Author(s): Földes, Zsuzsa; Ala-Ruona, Esa; Burger, Birgitta; Orsi, Gergely

Title: Anxiety reduction with music and tempo synchronization on magnetic resonance imaging patients

Year: 2017

Version: Accepted version (Final draft)

Please cite the original version:

Földes, Z., Ala-Ruona, E., Burger, B., & Orsi, G. (2017). Anxiety reduction with music and tempo synchronization on magnetic resonance imaging patients. Psychomusicology: Music, Mind, and Brain, 27(4), 343-349. https://doi.org/10.1037/pmu0000199

Anxiety Reduction with Music and Tempo Synchronization on Magnetic Resonance Imaging

Patients

Zsuzsa Földes[a], Esa Ala-Ruona[a], Birgitta Burger[a] & Gergely Orsi[b]

[a]University of Jyväskylä

[b]University of Pécs

Author Note

Zsuzsa Földes, Esa Ala-Ruona and Birgitta Burger, Department of Music, University of

Jyväskylä.

Gergely Orsi, MTA-PTE Clinical Neuroscience MR Research Group, University of Pécs.

The article is based on Zsuzsa Földes' Master's Thesis in the subject of Music Therapy.

Correspondence concerning this article should be addressed to Zsuzsa Földes.

Contact: fold.s.zsuzsa@gmail.com

Abstract

Anxiety and claustrophobic reactions in Magnetic Resonance Imaging (MRI) cause unintentional movements (motion artifact) and thus interpretation problems, furthermore the requested anaesthesia makes the process costly. Sixty outpatients were examined in the Diagnostic Centre of Pécs (Hungary) to test whether synchronizing recorded music to the gradient pulsation of the MRI device can improve the sedative effect of the music. The patients were assigned into three groups, a non-music (control), an original tempo (random) and a synchronized music (synchronous) group. Results showed music listening significantly decreased the state anxiety level after the examination in the random and synchronous groups, while noise cancellation devices (headphone or earplugs) alone did not cause the same effect in the control group. However, there was no difference in the effectivity of either music conditions regarding state anxiety level after the examination. Participants in the music groups found the examination significantly more pleasant compared to the control group. In conclusion, the present study provides support that listening to music during MRI examination significantly reduces patients' anxiety, while noise cancellation devices do not provide the same effect.

Keywords: Music; Anxiety; Synchronization; Magnetic Resonance Imaging

Anxiety Reduction with Music and Tempo Synchronization on Magnetic Resonance Imaging

Patients

Introduction

The last two decades have seen a growing interest in the topic of claustrophobia and anxiety during Magnetic Resonance Imaging (MRI) scans. There are many reasons for the appearance of these 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 (Dantendorfer, 1997; Quirk, Latendre, Ciottone & Linley, 1989). The gradient pulsation (a radio frequency current that is turned off and on) causes a knocking sound in the gradient coils of the MR scanner, and it is the main source of the acoustic noise. Price, De Wilde, Papadaki, Curran and Kitney (2001) found that the noise level increases with higher magnetic flux density (measured in units of tesla): 82.5 dBA was measured on the 0.23 T system, while 118.4 dBA on the 3 T system. A stronger magnetic field is required for better image quality; therefore the demand for hearing related interventions is expected to increase in the future.

Our emotions are not just feelings, but they are accompanied by physiological and behavioral changes (Steimer, 2002), e.g. respiratory patterns reflect emotional responses. As Barlow (2002, p. 3) stated, anxiety and panic "represent the organism's alarm reaction to potentially life-threatening emergencies", with physical symptoms such as the activation of the cardio-vascular system, trembling, rapid breath and faint. Cabanac (1979, p. 9) introduces the term *alliesthesia* ("changed sensation"), which is the ability of a stimulus to cause either pleasure or displeasure depending on the subject's internal state. In the case of MRI examination, music can become a reward helping the patient to distract attention from the anxiety evoking circumstances. As Cabanac (1979, p. 1) noted, "pleasure is a sign of a stimulus useful to the subject".

With the development of music psychology, we know more about the effect of different musical features on our emotions and body. Chen, Wang, Shih and Wu (2013, p. 437) used a "slow-paced, soft, melodic music at low volume" with consistent 60-80 BPM tempo and consistent dynamics to relax oncology patients before radiation treatment. *Tempo, rhythm* and *dynamics* are key aspects to consider for relaxation purposes. There is a positive correlation between the complexity of the rhythm and blood pressure, and the respiration tends to synchronize to the musical rhythms (Gomez & Danuser, 2004). Furthermore, in terms of physiological reactions to music, tempo has a greater effect than individual music preference or music styles (Bernardi, Porta & Sleight, 2006). Bernardi and his colleagues found that music, and specifically tempo induces a cardiovascular and respiratory effect (ventilation, heart rate and blood pressure increased with faster tempi) by increasing the arousal level. This effect might be caused by respiratory entrainment. Tempo also seems to be a greater determinant to "happy-sad" judgements than mode (major mode and fast tempo convey happiness) (Gagnon & Peretz, 2003). Staum and Brotons (2000) have measured the effect of music amplitude on relaxation responses both on a physical (heart rate) and psychological level. They used three different volume levels (soft: 60-70 dB, medium: 70-80 dB, loud: 80-90 dB), and the subjects significantly preferred the softer music for relaxation purposes. However, males and non-music major students preferred louder music more than females and music major students. The heart rate was not influenced by the changes in the amplitude level, furthermore subjective reports indicated, the musical selection itself determined the relaxation responses more than the amplitude level. In conclusion, these findings confirm why the MRI noise is anxiety evoking: it is loud (80-118 dBA), forcefully rhythmic and dynamic.

Music has been widely used during diagnostic procedures and in hospital settings. Jaw relaxation, music and their combination significantly reduced pain after intestinal surgery

(Good, Anderson, Ahn, Cong & Stanton-Hicks, 2005), while in the study of Chen et al. (2013), music-receiving oncology patients had significantly lower state and trait anxiety levels, and systolic pressure compared to the control (resting) group. Walworth (2010) compared the effects of live music therapy (MT) to the effects of preferred recorded music on patients undergoing MRI. The music therapist could listen to the rhythmic pattern of the gradient switching and match the songs she played live with the specific tempo. The participant's anxiety level was measured with the Visual Analogue Scale (VAS). Patients with MT intervention had less repeated scans because of movement, compared to the recorded music group (MT: 26%, while recorded music: 73%), less requested breaks (MT: 2%, while recorded music: 17.6%) and shorter examination length for the same type of scan. The freestyle narrative comments also support that MT made the MRI experience more enjoyable than recorded music which tempo was not modified to the scanner's rhythm. Instead of trying to distract the attention from the noise, Ma et al. (2016) converted a classical music piece to the encoding gradients, while quantifying T1, T2 and proton density maps. The method (Magnetic Resonance Fingerprinting-Music or MRF-Music) has improved the patients comfort, although it was louder than the conventional acquisitions.

Rhythmic auditory cues can entrain body movements and evoke entrainment responses even in an injured brain. The effect of asynchronous (background) and synchronous music (where the temporal aspects of music is used as a movement regulator) on sport performance and in rehabilitation are widely researched (Thaut, McIntosh & Hoemberg, 2015, Terry & Karageorghis, 2006; Karageorghis et al., 2009). The auditory system is made to be fast in recognition of any temporal, rhythm cue (Thaut, Kenyon, Schauer & McIntosh; 1999), and synchronous music was found to improve performance and mood, and reduce metabolic costs more effectively than asynchronous music (Hayakawa et al., 2000; Karageorghis et al., 1999). On the other hand, noise contributes to sleep disturbance,

hypertension, furthermore, hypersensitivity to noise is associated with anxiety and depression (Beutel et al., 2016).

Following these notions, in this study we aimed to mask the MRI's ambient noise by synchronous music playing, and tested two hypotheses: 1) Music has better relaxation ability during MRI examination than noise cancellation devices (headphone/earplugs) alone. 2) Music which tempo is synchronized to the MRI pulsation has better relaxation ability during MRI examination than music in its original tempo.

Method

Participants

The participants were cooperative adults undergoing MRI scans between January and March of 2016 at the Diagnostic Center of Pécs. The Regional and Institutional Research Ethical Committee of the Clinical Center of the University of Pécs provided the ethical permission for the experiment. Parts of the body examined in the experiment: skull, spine, joints (hip, knee, ankle, shoulder), lungs, shin and shank. From N = 60 patients, 33 were female. Participants ranged in age from 18 to 82 years, with a mean of 47.18 years (*SD* = 14.61). 37.3% of the patients had no previous experience with MRI.

Design and stimuli

The patients were assigned into three groups (20 patients in each), one control and two music groups. Two MRI units (1.5 T and 3T) were involved in the experiment, the music facilities were established in the 3 T unit. The *control* group only received headphones or earplugs without music (10 patients with headphones, 1 with earplugs and 9 patients were either assigned to the 1.5 T MRI unit, where it was not possible to give any noise cancellation devices or refused to use any of the tools). The reason for giving earplugs for one patient was the type of the scan (cervical spine), where the headphone was not applicable. The same electrostatic headphone was used in all groups. The *random* group listened to a playlist in its

original tempo, while in the *synchronous* group the tempo of the songs were manually modified to the tempo of the gradient pulsation with MAX7. MAX is a visual programming language for electronic art and music (https://cycling74.com/max7), and was used to stretch the time of the audio files without changing the pitch. Figure 1 shows the MAX patch used for time stretching. It should be noted that there was an attempt to use the so called *Beat Seeker* device (Ableton), which was developed to automatically modulate the tempo of a given song to an outer sound source, but it failed to recognize the MRI noises. The aim with the tempo modification was to create a seemingly, aesthetically synchronous state. With a microphone at the air-gate of the MRI room, the rhythmic pattern of the noise was precisely audible in the control room, where the tempo was adjusted manually. Every time the MRI pulsation rate changed, it took 10-20 seconds to adjust the songs tempi, so the change was gradual and not sudden. Within one scan, ca. 6-9 tempo changes were applied. A similar design was implemented in the study of Walworth (2010), who compared the effects of live music therapy to preferred recorded music on patients undergoing MRI.
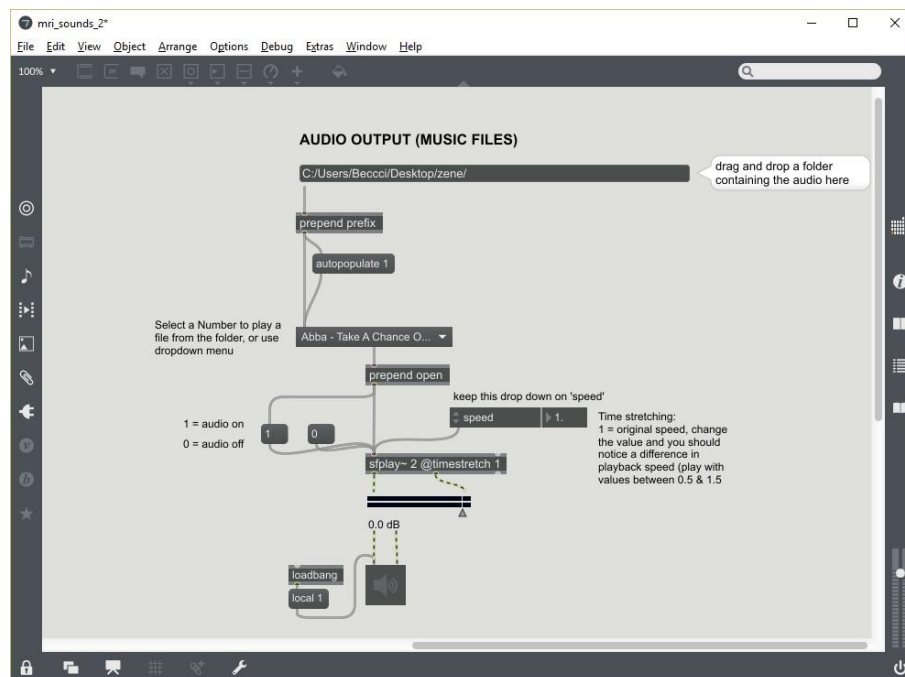

FIGURE 1. MAX patch for time stretching.

The selection criteria for the songs were to have an easily recognizable tempo with diverse genres, with and without lyrics. Table 1 shows the details of the songs. Since the focus of this study was to measure the effects of tempo synchronisation, the same songs were provided to both music groups without the possibility to choose their preferred music.

TABLE 1. The songs of the playlist.

	Author	Title	Genre	Original tempo (BPM)
1.	ABBA	Take a chance on me	pop	106,6
2.	Renaud Garcia-Fons	Fortaleza	world music/jazz	120
3.	C. Young	Cindy Supermarket	synthpop	116,3
4.	Jace Everett	Bad things	country/rock	131
5.	Karl Jenkins	Tlep (Jailau)	classical/new age	140
6.	Queen	Somebody to love	glam rock	109,4
7.	Mittland och Leo	Decades	minimal electronic	88,1
8.	Michael Jackson	Will you be there	pop	82,9
9.	Nine Inch Nails	Ghosts II-13	dark ambient	59
10.	Alabama Shakes	Hang Loose	garage rock	119,4
11.	Jorge Ben Jor	Oba, la vem ela	samba	98,9
12.	Péterfy Bori és a Pluto	A nagy szívbűvölő	alternative rock	79
13.	Tashaki Miyaki	Best friend	indie pop	90
14.	Avicii	Wake me up	progressive house	124
15.	Parov Stelar	All night	electro swing	125

Questionnaires

To compare the patients' anxiety level, State-Trait Anxiety Inventory (STAI) were filled before, while STAI-State anxiety level, Claustrophobia Questionnaire (CLQ), open-ended questions, Visual Analogue Scale (VAS) and demographic questions (gender, age,

educational background and number of previous MRI examinations) were recorded after the examination. The examination's duration, examined body part, position and weight were also registered.

The *State-Trait Anxiety Inventory* (STAI) includes two 20-item measures that evaluate the patients' anxiety level: The STAI-State (e.g. "I feel calm") measures the current anxiety level "right now, at this moment", while the STAI-Trait (e.g. "I feel like a failure") estimates the general anxiety level (Spielberger, 1983). Participants are asked to rate themselves on each item using a 4-point Likert scale (1="not at all", 4="very much so" in the STAI-State, and 1="almost never", 4="almost always" in the STAI-Trait). The individual scores are created by summing the scores for direct- and reverse-worded items. Scores range from 20 to 80, where higher scores correspond to higher anxiety level. The Hungarian version was developed by Sipos and Sipos (1983).

The *Claustrophobia Questionnaire* (CLQ) was designed to measure two different fear components of claustrophobia: the fear of *suffocation* (e.g. "Swimming while wearing a nose plug") and *restriction* (e.g. "Having your legs tied to an immovable chair"). It includes 26 items (14 items of suffocation and 12 items of restriction), and respondents are asked to rate the items from 0 to 4 according to their anxiety level in the situations (0="Not at all anxious", 4="Extremely anxious") (Radomsky et al., 2001; Radomsky et al., 2006). The overall scores range from 0 (no anxiety about claustrophobic situations) to 104 (maximal anxiety). Lisa and Lois' (2013) results suggest, the Claustrophobia Questionnaire (CLQ) can be an efficient tool for screening patients who might not be able to finish the MRI procedure due to claustrophobic reactions.

The *Visual Analogue Scale* (VAS) is a 10 cm long scale, where respondents are asked to mark the line to express freely their feelings about a certain stimulus (Wewers & Lowe, 1990). In this study, VAS was used to measure the overall experience of the MRI

examination. The following question was asked: *How was the overall experience of the MRI examination?* The two endpoints of the scale were *very unpleasant* and *very pleasant*. A higher score would correspond to a more pleasurable overall experience of the participant.

Furthermore, for investigating how hearing protection devices and music influence the MRI experience, *open-ended questions* were asked and subsequently analysed using thematic analysis. Thematic analysis is an essential and flexible method in qualitative research. Led by the research question, thematic analysis identifies and reports patterned meanings (themes) from the data through a 6-phase process (Braun & Clarke, 2006). To measure more directly the effects of the music, patients were asked in Hungarian to answer the following questions: "How difficult was it for you to stay immovably in a narrow space?", "How did the music influence the experience of the examination?", "How satisfied are you with the genres of the music? What would you prefer to listen to?" and "How did the music change your environment?". With the non-music group the following questions were asked: "How difficult was for you to stay immovably in a narrow space?" and "How did the headphone/earplugs influence the experience of the examination?".

Results

The main analysis consists of a two-way mixed ANOVA to compare the pre- and post-assessment STAI-State anxiety scores in the different groups. Kruskal-Wallis H tests were used to compare the STAI-Trait anxiety, CLQ and VAS scores between groups. The effect of gender is tested with Mann-Whitney U tests.

STAI-State anxiety scores

A two-way mixed ANOVA was conducted to investigate the impact of conditions (control, random, synchronous) and time (pre- and post-assessment) on the STAI-State anxiety level. There was a significant interaction between the conditions and time, $F(2,57) = 5.71$, $p = .006$.

and a significant main effect for time, $F(1,57) = 15.27$, $p < .001$, η2 = 0.05. Simple main effect analysis showed that state anxiety level was significantly lower at the post-assessment point in the random group, $F(1,57) = 8.56$, $p = .005$, and in the synchronous group, $F(1,57) = 17.96$, $p < .001$. However, state anxiety level was not statistically different in the control group between the pre- and post-assessment points ($F(1,57) = .16$ $p = .69$). The effect of time was significantly different between the conditions, with higher pre-assessment anxiety levels and lower post-assessment anxiety levels for participants among the music groups (random and synchronous) compared to the control group. The synchronous group had the highest STAI-State anxiety level before the examination, but the lowest level at the end of the examination, and therefore the biggest reduction after the scanning. Figure 2 shows the interaction between time and conditions (groups), while Table 2 the mean scores of the STAI-State anxiety level within each condition at the pre- and post-assessment points.
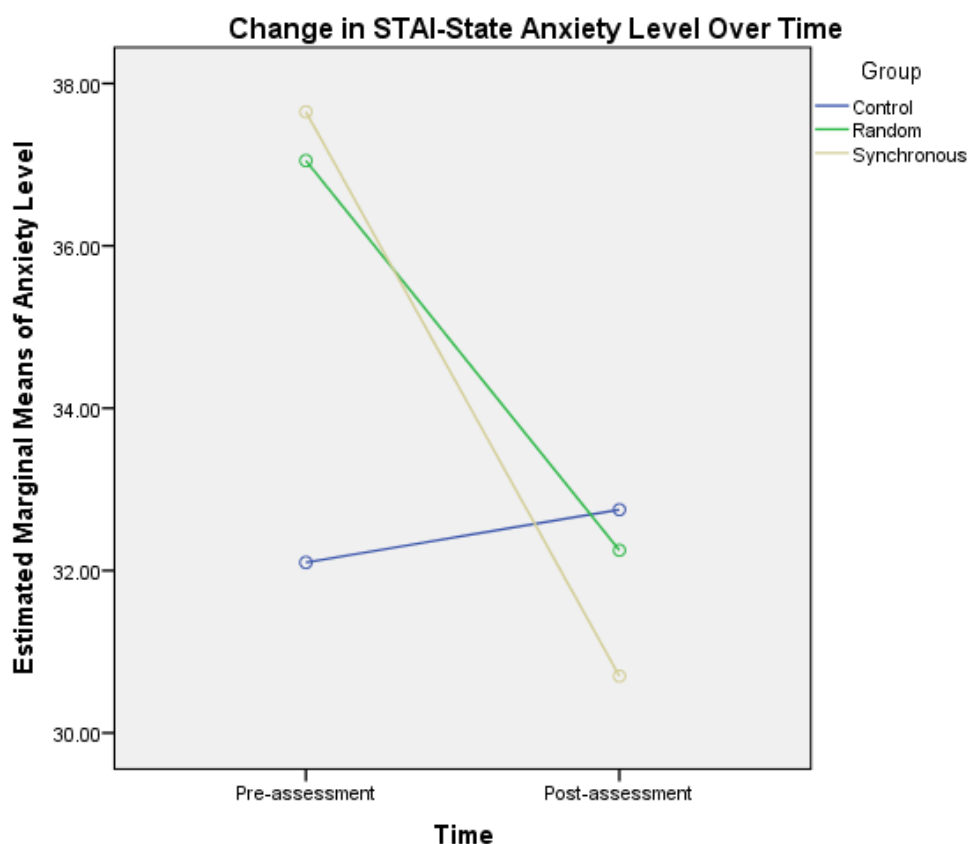

FIGURE 2. Change in STAI-State anxiety level over time.

TABLE 2. Pre- and post-assessment STAI-State anxiety level in the different groups.

Conditions * Time							
Measure: STAI-State anxiety							
Condition	Time	N	Mean	SD	SE	95% Confidence Interval for Mean	
						Lower	Upper
Control	Pre-assessment	20	32.01	7.45	1.93	28.23	35.97
	Post-assessment	20	32.75	9.94	1.81	29.12	36.38
Random	Pre-assessment	20	37.05	8.73	1.93	33.18	40.92
	Post-assessment	20	32.25	6.50	1.81	28.62	35.88
Synchronous	Pre-assessment	20	37.65	9.62	1.93	33.78	41.52
	Post-assessment	20	30.70	7.51	1.81	27.07	34.33
Total	Pre-assessment	60	35.60	8.86			
	Post-assessment	60	31.90	8.02			

There was no significant main effect of conditions, $F(2,57) = .48$, $p = .62$. State anxiety level was not significantly different at the pre-assessment point, $F(2,57) = 2.48$, $p = 0.09$, and at the post-assessment point, $F(2,57) = .35$, $p = .71$ between groups.

STAI-Trait anxiety, CLQ and VAS scores

Median STAI-Trait anxiety scores ($\chi2$ $(2, N = 60) = .411$, $p = .814$.) and median Claustrophobia Questionnaire scores, ($\chi2$ $(2, N = 55) = .638$, $p = .727$.) were not statistically significantly different between groups.

A Kruskal-Wallis H test was conducted to evaluate the differences among the three conditions (control, random, synchronous) on median VAS scores (overall experience of the examination). The test, which was corrected for tied ranks, was significant $\chi2$ $(2, N = 59.) = 12.13$, $p = .002$. The proportion of variability in the ranked dependent variable accounted for

by the different conditions was .21, indicating a fairly strong relationship between the conditions and overall experience of the MRI examination. Follow-up tests were conducted to evaluate pair wise differences among the three groups, controlling for Type I error across tests by using the Bonferroni approach. This post hoc analysis revealed statistically significant differences in the VAS scores between the control (*Mdn* = 54.41) and random (*Mdn* = 83.82) (*p* = .009), and control and synchronous (*Mdn* = 89.71) (*p* = .001) groups, but not between the random and synchronous groups. That is, both of the music groups had significantly more pleasant experience about the MRI examination than the control group. Table 3 shows the medians for VAS, STAI-Trait and CLQ scores between conditions.

TABLE 3. Medians for VAS, STAI-Trait and CLQ scores between conditions.

Report				
Condition		VAS(%)	STAI-Trait	CLQ
Control	N	19	20	16
	Median	54.41	40.00	18.00
Random	N	20	20	20
	Median	83.82	41.50	28.00
Synchronous	N	20	20	19
	Median	89.71	41.50	29.00
Total	N	59	60	55
	Median	82.35	40.00	25.00

Gender differences

A Mann-Whitney U test was run to determine if there were differences in pre- and post-assessment STAI-State anxiety, STAI-Trait anxiety, CLQ and VAS scores between males and females.

Median pre-assessment STAI-State anxiety score was statistically significantly higher in females (*Mdn* = 36.00) than in males (*Mdn* = 30.00), *U* = 301.50, *z* = -2.14, *p* = .032, η2 =

.08, indicating a medium relationship between gender and pre-assessment STAI-State anxiety level. At the post-assessment point the state anxiety scores were not statistically different between males and females ($U = 373.50$, $z = -1.07$, $p = .28$).

There was no statistically significant difference between females and males in any of the other examined measurements, but female patients had higher post-assessment STAI-State anxiety, STAI-Trait anxiety and CLQ scores, furthermore females found the examination less pleasant than males. Table 4 shows the median scores of the above mentioned measurements between female and male participants.

TABLE 4. Median scores of different measurements between female and male participants.

Gender differences (Median)					
Gender	Pre-assesment STAI-State	Post-assesment STAI-State	STAI-Trait	CLQ	VAS
Male	30	30	38	19	82.35
Female	36	32	42	33	75.74
Total	34	32	40	25	82.35

Open-ended questions

The open-ended questions were aimed at providing a rich, thematic description of the entire data set. The quotes were translated from Hungarian. The brackets show the identification number of the participant, 'S' means synchronous, 'R' means random and 'C' means control group.

The first theme that emerged was titled *Positive Change: Masking*, meaning that the intervention changed the participants' environment in a positive way, made it less noisy and caused satisfaction. The majority of the participants mentioned the noise cancellation, masking effect of the headphones and music, and how the intervention helped them to go through the procedure.

It was more pleasant than without music. The noise didn't sound that much. (2-S)

> It was friendlier, more tolerable; it was more cheerful *(with music).* (30-R)
>
> The last minutes were hard. The headphones helped me. (6-C)

The participants also used music as a *Distraction* from the uncomfortable circumstances. Being out of space and time are returning themes in the narrative. With music, time goes faster, patients find themselves in a timeless, infinite space, and often, they forget where they are.

> I could forget where I am. (35-S)
>
> I didn't feel that I am closed up. (56-S)
>
> Time passed faster, I didn't listen to the machine's noise. I could think about other things. (28-R)

Music made the patients calmer, less frustrated or anxious; in many cases they were even close to fall asleep. The participants in the following quotes are talking about the *Relaxing* effect of music:

> You could fall asleep on it. It's good. (20-S)
>
> It helped to relax, I concentrated on the music and I didn't feel the incentive to make a motion. (42-S)
>
> I had a good time, it was pleasant and I relaxed. (29-R)
>
> It was good, pleasant, I almost fell asleep. It was refreshing, relaxing, which is rare in my case! (44-R)

In terms of the musical selection, *Diversity* of the genres caused satisfaction, but there is a desire to choose or listen to familiar music. Some of the examples of preferred musical genres: more/less classical music, 90s songs, more vocal, gypsy, rock, dance music, nature sounds and radio shows.

> I was absolutely satisfied with the genres of the music. I wouldn't listen to anything else, because it was appropriate. (7-S)
>
> It was good, diverse. (11-S)
>
> Hit songs could have distracted the attention more, or music that I know. (26-R)
>
> I like classical music, but I enjoyed more the funky, faster music here. It was playful and cheered me up. (51-R)

Finally, the majority of the participants expressed their wish to listen to *Music During Future Examinations* and praised the novelty of the intervention. Patients perceived music as an extra care from the hospital.

> Thank you for the kind care. I will recommend the place for everybody. (32-S)
>
> By all means, you should keep using music. Now I have a basis for comparison. (38-R)
>
> This should be always part of the process, if possible. (44-R)

In conclusion, positive change (masking effect), distraction, relaxation, the need of diversity and the desire for future music interventions were the main themes related to music and noise cancellation devices.

Discussion

The present study tested the hypotheses that (1) during MRI examination music listening has better relaxation ability than headphones/earplugs alone, and that (2) music which tempo is synchronized to the gradient pulsation has better relaxation ability than music in its original tempo. Sixty outpatients were examined in the Diagnostic Center of Pécs (Hungary). The patients were assigned into three groups, a non-music (control), an original tempo (random) and a synchronized tempo (synchronous) group.

Results support the first hypothesis showing that music conditions (random and synchronous) significantly lowered the participants state anxiety level after the examination, while the anxiety level did not change significantly in the control group. Furthermore, both music groups experienced the examination significantly more pleasant than the control group (VAS scores). These results are consistent with Walworth's (2010) findings that compared the effects of live music therapy to preferred recorded music. Similarly to that design, in this experiment the synchronous group could listen to music which tempo was modified, while the other music group only listened to recorded music with its original tempo.

Although the STAI-State anxiety level between the music groups was not statistically significantly different at the post-assessment point, the synchronous group had lower scores and evaluated the examination more pleasant than the random group. This could suggest a trend for the second hypothesis. The relatively low sample size (N=60) and the manual synchronization could be the reasons for the lack of significance. The constantly changing gradient pulsation and certain sequences with sustained, iterative sounds create a very challenging ambient environment for musical adaptations. Sensorimotor synchronization, as a form of entrainment between a motor and a perceptual oscillatory process, requires adaptation to tempo changes, and rests on the phase and period corrections (Repp & Keller, 2004). Phase correction is largely an automatic process that is based solely on intention; furthermore it is inoperative in the absence of an external reference. On the other hand, period correction is an intentional cognitive process adjusting the period of an internal timekeeper and requires attention and the awareness of the tempo change as well (Repp & Keller, 2004). As Mills, Steen, Schultz and Keller (2015) conclude, individual differences in sensorimotor synchronization rest on the ability of temporal anticipation and temporal error correction (adaptation), and these processes are not independent from each other. Temporal error correction also determines the accuracy of the synchronization. Future research should therefore focus on finding solutions for automatic music synchronization in this challenging environment.

The STAI-Trait anxiety and CLQ scores were not statistically significantly different between the groups. While the State anxiety measures the intensity of the present symptoms, the Trait anxiety is a consistent personality attribute and measures the general tendency to be anxious (Spielberger, 1983; Julian, 2011). Therefore, the patients were not different in terms of their general tendency to feel anxiety, but there were more patients in the music conditions who felt anxiety in-the-moment than in the control group. There is no demographical

deviation that could explain this difference. As Argstatter, Haberbosch and Bolay (2006) suggested, music interventions are more efficient with patients who have higher state and trait anxiety than those with lower level of anxiety, and these findings were confirmed in the present study. Additionally, Domar et al. (2005) found that listening to a relaxation audiotape or music (classical music, jazz or soft rock) did not cause significant differences in the subjective anxiety or pain level of mammography patients, when the mean scores of anxiety for all of the three groups (relaxation, music and control) were low during the whole procedure. Further research could look more systematically into this difference.

The results support previous findings on the role of gender (Eshed, Althoff, Hamm & Hermann, 2007): female participants significantly felt more anxiety before the MRI examination, had higher post-assessment STAI-State, STAI-Trait, CLQ scores and found the experience less pleasant than males in this study. According to the American Psychiatric Association (2013), females are twice as likely to be diagnosed with anxiety disorders than males, but the occurrence is culturally affected, and in Eastern cultures it is more common for males to seek help for anxiety symptoms than in Western countries (Barlow, 2002). As Barlow (2002) concludes, the main reasons accounting for these gender differences are the effects of negative life events (e.g. sexual abuse) in childhood and adolescence that affects more girls than boys; and a pessimistic attributional style, that is girls may learn that their behaviour have less impact on their environment compared to boys, causing a sense of helplessness (p. 267). Because females are more likely to feel anxiety during MRI scans, they are also more likely to experience the advantages of music in this situation.

The thematic analysis of the open-ended questions suggests that the headphones and earplugs are protective and noise cancellation tools (masking) for the participants, while music has an additional emotional effect, causing positive change in the environment, providing help, distracting attention from the examination and relaxing patients. Roy, Peretz

and Rainville (2008) support these conclusions, but further investigation is needed to specify which one of these (masking, emotional or distractive) is the most important effect.

Since uncertainty is a basic aspect of anxiety, future interventions could increase the clients' sense of control by providing their preferred music. Krout (2007) emphasises, that the possibility for the client to choose between different music pieces is important to achieve better relaxation. In conclusion, the present study provides support that listening to music during MRI examination significantly reduces patients' anxiety, while (non-music) noise cancellation devices (headphones and earplugs) do not provide the same effect. Future research should investigate the potential of music (genres, pitch, tempo, length) to find cheap, fast and safe ways to relax patients within the MRI environment.

References

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders (Fifth edition).* Washington, D.C.: American Psychiatric Association.

Argstatter, H., Haberbosch, W., & Bolay, H. V. (2006). Study of the effectiveness of musical stimulation during intracardiac catheterization. *Clin Res Cardiol, 95,* 1–9. doi:10.1007/s00392-006-0425-4

Barlow, D. H. (2002). *Anxiety and its disorders, the nature and treatment of anxiety and panic.* Second Edition. New York, NY: The Guilford Press.

Bernardi, L., Porta, C. & Sleight, P. (2006). Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence. *Heart, 92 (4),* 445-452.

Beutel, M.E., Jünger, C., Klein, E.M., Wild, P., Lackner, K., Blettner, M., … Münzel, T. (2016). Noise Annoyance Is Associated with Depression and Anxiety in the General Population- The Contribution of Aircraft Noise. *PLoS ONE, 11(5),* doi:10.1371/journal.pone.0155357.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3 (2), 77-101. ISSN1478-0887

Cabanac, M. (1979). Sensory pleasure. *The Quarterly Review of Biology, 54* (1), 1-29.

Chen, L. C., Wang, T. F., Shih, Y. N., & Wu, L. J.(2013). Fifteen-minute music intervention reduces pre-radiotherapy anxiety in oncology patients. *European Journal of Oncology Nursing 17,* 436-441.

Dantendorfer, K., Amering, M., Bankier, A., Helbich, T., Prayer, D., Youssefzadeh, S., … Katschnig, H. (1997). A study of the effects of patient anxiety, perceptions and equipment on motion artifacts in Magnetic Resonance Imaging. *Magnetic Resonance Imaging, 15*(3), 301-306.

Domar, A.D., Eyvazzadeh, A., Allen, S., Roman, K., Wolf, R., Orav, J., Albright, N. & Baum, J. (2005). Relaxation techniques for reducing pain and anxiety during screening mammography. *American Journal of Roentgenology, 184*, 445-447.

Eshed, I., Althoff, C. E., Hamm, B., & Hermann, KG. A. (2007). Claustrophobia and premature termination of Magnetic Resonance Imaging examinations. *Journal Of Magnetic Resonance Imaging, 26,* 401–404.

Gagnon, L. & Peretz, I. (2003). Mode and tempo relative contributions to "happy-sad" judgements in equitone melodies. *Cognition and Emotions, 17 (1),* 25-40.

Gomez, P. & Danuser, B. (2004). Affective and physiological responses to environmental noises and music. *International Journal of Psychophysiology, 53,* 91– 103.

Good, M., Anderson, G. C., Ahn, S., Cong, X., & Stanton-Hicks, M. (2005). Relaxation and music reduce pain following intestinal surgery. *Research in Nursing & Health, 28,* 240-251.

Hayakawa, Y., Miki, H., Takada, K. & Tanaka, K. (2000). Effects of music on mood during bench stepping performance. *Perceptual and Motor Skills*, *90*, 307–314.

Julian, L. J. (2011). Measures of anxiety. *Arthritis Care & Research*, *63*(0 11), 10.1002/acr.20561. http://doi.org/10.1002/acr.20561

Karageorghis, C.I., Mouzourides, D.A., Priest, D.L., Sasso TA, Morrish, D.J., Walley, C.J. (2009). Psychophysical and ergogenic effects of synchronous music during treadmill walking. *Journal of Sport and Exercise Psychology, 31(1),* 18-36.

Karageorghis, C.I., Terry, P.C. & Lane, A.M. (1999). Development and validation of an instrument to assess the motivational qualities of music in exercise and sport: the Brunel Music Rating Inventory. *Journal of Sports Sciences, 17,* 713–724.

Krout, R. E. (2007). Music listening to facilitate relaxation and promote wellness: Integrated aspects of our neurophysiological responses to music. *The Arts in Psychotherapy 34,* 134–141.

Lisa, B. & Lois, B. (2013). Screening for claustrophobia in MRI – A Pilot study. *European Scientific Journal, 9(18).*

Ma, D., Pierre, E. Y., Jiang, Y., Schluchter, M. D., Setsompop, K., Gulani, V. & Griswold, M. A. (2016). Music-based Magnetic Resonance Fingerprinting to improve patient comfort during MRI exams. *Magnetic Resonance in Medicine, 75(6),* 2303–2314, doi:10.1002/mrm.25818.

Mills, P. F., van der Steen, M. C., Schultz, B. G. & Keller, P. E. (2015). Individual Differences in Temporal Anticipation and Adaptation During Sensorimotor Synchronization. *Timing & Time Perception.* DOI:10.1163/22134468-03002040

Price, D. L., De Wilde, J. P., Papadaki, A. M., Curran, L. S., & Kitney, R. I. (2001). Investigation of acoustic noise on 15 MRI scanners from 0.2T to 3T. *Journal of Magnetic Resonance Imaging, 13*, 288–293.

Quirk M., Letendre A., Ciottone R., & Lingley J. (1989). Anxiety in patients undergoing MR imaging. *Radiology, 170,* 463-6.

Radomsky, A. S., Ouimet, A. J., Ashbaugh, A. R., Paradis, M. R., Lavoie, S. L. & O'Connor, K. P. (2006). Psychometric properties of the French and English versions of the Claustrophobia Questionnaire (CLQ). *Anxiety Disorders, 20,* 818–828.

Radomsky, A. S., Rachman, S., Thordarson, D. S., McIsaac, H.K., Teachman, B. A. (2001). The claustrophobia questionnaires. *J. Anxiety Disord. 15*, 287–297.

Repp, B. H. & Keller, P. E. (2004). Adaptation to tempo changes in sensorimotor synchronization: Effects of intention, attention, and aweraness. *The Quarterly Journal of Experimental Psychology, 57A (3),* 499-521.

Roy, M., Peretz, I., & Rainville, P. (2008). Emotional valence contributes to music-induced analgesia. *Pain, 134*, 140–147. doi:10.1016/j.pain.2007.04.003

Sipos, K., & Sipos, M. (1983) *The development and validation of the Hungarian form of the State-Trait Anxiety Inventory.* In: C. D. Spielberger and R. Diaz-Guerrero (Eds.) Cross-cultural Anxiety. Vol. 2, Hemisphere, Washington, D. C., 27-39. Retrieved from: http://www.drsiposkornel.com/publikaciok.html

Spielberger, C. D. (1983). *Manual for the State–Trait Anxiety Inventory (Form Y)*. Palo Alto, CA: Mind Garden.

Staum, M. J., & Brotons, M. (2000). The effect of music amplitude on the relaxation response. *Journal of Music Therapy, 37*(1), 22-39.

Steimer, T. (2002). The biology of fear- and anxiety-related behaviors. *Dialogues Clin. Neurosci., 4(3),* 231–249.

Terry, P.C., & Karageorghis, C.I. (2006). Psychophysical effects of music in sport and exercise: An update on theory, research and application. In M. Katsikitis (Ed.), *Psychology bridging the Tasman: Science, culture and practice – Proceedings of the 2006 Joint Conference of the Australian Psychological Society and the New Zealand Psychological Society* (pp. 415-419). Melbourne, VIC: Australian Psychological Society.

Thaut, M.H., Kenyon, G.P., Schauer, M.L. & McIntosh, G.C. (1999). The Connection Between Rhytmicity and Brain Function; Implications for Therapy of Movement Disorders. *IEEE Engineering in Medicine and Biology, 101-108*

Thaut, M.H., McIntosh, G.C. & Hoemberg, V. (2015). Neurobiological foundations of neurologic music therapy: rhythmic entrainment and the motor system. *Frontiers in Psychology, doi: 10.3389/fpsyg.2014.01185*

Walworth, D. D. (2010). Effect of live music therapy for patients undergoing Magnetic Resonance Imaging. *Journal of Music Therapy, XLVII(4),* 335-350.

Wewers, M. E., & Lowe, N. K. (1990). A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing & Health, 13*, 227–236.