Magnetic Resonance Imaging and music: an experimental research with the acoustic environment.

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1. Study aims and research questions

Anxiety and claustrophobic reactions during Magnetic Resonance Imaging (MRI) increase the length and costs of examinations through involuntary movements (causing Motion Artifact (MoA)), scan repetition and requested anaesthesia. There are many reasons for claustrophobic reactions, such as the fear of closeness and diagnosis' result, the loss of control, the requirement to stay still and the loudness of the equipment. The gradient pulsation causes a knocking sound in the gradient coils of the MR scanner, and it is the main source of the acoustic noise.

Music as an inexpensive and safe tool is widely used in therapeutic contexts for its physical and psychological benefits. In this study, we aim to develop a music listening protocol for MRI scans. By synchronising the tempo of preferred music genres to the MRI sequences, music could modulate the soundscape of the MRI environment and promote well-being and relaxation, and as a result, reduce the amount of MoA and anaesthesia. The research could help to better understand how music helps to relax people in general, reduce the costs of MRI scans and create a more patient-centred diagnostic protocol.

The research questions are the following:
- How can music reduce anxiety in the MRI environment? How does music change the perception of noise during the examination?
- How does music influence the physiological reactions (micromotions, breathing, skin conductance, heart rate variability) during the examination?
- What are the most suitable musical features and genres to reduce anxiety in the MRI context?

2. Experiment design and methods

The experiment, which followed the protocol of a structural head MRI scan, was conducted in the small Recording Studio of the University of Jyväskylä. The following objective measures were used: an accelerometer (National Instruments, LabView) to measure head movement, and thus possible MoA; ECG (electrocardiogram) electrodes for measuring heart rate variability (HRV) (NeXus); a respiration sensor (NeXus) to measure

the frequency and depth of breathing; and skin conductance sensor (NeXus) to measure sweat gland activity on the hand. The latter is closely correlated with sympathetic nervous system activity, arousal and stress. Furthermore, subjective experiences were reported with the State-Trait Anxiety Inventory (Spielberger, 1983), and qualitative analysis of open questions in form of a post-experiment questionnaire.

The procedure:

Before the experiment, participants were asked to fill the following forms: Consent form, Information letter, Privacy notice, Emotion Regulation Questionnaire and State-Trait Anxiety Inventory. After removing any metal objects (jewellery, hair pins, phone, keys, glasses, watch, belt, etc.) from their body, participants were asked to lie down in the simulated MRI device, and to stay still as much as possible for the time of the experiment. During the music listening experience, an accelerometer, skin conductance sensor, HRV and a respiration sensor were attached to the participants, while they listened to ten music/noise conditions (each song lasting for 2.5 minutes) based on their individual genre preference (classical, pop, rock or soul).

The duration of the listening experience was 30 minutes. In between the conditions, participants were asked how relaxed are they at that moment (on a ten-point scale, the response options range from ''not at all'' (1) to "very much" (10)). The participants could terminate the experiment at any given point. Additionally, a panic button was given to the participants that would signal to the researcher to interrupt the experiment immediately (common practice in diagnostic institutions).

After the experiment open questions about the perception of the music/noise, the environment and the synchronization were collected together with a post State-Trait Anxiety Inventory. The overall time of the experiment was 90 minutes.

Sound stimuli:

The loudspeakers played the sound of routine head MRI sequences on 95 dBA, which is an average Sound Pressure Level (SPL) for an MRI scan. The sound of the sequences were recorded at the Pécs Diagnostic Institute (Hungary) in 2015 using a Siemens 3 Tesla MRI System (MAGNETOM Trio A Tim). The specific relaxing songs of the music stimuli were selected through a public survey. In certain conditions the songs were synchronised with the MRI sequences, meaning that their tempo were matched using the LogicPro software.

<u>The conditions:</u>

The five conditions are as follows: (1) MRI pulsation without music; (2) MRI pulsation+original tempo preferred music; (3) MRI pulsation+synchronised tempo preferred music; (4) MRI pulsation+original tempo new age music; (5) MRI pulsation+ synchronised tempo new age music. Participants listened to all together four different songs (two in the preferred genre and two new age songs), and listened to each songs synchronised and in the original tempo as well. The order of the conditions were randomised.

<u>Participants:</u>

19 subjects were recruited from Jyväskylä on a voluntary basis. Anybody, who were healthy, and at least 18 years old could partake in the experiment. A movie ticket were offered for the participants as incentive. All subjects went through the same conditions in a randomised order. Potential participants were excluded if any of the following were true for them:

- weigh more than 120 kg,
- are taller than 195 cm,
- have any psychiatric disorder
- have epilepsy,
- have hearing aids,
- have a body temperature of more than 38,0°C (i.e., fever),
- consumed a strong caffeinated beverage prior to the experiment or consumed more than their regular intake of caffeinated beverage during the day of the experiment,
- are pregnant.

3. Analysis, future plans

This research is part of my doctorate study, which estimated completion is by 2023. The research will result in scientific publications, theses, conference and seminar presentations, teaching and practical applications. After finishing with the data analysis of this experiment, the results will be published in a peer-reviewed article.

Future plans include making another data collection focusing on different elements of music and sounds (pitch, timbre, dynamics, tempo, etc.) in the same artificial environment, and finally testing the results in a real diagnostic setting at the Pécs Diagnostic Institute in Hungary. The overall aim is to develop a new music listening protocol and an application for MRI scans.

4. Supervision

The research is supervised by Dr. Esa Ala-Ruona (University of Jyväskylä) and Dr. Birgitta Burger (Universität Hamburg).

5. Funding

Breakdown of how the funding was spent:

It covered the travel and accommodation costs of two research visits in 2019, the first one being between 25th of February and 16th of March, the second one between 5th-27th of May. During these visits the required softwares, measurement tools and the research environment was tested and developed. The data collection itself happened between the 5th-31th of January, 2020.

• Flight costs (Manchester - Helsinki return): £259.40 (February) + £222.40 (May)

• Train (Helsinki - Jyväskylä return): £23 (February) + £36.09 (May)

• Accommodation: £410.84 (February) + £300 (May)

• Altogether: £1251,73

I have not received any other funding for this research and I do not have a scholarship from my university. I am funding it myself as a self-employed care assistant and music therapist.
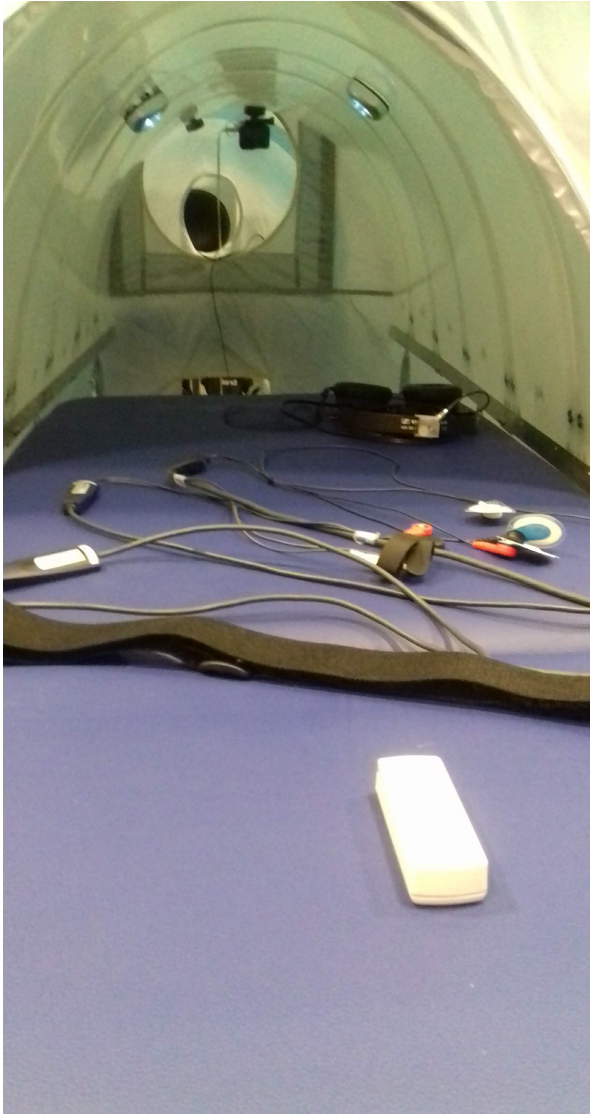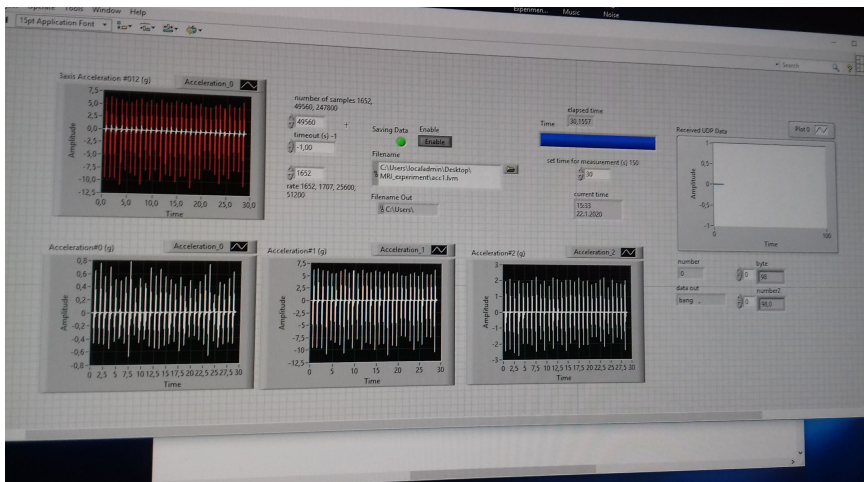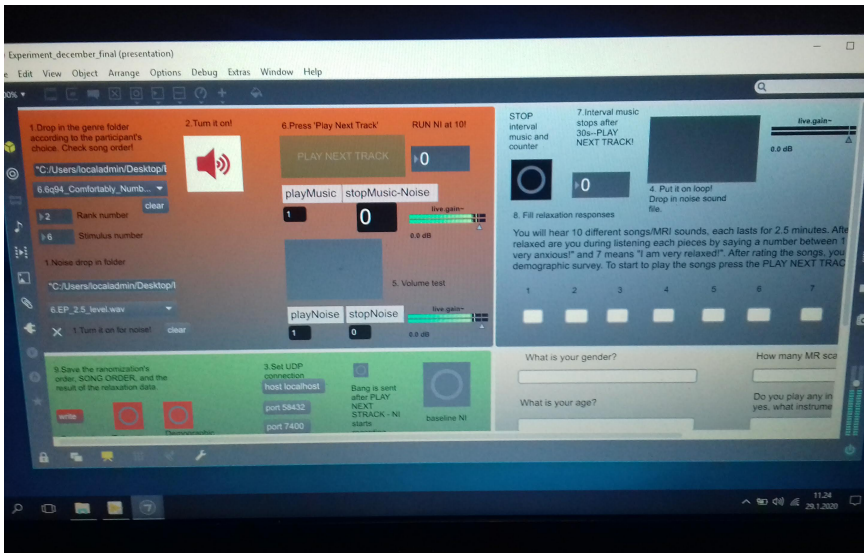
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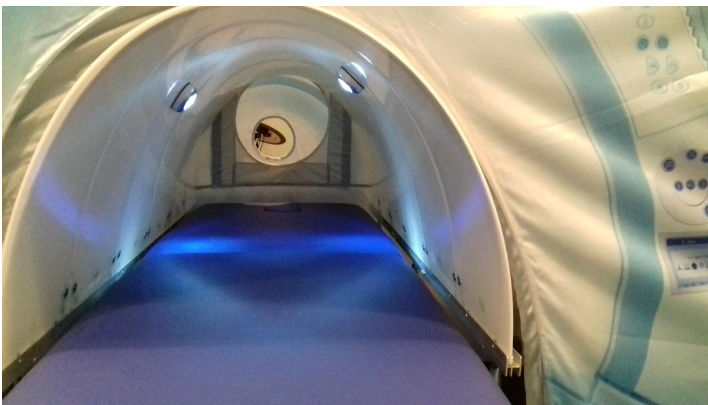
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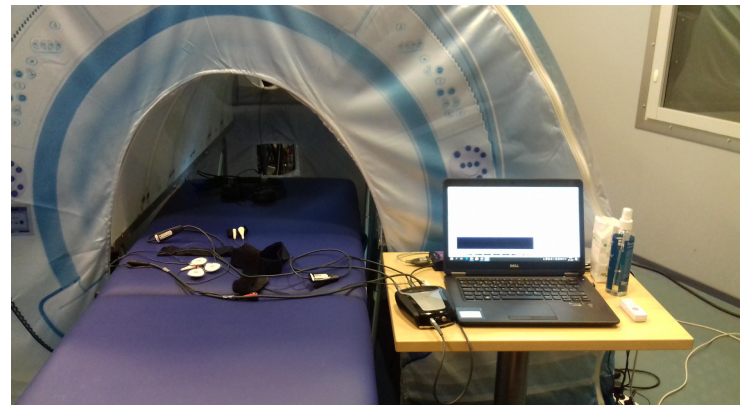
MRI2

MRI4

MRI3

ENTRANCE

VIEW FROM THE CONTROL ROOM

ACCELEROMETER

MAX PATCH FOR MUSIC CONTROL

NOISE

IN THE CONTROL ROOM