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Tala Box: an Interactive Embedded System to Accompany Patients with Cognitive Disorders

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ABSTRACT

Given the lack of drugs to treat cognitive deficit disorders, non-pharmacological approaches have become popular to address these pathologies. In particular, music therapy has been successfully used with Alzheimer's patients to improve their mood and functional abilities. The Tala Sound project studies whether non-Western music from the southern regions of India can be used to improve the mood and functional abilities of Western people suffering from Alzheimer's disease. This traditional style of music, called Carnatic music, is based on specific rhythm sequences, called "talas", that have an irregular rhythm compared to the ones found in Western music.

In this paper, we describe the Tala Box, a new multimedia sensory device with which patients can interact while a Carnatic song is being played. The motivation for the development of this embedded system is the intent, in addition to the unusual nature of the music played, to use motor and cognitive stimulation to better engage Alzheimer's patients and, hopefully, improve their mood and mental state. Preliminary testing with healthy seniors has shown great interest in the Tala Box.

CCS CONCEPTS

• **Computer systems organization** → **Embedded systems**; • **Human-centered computing** → *Human-computer interaction (HCI)*; • **Applied computing** → **Health informatics**.

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1 THE TALA SOUND PROJECT

With the aim of reducing the spread of Alzheimer's disease, impacting more than 30 million people worldwide [5], or of at least mitigating its effects, many medical research studies have been carried out in recent years to find an effective cure. Although a few of these experiments using pharmaceutics turned out to show some limited success, their effectiveness was not as high as expected in many of the illness aspects [4]. Other approaches [3] are thus emerging to attempt to address Alzheimer's disease and other cognitive disorders.

One of these non-drug-based approaches is music therapy, which seems particularly promising since the sense of music is one of the last human abilities to be affected in cognitive disorders [1]. Several music-therapy studies have focused on the impact of the repetitive listening of rhythmic groups [2] or the effect of music already well-known by patients [7]. However, we have not found proper studies that analyze the effects of non-familiar music built upon complex rhythmic patterns on patients.

The Tala Sound multidisciplinary project intends to fill that gap by bringing together Indian music, embedded systems and health [6]. At the fundamental level, we want to test the scientific research hypothesis that, when interacting with Indian rhythms, or "talas", originating from the southern regions of India (Carnatic music), the rhythmic structure of the talas interferes in a positive way with cognitive processes and thus, at least partially, improves the state of mind of cognitively-impaired patients, even from Western countries. For this specific goal, we designed a dedicated interaction device, the Tala Box, a new multi-sensory device that mixes audio, visual and tactile stimuli to provide an immersive experience even to often-apathic older patients (see a short demo[1] of the Tala Box being used by French seniors).

[1] https://www.youtube.com/watch?v=zRQf40-VfI4

2 TALA BOX

The Tala Box is a wooden enclosure totally covered by a piece of fabric (see Figure 1) designed to be used in medical environments where the user is therefore a person considered at risk, which calls for specific requirements. In particular, COVID-19 new standards have been taken into account when building the prototype. We chose a removable flexible top based on a semi-synthetic fabric coated with a natural elastomere so that it can be easily disinfected after each session. Wood is a material that is easy to manipulate and repair; in addition, its rigidity helps avoiding spurious resonances, which is important given that the Tala Box sound module is enclosed within. The choice of a uniform blue color is motivated by its soothing appeal and lack of distinctly visible features, thus possibly helping patients to project their own memories during sessions.

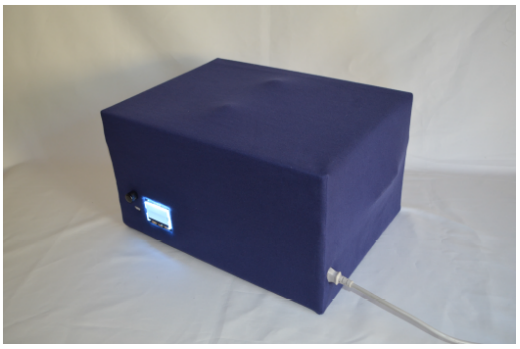


Figure 1: Tala Box final design

The Tala Box core is composed of two mobile structures (the two balls and mountings at the left of Figure 2) designed via CAD and manufactured by 3D printing. Each structure can be moved via two stepper motors that allow vertical and horizontal displacements, while four limit switches have been installed on each movable arm in order to detect the vertical and horizontal bounds.

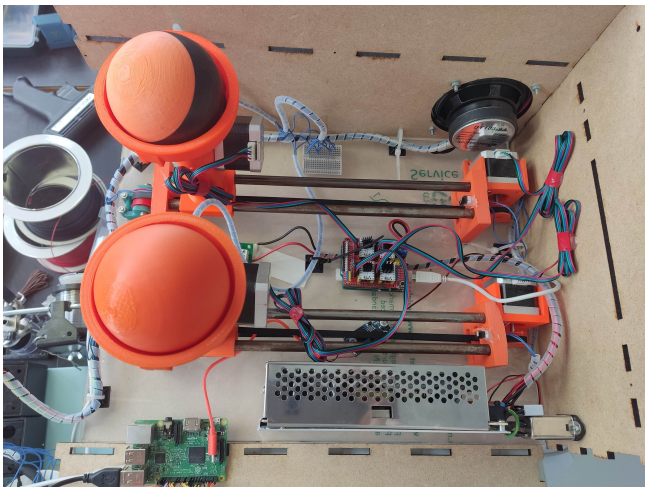


Figure 2: Tala Box mechanism

The coordination of the different elements in the device is managed by two controllers. An Arduino UNO microcontroller is responsible for issuing the stepper-motor-movement commands, while a Raspberry PI 3B manages the rest of the modules in the device, including music storage, sound generation and user interfacing.

To play music, two HP928 speakers have been installed, while a Module LCD 2,15" touch screen and a double rotary potentiometer are used as user interface for music and volume selection.

As a sound-mediation device, the Tala Box movements are synced to the music being simultaneously played. This requires signal processing software to both analyze the sound files and generate those movements. The Tala Box software environment thus provides two core modules that are aimed at (1) extracting musical dynamic characteristics from `.wav`-formatted files and (2) designing and scheduling, from the musical characteristics previously obtained, the movements to be performed by the Tala Box . We used the librosa[2] library to extract and study various parameters such as amplitude, tempo or frequency, which can be used as inputs to determine the path of locations that the balls in the Tala Box will ultimately follow.

3 EXPERIMENTS

Using surveys and questionnaires, we already confirmed, first, the positive impact of passive listening to Carnatic music on patients suffering from cognitive disorders in a hospital and, subsequently, the affordance of the Tala Box for healthy seniors in a residence. These two preliminary tests already hint at the potential of the Tala Box for this type of population.

Further experiments with more patients will assess whether using the Tala Box helps the most critically affected ones to reduce their anxiety and increase their overall awareness, thus improving their well-being. Also, we intend to add a force-sensor-based mechanism to the Tala Box for measuring the patients' strength and response time (pushing down on the balls, swiping the cover, etc.). This mechanism would provide a non-intrusive manner to gather quantitative evidence, e.g., via machine-learning techniques based on sensor data, regarding the patient's response to the practice.

REFERENCES

[1] Ronald Devere. 2017. Music and dementia: An overview. *Practical Neurology* 16, 5 (2017), 32–35.
[2] W Jay Dowling. 1973. Rhythmic groups and subjective chunks in memory for melodies. *Perception & Psychophysics* 14, 1 (1973), 37–40.
[3] P.-A. Kenigsberg, J.-P. Aquino, A. Berard, K. Charras, T. Dening, R.-M. Dröes, F. Gzil, B. Hicks, A. Innes, M. Nguyen, L. Nygård, M. Pino, S. Guillaume, E. Salmon, H. van der Roest, H. Villet, M. Villez, P. Robert, and V. Manera. 2017. Assistive Technologies to Address Capabilities of People with Dementia: From Research to Practice. *Dementia* 18, 1 (05 2017), 28. https://doi.org/10.1177/1471301217714093
[4] Celia Moreno-Morales, Raul Calero, Pedro Moreno-Morales, and Cristina Pintado. 2020. Music therapy in the treatment of dementia: A systematic review and meta-analysis. *Frontiers in medicine* 7, 1 (2020), 160.
[5] World Health Organization. 2021. Dementia. https://www.who.int/news-room/fact-sheets/detail/dementia
[6] Luc Perera and Pierre Jouvelot. 2021. Tala Sound : un projet interdisciplinaire innovant en design social pour la santé. *Innovations* 65, 2 (2021), 111–133.
[7] Hervé Platel, Jean-Claude Baron, Béatrice Desgranges, Frédéric Bernard, and Francis Eustache. 2003. Semantic and episodic memory of music are subserved by distinct neural networks. *Neuroimage* 20, 1 (2003), 244–256.

[2] https://librosa.org