescribed scenario. After completing the drive, they will answer those three questionnaires one more time.

5. CONCLUSION AND FUTURE WORK

Based on the results of this study, we hope to construct a model relating emotional driving and sonification variables. We also plan future studies with more behavior measurement techniques, such as SCR (skin conductance response), EEG (electroencephalogram), fNIRS (functional near infrared spectroscopy), etc. In-vehicle sonification can also be extended to eco-driving research. For example, we plan to conduct an actual driving study on the road with real-time driving performance sonification based on the data extracted from CAN (controller area network) bus.

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