Effects of Sound Features on the Affective State of Dementia Patients

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Introduction

In the context of a large-scale mixed reality space called the eXperience Induction Machine (XIM), we have developed a real-world sound and music generator called RoBose. In order to express the emotional state of XIM with music, we would like to assess the impact of different sound features on emotions. The effect of music on stress and anxiety has been established using a variety of self-report, physiological, and observational measures. Indeed, music therapy can have physiological and psychological benefits on patients with a variety of pathologies and undergoing differing medical treatments. Nevertheless, recent meta-analyses have shown that strong conclusions cannot be drawn from the literature on music therapy due to a number of methodological problems. Hence, although music is widely used in therapeutic settings, the precise relationship between different musical parameters and affective states is still not clear.

To address this issue in the context of Alzheimer Disease (AD) we developed an automated test procedure that assesses the correlation between the timbre, spectral content, intensity, tempo and consonance of a set of parameterized sound samples with the self-reported emotional state of AD patients and age matched controls.

Methods

We performed a quantitative psychosocial study using self-report measures. A total of 82 subjects ranging from 51 to 92 years of age, diagnosed with dementia, and with sufficient verbal ability participated in this study. Also 24 aged matched controls served as control subjects.

Each subject was seated in front of a computer and interacted with a custom-made stimulus delivery and data acquisition software system (Figure 1). A number of sound samples from a database of 54 samples were randomly presented together with a dialog. Each sample was defined as a triplet of sound parameters (Figure 2) based on sound source (Synthesizer, Water, Singing Voice), sound feature (Loudness, Brightness, Consonance, Tempo) and feature levels (Low, Medium, High). The subject had to rate each sample in terms of their emotional content (Valence, Arousal, Anger, Pleasants) using a percentage scale by moving a slider on the screen.

Results

Our results show that the control and patient groups had significantly different emotional reactions to the sound samples for valence and arousal. We also found that the sound source had a direct impact on the reported emotional state of the patients. On the other hand we found that the other sonic features didn’t have any significant impact on the patients’ ratings.

Alzheimer Patients and Control Group Rate the Sounds Differently for Valence and Arousal

The Mann-Whitney non-parametric test (Figure 3) shows that Alzheimer patients and Controls give statistically significant different ratings for Valence and Arousal only (p<0.05). The patients tend to give lower valence and higher arousal than Controls.

The Origin of the Sound Matters

The Kruskal Wallis non-parametric test (Figure 6 and 7) shows that the origin of the sound (water, synthetic, vocal) is significant (p<0.05) for Valence, Arousal and Pleasantness ratings but not for the Fear ratings.

Per Alzheimer Patients: Water is the happiest while Voice is the saddest. Water is the most relaxing while Voice is the most stressing and they liked the water the most while they disliked the voice the most.

Per the Control Group: Water is the happiest while Synthesizer is the saddest. Synthesizer is the most relaxing while Voice is the most stressing, and they liked the water the most while they disliked the voice the most.

The Other Sound Properties Are Not Significant in this Pilot Study

The Kruskal-Wallis nonparametric test (Figure 8) on the other sound properties (Sadness, Spectrum, Consonance, Tempo) didn’t show any statistical significance. Non-parametric methods are prone to type I errors, but still the p-values are high for both Alzheimer patients and controls.

Conclusions

To our knowledge this has been the first study that has systematically assessed the emotional evaluation of a systematic set of sound features. Moreover, we have been able to identify a distinct difference in emotional evaluation between AD patients and controls. Since specific sound sources were shown to trigger specific emotional response, we will use these correlations as a means to induce soothing emotional states in AD patients through interactive music composition systems. The significant difference in the responses from the control and alzheimer groups also suggest possible applications in automatic AD diagnosis.