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Music for relaxation: A comparison across two age groups

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Conflict of interest

This study was designed and conducted for the purpose of research progress in this area. New musical compositions used in the study were composed for a different purpose and are freely available to the public.

Abstract

There are currently many types of music sold commercially that are branded as 'relaxation aids'. However, the claims that the music can induce psychological and physical relaxation are rarely validated on an empirical basis. This study investigated the effectiveness of a particular type of 'relaxation' music that we call Meditative Binaural Music (MBM), which incorporates binaurally recorded sounds, binaural beats, a slow tempo, and gradual changes. The effect of listening to MBM with and without binaural beats on self-reported emotion state and measured physiological arousal was compared to the effect of listening to classical music previously categorised as 'low' or 'high' in emotional arousal. Individuals from two age groups were recruited. The effect of listening to MBM was comparable to listening to calm classical music. The changes in self-reported arousal were more pronounced for the younger age group, for whom the MBM including binaural beats was significantly more calming than listening to low arousal classical music. The older age group showed stronger differences in positivity evaluations, evaluating low arousal classical music as most comforting, followed by MBM. These results indicate that MBM may effectively contribute to relaxation, but in a way that differs depending on age.

Key words: music listening, binaural beats, relaxation, arousal, age differences

The general public regularly use music for self-initiated mood and emotion regulation (Saarikallio, 2011). This mood regulation may concern getting in the right spirit for a high-arousal performance, such as a sports event or a party, or it may concern winding down as preparation for going to sleep, to enjoy a quiet moment, or to release stress and agitation. Focusing on the latter, music is commercially available that is being advertised as 'relaxation aid', often including special sonic techniques such as binaural beats or binaurally recorded sounds. Whilst researchers have investigated personal and psychoacoustic factors contributing to the evaluation of music as relaxing or arousing (Coutinho & Cangelosi, 2011; Pelletier, 2004, Tan, Yowler, Super, & Fratianne, 2012), few studies exist that have directly compared the effect of music conceived as 'relaxation aid' with popular or classical music not specifically composed for the purpose of relaxation. Moreover, it is not clear how special techniques such as binaural beats and binaurally recorded sounds contribute to feelings of 'relaxation'. Within Russell's (1980) circumplex model, relaxation is both low in emotional arousal and positive in affect, suggesting that relaxation requires both. On the other hand, Sloboda, O'Neill, and Ivaldi (2001) found that feelings of relaxation in response to music were positively correlated with positive feelings of comfort and security, but not negatively correlated with arousal and energy. To further complicate the concept, it is not uncommon to play 'relaxation' music as a background for meditation, suggesting the relevance of the induction of a state of mind associated with meditation.

To investigate these questions, an empirical study was designed that tested the effect of 'meditative binaural music' (MBM) on dimensions associated with relaxation including subjective experiences of emotional arousal, valence, tension and present-mindedness and objectively measured changes in physiological arousal. The effect of MBM with and without binaural beats was compared to the effect of classical music previously found to be experienced as positive in valence, and either 'low' or 'high' in emotional arousal. As subjective preferences and emotional responses to music have been shown to vary with age (Bonneville-Roussy, Stillwell, Kosinski, & Rust, 2017; Vieillard & Gilet, 2013), these associations and effects were examined in an older and younger group of participants. By clarifying the subjective experience of MBM, in relation to music from standard repertoire, and by examining differences in experience depending on age, we aim to enhance understanding of this genre of music and contribute to *foundational research* that informs music therapy practices (Bruscia, 2005, cited in Wheeler, 2016). Specifically, the choice of particular music and its employment is supported by theory and empirical findings. The study contributes to an improved understanding of what is afforded by listening to various genres of music, in this case music including binaural sounds and beats, what constitutes 'relaxation', and how these may vary for different population groups.

Before advancing onto the details of the study, we will first more closely define the genre that we call 'meditative binaural music' and briefly review the measurement of emotional responses as well as age differences in emotional experiences of music. This will prepare for the formulation of the main hypotheses that are being tested in the perceptual experiment.

Binaural Beats and Meditative Binaural Music

Modern 'relaxation' music regularly includes binaural beats (Weiland et al., 2011). Binaural beats are a sensation created by presenting sine tones of slightly different frequencies to each ear. This sensation is a percussive 'beat' effect that is present independently of the two original tones (the carrier tones). The speed or type of beat is equal to the difference between the frequencies of the two tones. For example, two tones at 30 and 37Hz create a binaural beat with a frequency of 7Hz. Frequency ranges are distinguished in correspondence with alpha, beta, gamma, delta and theta brain activity frequency bands as measurable through Electroencephalography (EEG) recordings. Presenting binaural beats of different categories have been hypothesised to have different effects on the listener. Theta and delta wave binaural beats have been associated with decreased anxiety and increased relaxation (Le Scouarnec et al., 2001; Padmanabhan, Hildreth, & Laws, 2005; Weiland et al., 2011).

The mechanism for the effect of binaural beats is yet to be found, and previous theories, including brainwave 'entrainment', have not been validated by EEG studies (Gao et al., 2014; Goodin et al., 2012; Vernon, Peryer, Louch, & Shaw, 2014). Despite this, binaural beats continue to be marketed commercially for many different purposes, and researchers have shown a potential efficacy for a number of therapeutic uses (Le Scouarnec et al., 2001; Padmanabhan, Hildreth, & Laws, 2005; Weiland et al., 2011). Most relevant for our study, Padmanabhan, Hildreth, & Laws, (2005) found that listening to music with embedded binaural beats was more effective in reducing anxiety in pre-operative hospital patients, than music without binaural beats. This suggests that incorporating binaural beats into an already effective music-based intervention may increase its benefit, and help to further reduce anxiety and increase relaxation.

Both music and meditation are frequently used to facilitate stress release, whether in everyday life or in the context of therapy. Evidence is growing that, depending on the type of meditation, meditation may indeed facilitate relaxation, as indicated by enhanced parasympathetic activation. Other forms of meditation may however produce sympathetic activation and greater alertness of the mind (e.g. Amihai & Kozhevnikov, 2014; Lomas, Ivtzan, & Fu, 2015). The musical genre that we coin to be ‘meditative binaural music’ makes use of binaurally recorded sounds and slowly unfolding musical patterns, intended for calming the mind and body. The binaural recordings capture sounds within its sonic environment generating a sense of acoustic space. For this study, musical pieces included two compositions from Nigel Humberstone that were composed for the purpose of stress release and relaxation in an elderly population, including people suffering from dementia. The compositions use a combination of natural and musical sounds, as further explained in the method section.

Age Dependent Emotional Responses

Changes in emotional state in response to music are commonly measured using self-report of felt emotion as the primary measure. As emotion is a multifaceted phenomenon, it has been advocated to additionally include measurements of physiology, behaviour (such as muscle tension) and/or cognition (e.g. changes in perception or judgment) (Ridder, Stige, Qvale, & Gold, 2013). Measures of skin conductance, heart rate and blood pressure have been used as markers of sympathetic arousal in trials studying music and emotion (Koger & Brotons, 2000). Of these measures, skin conductance seems to be the most sensitive marker of physiological arousal in response to arousing or calming music (Rickard, 2004).

A complication of the use of physiological measures is posed by the observed lack of variation in physiological response in older individuals (Appenzeller, 1994). Subjective measures have been previously reported to be more sensitive in this context than physiological measures (Iwanaga, Ikeda, & Iwaki, 1996). Using both physiological and subjective outcome measures in a mixed methods design may be the best way to improve understanding in this field (Ridder et al., 2013). The self-report outcome measures may concern post-listening questionnaires or continuous response data collection during listening (e.g. Coutinho & Dibben, 2013; Diaz, 2013). Summative questionnaires allow for the evaluation of multiple measures, but rely on post-listening reflection. An advantage of continuous response paradigms is that they allow for the measurement of changes in emotional state as they develop over time.

Previous research investigating differential responses to music in a younger and older population has shown differences in emotional evaluation of music: Older adults seem less sensitive to emotional expressions in music than younger adults. In particular, lower recognition rates in older compared to younger adults have been found for emotional expressions of sadness and fear (Laukka & Juslin, 2007; Lima & Castro, 2011), and, in some studies, also for expressions of happiness and peacefulness (Sutcliffe, Rendell, Henry, Bailey, & Ruffman, 2017). Vieillard and Gilet (2013) extended the investigation to the emotional experience of music and found a stronger tendency in older adults to experience happiness in music.

Multiple factors related to the music, person and context contribute to the experience of emotional responses to music and associated changes in affective state. Feeling the perceived emotion is only one of multiple routes (Juslin & Västfjäll, 2008). In particular, whether listeners respond positively to music strongly depends on their familiarity with and preference for that music (Craig, 2014; Salimpoor et al., 2013; Tan et al., 2012). As preferences and familiarity vary with age (Bonneville-Roussy et al., 2017), positive emotional responses to particular genres may similarly vary.

Design and Hypotheses

An experimental study was designed to investigate 1) whether and in what way binaural beats and binaural music contributes to relaxation compared to two control pieces of classical music, and 2) whether the effect of type of music on experienced relaxation varies with age. A 4 x 2 experimental design was used that included four types of music and two age groups. The four types of music were MBM without binaural beats, MBM with binaural beats, classical music low in arousal and positive in valence, and classical music high in arousal and positive in valence. Multiple measures associated with relaxation were included as dependent variables to differentiate in more detail the effects of music type and age. These included variables differentiating emotional valence, emotional arousal, and present-mindedness (Sloboda, O'Neill, & Ivaldi, 2001), continuously reported levels of alertness vs. relaxation, and physiological arousal. It was hypothesised that MBM would be experienced as lower in felt arousal than either high or low arousal classical music. Additionally, we hypothesised that including binaural beats would increase the effect of MBM.

We predicted that physiological and felt arousal would correlate with each other and with other measures associated with relaxation; valence and present-mindedness. We expected interactions with age group for experienced valence and physiological arousal.

Method

Participants

Two groups of participants were recruited that differed in age: Fifteen participants were aged between 18 and 25, and fifteen participants were aged between 50 and 80, making up a sample of 30 participants. Previous studies found highly significant effects of music varying in activation and valence on subjective and physiological responses with a similar sample size (e.g. Lundqvist, Carlsson, Hilmersson, & Juslin, 2009; Rickard, 2004). Participants were recruited using e-mail lists of the University of the Third Age and The University of Sheffield, with a few additional participants in both groups recruited through word of mouth. The only exclusion criterium was any self-reported hearing problems. All participants reported a normal level of hearing.

Table 1. Descriptive statistics for age, depression score (PHQ9), and anxiety score (GAD7) for the younger and older participant group.

	Age		PHQ9		GAD7	
Younger (N=15)	Mean	21.13	Median	3	Median	2
	SD	1.19	Min	1	Min	1
			Max	12	Max*	7/20
Older (N=15)	Mean	68.20	Median	3	Median	1
	SD	7.41	Min	1	Min	0
			Max	9	Max	10

* Two values are given as the highest two scores are wide apart.

Most participants had very low depression and anxiety baseline scores, except for 3 participants in each age group who showed mild (PHQ9 > 5) to moderate (PHQ9 > 10) levels of depression, and 3 participants in each age group who showed mild (GAD7 > 5) to severe (GAD7 > 15) levels of anxiety (see Table 1). All participants indicated to listen frequently to music. A greater number of participants in the older age group (N=10) indicated listening to classical music regularly than in the younger age group (N=5). Written responses to these questions related to the personal background of participants were collected at the start of the experimental session by the experimenter GLH. All participants completed the study in a single session.

Musical Material

Two MBM pieces were composed by Nigel Humberstone. Two out of five originally composed pieces[1] were chosen for use in the study on the basis that both pieces make use of a combination of natural sounds in the background and instrumental sounds more in the foreground. Furthermore, the solo instruments perform simple melodic and rhythmic patterns in an even manner and at a calm pace. Pauses in the instrumental parts add to a sense of low density of events. Although there was no intention to explicitly mimic certain commercially available music, these characteristics are not untypical of meditative music intended for relaxation, which may or may not be combined with binaural beats. The two selected MBM compositions include:

1. Loxley Sansula: Kalimba and meditational bamboo flute combined with binaural field recordings of running water and birdsong (Humberstone, 2014a)
2. Solstice Dawn: Pedal harp combined with binaural field recording of dawn chorus at Graves Park on summer solstice (Humberstone, 2014b)

Given previously reported calming effect with Theta wave binaural beats (McConnell, Froeliger, Garland, Ives, & Sforzo, 2014; Weiland et al., 2011), 7Hz binaural beats were incorporated into the two MBM tracks that were chosen for use in the study. The two pure sine waves used to produce the

[1] The five pieces were composed for a Festival of the Mind exhibition and were conceived as creating a serene sound space for relaxation for people with dementia. The music is freely accessible online: http://aprirsi.group.shef.ac.uk/

beat were 520Hz and 527Hz, using commonly used carrier tones around 500Hz (Goodin et al., 2012; Oster, 1973). The presence of the carrier tones was masked by the music.

Two pieces of classical music were included as control piece - Mozart's Divertimento in Bb for string ensemble (Glover & London Mozart Players, 2002) and Chopin's Nocturne No. 2 in Eb for piano solo (Barenboim, 1982). These pieces were used in a study by Coutinho and Cangelosi (2011), and evaluated by participants as positive in valence, but distinct in arousal. The first has a faster tempo and received a high arousal evaluation, while the second is slower in tempo and received a low arousal evaluation. An overview of the main characteristics of the musical pieces is given in Table 2. All pieces were trimmed to a duration of 3 minutes.

Table 2. Main characteristics of musical pieces. Tempo was estimated through manual tapping of the beat in the opening phrases of the pieces. All pieces were 3 minutes in duration.

Music	Tempo	Texture	Intensity
Loxley Sansula	98 BPM	Water, birdsong, flute, kalimba	Soft
Solstice Dawn	90 BPM	Birdsong, harp	Soft
Divertimento	150 BPM	String orchestra	Moderately loud
Nocturne	102 BPM	Piano	Soft-Moderate

Procedure

Ethical approval was obtained in accordance with The University of Sheffield ethics procedures and guidelines. Participants gave written informed consent prior to participating in the study, and participation was on a voluntary basis. No monetary compensation was given to participants. All sessions were run by GLH.

Participants were tested on an individual basis and came to the Music Psychology Lab at The University of Sheffield to participate in the study. They were seated in a comfortable chair behind a desk and listened to the music through JVC HA-NC250 noise-cancelling headphones. After giving written informed consent and filling in the background questionnaire, skin conductance electrodes were placed on participants' index and ring finger of the non-dominant hand. Subsequently, participants were guided through a practical trial of listening to music and providing their subjective response whilst listening and after listening to a musical excerpt. Participants were asked to indicate their level of alertness-relaxation and any changes in these, whilst listening to the music. The slider was positioned at the mid-point at the start of each musical piece. The same procedure and written instructions were used for each participant, except for the order of the musical tracks, which was varied randomly across participants. As explained, participants listened to the two classical music pieces and the two MBM pieces. One of the MBM tracks included binaural beats, the other did not. Which of the two MBM tracks contained binaural beats was counter-balanced across participants. Three measures were taken for each presented musical piece: A post-listening subjective response questionnaire, a continuous alertness-relaxation response measure during listening, and measures of physiological arousal. After listening to all four musical pieces, participants were asked to write down their responses to a few open-ended questions related to their experience of the MBM tracks.

Outcome measures

Subjective post-listening responses. The questionnaire used by Sloboda, O'Neill, and Ivaldi (2001) was implemented after each piece of music, to obtain a self-reported measure of felt emotion in response to the music. Variables were bipolar and rated on a 5-point scale, ranging from I feel very (one pole) to very (other pole). The mid-point is used when neither are applicable.

Following Sloboda, O'Neill, and Ivaldi (2001), Pearson's correlations between the subjective post-listening response variables were calculated to define groups of correlated variables. We only included variables in a group that showed a Pearson's correlation of .5 or higher with the other variables in that group (Cohen, 1988). Three groups were defined capturing 'Arousal', 'Positivity' and 'Present-mindedness' as in the original research (Sloboda, O'Neill, & Ivaldi, 2001). Table 3 shows the variables included in each group. Variables within a group were averaged to create the three aggregated measures. Notably, self-reported feelings of relaxed-tense correlated and grouped with other variables in the Positivity measure but not with variables of the Arousal or Present-mindedness measures.

Table 3. Variables included in the three response measures of Arousal, Positivity and Present-mindedness.

	Variables
Arousal	Alert-Drowsy, Energetic-Sleepy
Positivity	Comforted-Distressed, Relaxed-Tense, Secure-Insecure
Present-mindedness	Involved-Detached, Connected-Lonely, Interested-Bored

Continuous alertness-relaxation response. Levels of indicated relaxation vs. alertness were recorded in a continuous fashion during the listening experience through the use of a MIDI slider. The participant was free to move the slider up and down between the two poles, labelled ‘alert’ and ‘relaxed’, throughout the duration of each track in accordance with his or her felt relaxation. A weighted average of the slider levels for each track were calculated per participant, which took into account the duration and the level of the slider.

Physiological arousal. Physiological measures of skin conductance (µS) were obtained using sensors attached to the first and second finger of participants’ non-dominant hand. Skin conductance data were recorded during each track and averaged across the duration of a track using BioGraph Infiniti hardware and software.

Post-study open-ended questions. After the study, patients were asked a few open-ended questions about their experience of the MBM. They were asked:

- Whether they would want to listen to it regularly
- In what circumstances, they would listen to it
- In what way, they thought it might be useful to them

These questions were included with the aim of obtaining initial qualitative data on subjective responses to MBM.

Statistical methods

Mixed-model analyses of variance (ANOVA) were used to examine the effects of the within-participants variable music (4 levels) and between-participants variable age group (2 levels) on three types of dependent variables: self-reported emotional state post-listening (consisting of multiple dependent measures) and during listening (the averaged continuous rating response of alertness-relaxation) and measured physiological arousal (skin conductance). Post-hoc pairwise comparisons were run to further investigate significant effects of music. Alpha levels were adjusted using Bonferroni corrections for multiple testing.

Results

All participants completed the study and none of the participants indicated discontent or discomfort during the listening tasks, indicating that the experimental requirements were tolerable. Results are explained consecutively for each dependent measure.

Subjective post-listening responses: Arousal, Positivity, and Present-mindedness

The mixed-model ANOVA with music and age group as independent variables and self-reported felt Arousal as dependent variable showed a significant interaction between the effects of music and age (see Table 4), indicating that the effect of musical excerpts depended on the age group.

Table 4. Results of the mixed model ANOVA testing the effect of music and age group on ratings of Arousal, Positivity, and Present-mindedness.

		Arousal		Positivity		Present-mindedness	
	df^x	*F*	*r*	*F*	*r*	*F*	*r*
Music	3, 84	61.49***	.83	4.60*	.38	11.29***	.54
Age	1, 28	1.26	.21	9.26**	.50	10.05**	.52
Music*Age	3, 84	2.73*	.30	5.11**	.39		

[x] Degrees of freedom are corrected for violations of sphericity if appropriate. Corrections are not reported for readability of the table.

* $p < .05$, ** $p < .01$, *** $p < .001$

Illustrating this interaction, Figure 1 shows the mean felt Arousal ratings for each musical excerpt and age group. It also indicates per age group the mean felt arousal ratings of musical excerpts that were significantly different from each other. Stronger differences in felt arousal between musical excerpts were observed for the younger age group than the older age group. For both groups, responses to the high arousal music were reliably different from all other musical excerpts ($p \leq .001$). Additionally, for the younger age group, the low arousal classical music received higher felt arousal ratings than the MBM including binaural beats ($p = .014$). Responses to the MBM including binaural beats were evaluated as lowest in felt Arousal (see Figure 1). There was however no reliable difference between the evaluations of responses to the MBM with and without binaural beats ($p > .05$).

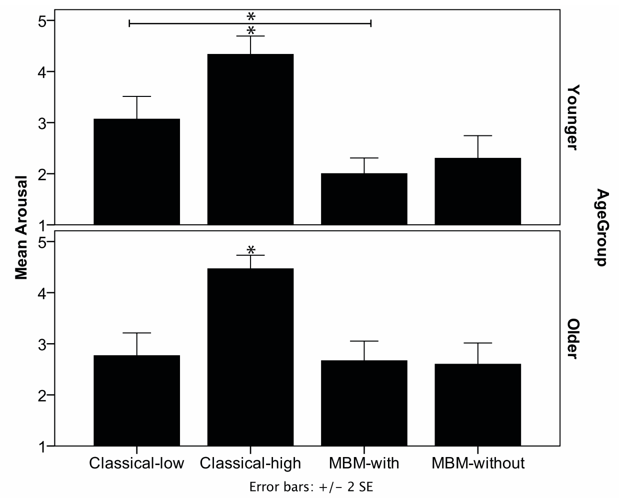

Figure 1. Mean felt Arousal ratings per musical excerpt and age group. * with brackets indicates a significant difference between two conditions. * without brackets marks a condition that is significantly different from all other conditions.

Ratings of Positivity also showed a significant interaction between the effects of music and age group (Table 4), showing that the evaluation of Positivity responses to the music depended on the age group. Figure 2 shows the mean Positivity ratings for each musical excerpt and age group, and the outcomes of pairwise comparisons between ratings of responses to musical excerpts for each group.

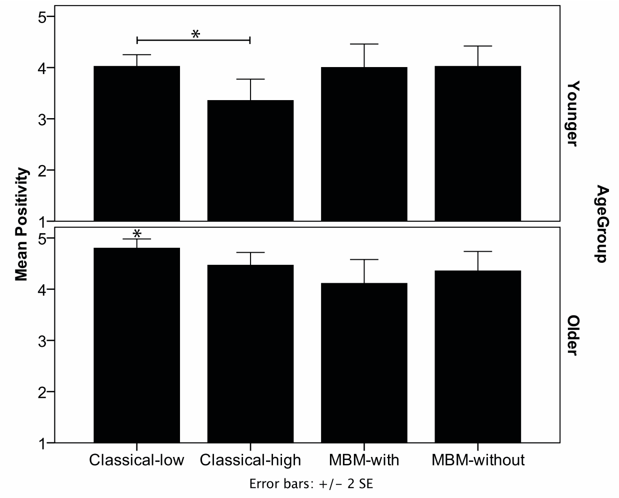

Figure 2. Mean Positivity ratings per musical excerpt and age group. * with brackets indicates a significant difference between two conditions. * without brackets marks a condition that is significantly different from all other conditions.

These pairwise comparisons showed that for the younger group, the mean Positivity responses to MBM were similarly high as to low arousal classical music, although with a greater variability (SE) between participants. Only the difference in Positivity responses to low and high arousal classical music were significant. For the older group of participants, responses to MBM were evaluated similarly in Positivity as to high arousal classical music. Responses to these three music excerpts were evaluated as significantly lower in Positivity than to low arousal classical music. Both groups evaluated all responses as positive in valence ($M \leq 3.35$). The responses to the music by the older group were on average more positive than the evaluations of responses by the younger group.

Thirdly, no significant interaction between music and age group was found for Present-mindedness (PM) ratings ($p = .72$). However, the main effects of music and group were significant. The main effect of music shows that the music reliably modulated feelings of Present-mindedness ($p < .001$, see Figure 3), while the main effect of group ($p = .004$) was related to a generally lower evaluation of PM by the younger age group ($M = 3.56$, $SE = 0.14$), than the older age group ($M = 4.17$, $SE = 0.14$). Pairwise comparisons between the responses to the musical tracks showed that the high arousal classical music was followed by higher PM ratings, than the other musical tracks ($p <$

.01). There were no other significant differences between the evaluations of PM in response to the musical tracks.

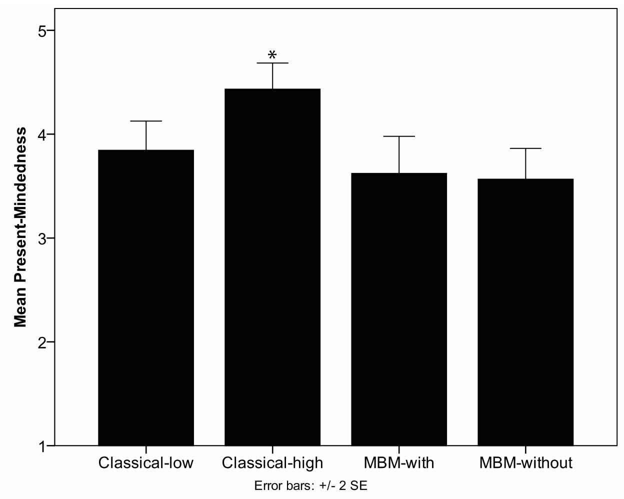

Figure 3. Mean Present-mindedness ratings per musical excerpt. * indicates a condition that is significantly different from all other conditions.

Continuous alertness-relaxation response

The weighted average of the continuous response of Relaxation-Alertness evaluations per musical excerpt were analysed in the same way as the post-listening measures, using a mixed model ANOVA. No significant interaction between the effects of music and age group was found (p = .12). Focussing on a main effects model, a highly significant effect of music was found (F (3, 84) = 65.43, p < .001, r = .84), but no significant main effect of age group (p = .92). Figure 4 shows the mean responses per musical excerpt. Responses during the high arousal classical music were higher in felt Alertness, than during the other musical tracks (p < .001 for all comparisons). There were no other significant differences between the evaluations of responses to the musical tracks.

Given the range of the evaluations (from -60 to 60), this analysis showed that the weighted mean for high arousal classical music fell above the evaluation mid-point, while the weighted means for the other musical tracks fell below the mid-point and were as such experienced as relaxing.

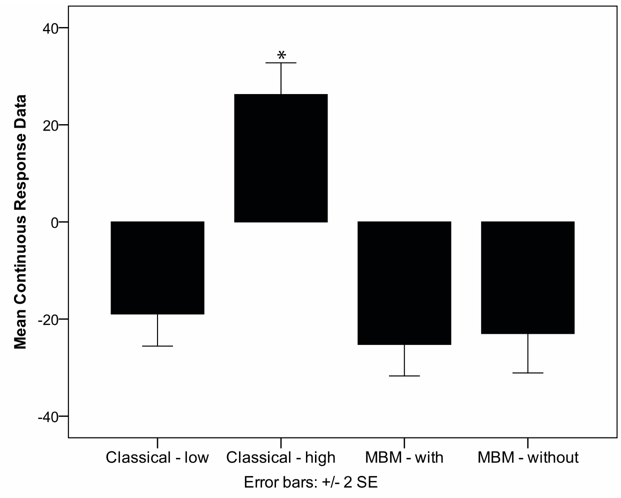

Figure 4. Mean Alertness-relaxation weighted average data per musical excerpt. * indicates a condition that is significantly different from all other conditions.

Physiological arousal: Skin conductance

The final quantitative analysis concerned the measured mean skin conductance per musical track and age group. The mixed model ANOVA showed no significant interaction between music and age group (p = .37). Focussing on the main effects, the effect of music was not significant (p = .27), nor was there a significant main effect of age group (p = .14). To explore trends within skin conductance across the two groups, Figure 5 plots mean and standard errors in skin conductance per experimental condition. As can be seen, skin conductance levels in the older group were unresponsive to differences in arousal of the musical excerpts. The younger participants did show some responsiveness in the predicted direction: a relatively high skin conductance level for the high arousal classical music. Given the absence of significant effects, the prediction that self-reported measures may be reflected in skin conductance changes was not confirmed.

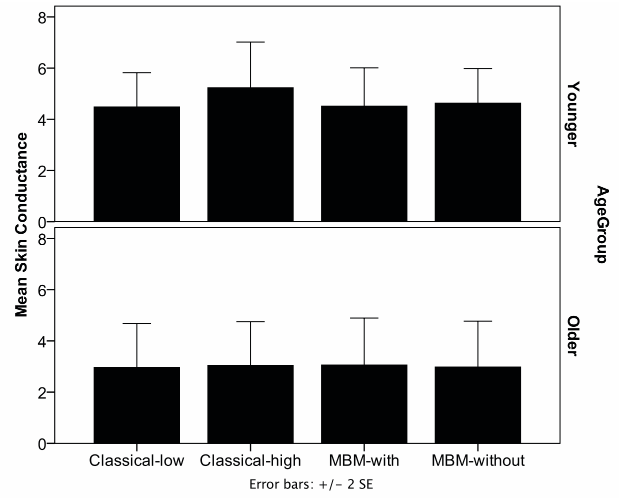

Figure 5. Mean skin conductance levels per musical excerpt and age group.

Post-study open-ended responses

After taking part in the study, participants were asked a few questions about their experience of MBM. When asked *whether they would listen to MBM regularly*, 21/30 said 'yes', while the others responded negatively. Opinions were similarly divided in both groups, with 11 of the younger participants responding positively, and 10 of the older participants. When asked *in what scenario they would choose to listen to MBM*, 10/21 said (without prompt or guidance) that they would listen when 'wanting to relax', and 12/21 said they would listen 'before bed' or 'when wanting to sleep'. Other responses included as background/whilst doing other things, or as a change from other music. When asked *how they thought MBM might help them*, 17/21 said it might help them 'relax'. 5/21 responses included help with sleep. Not everyone knew how it would help them (4/21).

Discussion

The main interest of the study was to investigate whether and in what way meditative binaural music may contribute to relaxation, how this compares to previously validated control pieces, and whether this may be different for younger and older participants. Participants indicated their affective state at the end of listening to each musical piece. In grouping the measures into clusters of correlated variables, it was found that evaluations of relaxation vs. tension were correlated with other variables of the Positivity group (comfort and security), but not with variables of the Arousal or Present-mindedness group. This suggests that a positive affective state is an important aspect of relaxation. The felt Positivity after listening to music depended on age group: The older group indicated the highest Positivity response to low arousal classical music. MBM and high arousal classical music received lower Positivity responses. For the younger group, only the contrast between responses to low and high arousal classical music was significant. This group evaluated responses to MBM as relatively high in Positivity, comparable to responses to low arousal classical music, but with greater between-participant variability.

Differences across age groups in reported feelings of Positivity was not associated with the reported frequency of listening to classical music. For both groups, responses to MBM were equally in Positivity as responses to either one or the other classical music piece. Nevertheless, it is noteworthy that the older age group (who listened more to classical music) showed a significant difference between responses to one of the classical pieces and MBM, while the younger group did not. As mentioned, for the younger group, responses to MBM were relatively high in Positivity, while for the older group, responses to MBM were less highly positive in emotion as for one of the classical pieces. It will be worthwhile for future studies to directly investigate a possible role of musical preference for positive responses (e.g. Salimpoor et al., 2013) to MBM compared to other genres. Notably, induced positive emotion for the low arousal classical music piece was close to ceiling for the older group (M = 4.8).

The strongest variation across musical pieces was however found in evaluations of felt Arousal, which may be expected from the experimental design that contrasted music low and high in arousal. The pattern of induced felt arousal across musical pieces varied again with age group: Stronger variations in felt arousal were reported by the younger compared to older participants. MBM with binaural beats in particular was found to induce a very calm, low in arousal emotional state in the younger age group, even lower than the low-arousal classical music. For the older age group, the effect on felt arousal of MBM significantly contrasted with the high arousal classical music. These results support the hypothesis that MBM may induce a sense of calmness and low activation.

In the continuous response evaluations, participants reported on levels of relaxation vs. alertness. In this context, both groups performed similarly and MBM was found to lead to similar levels of relaxation as low arousal classical music, contrasting indications related to high arousal classical music, and showing parallels with evaluations of post-listening felt Arousal. These results highlight the variable affordances of 'relaxation': Depending on context, participants may associate it in particular with low arousal and/or with a positive emotional state.

The association between low arousal and a relatively positive emotional state rather than high arousal and positive emotion contrasts with previous findings of a positive correlation between emotional arousal and valence in musical contexts (e.g. Coutinho & Cangelosi, 2011). This difference in results may be due to the particular stimuli used in our study: No music was included with a negative valence, and all excerpts received a positive evaluation. It could also be due to the particular concepts used to assess Positivity. In our study and in continuation of Sloboda, O'Neill, and Ivaldi (2001), positive emotion was measured using evaluations related to felt comfort, relaxation, and security compared to distress, tension, and insecurity. These concepts indeed indicate a different level of associated activation (arousal) than terms that are often used to assess positive emotion, such as pleasure, joy, wonder and happiness. Our study indicates the potential of certain types of music, including MBM, to induce a low-arousal, *positive* emotional state. This is relevant counter-evidence against commonly found confusions between positive and negative low-arousal emotions in response to music, where e.g. peacefulness is perceived as sadness (Laukka et al., 2013).

Additionally, MBM was associated with feelings of low Present-mindedness in a similar way to low arousal classical music. Responses to the high arousal classical music were evaluated as highest in PM, which means it triggered relatively strong feelings of being involved, connected, and interested. Indeed, our tentative prediction was that MBM may increase a sense of detachment, which seemed relatively speaking the case. No actual feelings of detachment were reported, however, as all evaluations were at or above the mid-range (indicating positively connected, involved and interested). Whether the induced state is related to a meditative state in any way cannot be inferred from the results of this study. Further investigations into the phenomenology of meditative music listening are required for a better-informed interpretation. For now, we confirm that PM was a variable that was modulated through music listening.

The effect of musical excerpt on self-reported arousal and relaxation were not corroborated by the measures of skin conductance. In particular, the older group showed hardly any variation in skin conductance in response to the music, in line with previous findings including older adults (Appenzeller, 1994). The younger group did show variability of skin conductance in the expected direction. However, none of the effects on skin conductance were significant. Admittedly, skin conductance is a variable measure, which limits its robustness as dependent variable. Nevertheless, skin conductance has previously been shown to be a relatively responsive measure to music of various emotional intensities and levels of arousal, in music of variable duration (e.g. Coutinho & Cangelosi, 2011; Krumhansl, 1997; Lundqvist et al. 2009; Rickard, 2004). Notably, such studies typically include younger rather than older participants.

The lack of variation in skin conductance means that the results of the study are primarily based on self-reported indications of emotional response. One of the limitations of self-report is that we depend on the honesty and ability of participants to for example differentiate between the reporting of perceived and felt emotion (e.g. Gabrielsson, 2001). Unfortunately, in the context of this study, we do not have a way of assuring whether certain emotional states were indeed induced through music listening, apart from relying on self-reports.

There was very little difference in response to the addition of binaural beats to binaural music. This may be due to a ceiling effect (MBM was already perceived as low in arousal), lack of statistical power (the participant pool was not very large) or may indicate a genuine lack of effect. The genre of MBM does seem to be a possible reliable candidate for so called ‘relaxation’ music, although its calming effect is not necessarily stronger than (validated) low arousal classical music. Nevertheless, it was subjectively experienced as suitable for use when going to sleep or to relax with. It may be particularly suited if the objective is to include calming music that is appreciated by people irrespective of their musical taste, and irrespective of age and musical listening habits. Even though responses to the music may differ in detail, the overall effect seems one of relaxation. This may be useful for contexts in which people lack the ability to clearly communicate their choice of music or preference for music due to communication or cognitive problems. The open-ended responses confirmed the potential for MBM to be used for relaxation in general as well as for relaxation before sleep. This was deemed feasible for participants in both age groups.

Future research may address some of the limitations of the study through the inclusion of several high and low arousal pieces of music, additional examples of MBM, and a baseline measurement of emotional state. The former three are to verify the generalisability of the results, while the last is to confirm a change in emotional state. It will be of interest to include a systematic assessment of preference or liking of the musical excerpts, and an assessment of what participants experience as 'relaxing' in every-day life and what they see as the purpose of relaxing music: Is it primarily a reduction of negative valence and increase of positivity, or a reduction in a high arousal stress state? Differences in baseline emotional state may also contribute to varying notions of 'relaxing' music.

To summarise, the main contribution of this study was to demonstrate a difference across two age groups in their response to music, which we have termed meditative binaural music. The younger age group responded relatively strongly in terms of changes in felt arousal, while the older age group showed relatively stronger modulations in felt positivity. For both groups, relaxation was associated with higher positive emotional valence and with lower emotional arousal. The strength of these associations depended on the measurement of relaxation and whether it was contrasted with 'tension' or 'alertness'. The interactions with age group and the differences in the evaluation of relaxation highlight the variability of what music may afford to listeners, depending on listeners' interests and predispositions. Evidence for subconscious contributions of binaural beats to relaxation was very weak in contrast. The broader relevance for music therapy practice seems to be further evidence of age-related emotional affordances of music, different ways in which music can be experienced as 'relaxing', and the positive potential for MBM to induce a calm and positive emotional state. Clarifications of the different ways in which 'relaxation' is achieved may help to explain some of the complex findings of what constitutes 'relaxing' music (e.g. Tan et al., 2013).

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Figure captions

Figure 1. Mean felt Arousal ratings per musical excerpt and age group. * with brackets indicates a significant difference between two conditions. * without brackets marks a condition that is significantly different from all other conditions.

Figure 2. Mean Positivity ratings per musical excerpt and age group. * with brackets indicates a significant difference between two conditions. * without brackets marks a condition that is significantly different from all other conditions.

Figure 3. Mean Present-mindedness ratings per musical excerpt. * indicates a condition that is significantly different from all other conditions.

Figure 4. Mean Alertness-relaxation weighted average data per musical excerpt. * indicates a condition that is significantly different from all other conditions.

Figure 5. Mean skin conductance levels per musical excerpt and age group.