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Music for anxiety? Meta-analysis of anxiety reduction in non-clinical samples

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Abstract

The beneficial influence of listening to music on anxiety states has often been discussed. However, the empirical evidence and theoretical mechanisms underlying these effects remain controversial. The aim of this study is to conduct a meta-analysis of randomized controlled trials on the effects of music on anxiety in healthy individuals. A comprehensive search in the PsycINFO, Cochrane Library, PubMed and Web of Knowledge databases produced 19 articles complying with the eligibility criteria. The main results of the study reveal an overall decrease in self-reported anxiety ($d = -0.30$, 95% CI [–0.55, –0.04]); however, the decrease was not significant for psychophysiological signals related to anxiety. Nevertheless, in several cases, listening to music greatly affects blood pressure, cortisol level and heart rate. The great heterogeneity of the studies and the lack of rigorous methodological standards, assessed with CONSORT guidelines, may have biased the results. Thus, listening to music should be cautiously considered as a part of more complex music-based psychological interventions for anxiety regulation. Nonetheless, as discussed in this article, the role of underlying processes (spontaneous memory recollections, mental imagery) must not be neglected. Further research perspectives are discussed.

Keywords

anxiety, emotion regulation, music listening, resilience, stress

Anxiety disorders are the most prevalent mental illnesses worldwide (Baxter, Vos, Scott, Ferrari, & Whiteford, 2014). Anxiety affects up to 28.8% of the population in Western countries (Michael, Zetsche, & Margraf, 2007), and its incidence appears to be increasing (Booth, Sharma,

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& Leader, 2015). Anxiety disorders have many detrimental impacts on health, daily life and well-being, and impair several cognitive processes, such as attention (Robinson, Vytal, Cornwell, & Grillon, 2013) and emotion regulation (D'Avanzato, Joormann, Siemer, & Gotlib, 2013). According to recent guidelines from the National Institute for Health and Clinical Excellence (NICE, 2014), psychological treatment must be the first-line intervention against anxiety disorders. Moreover, given the growing incidence of anxiety, the National Institute of Mental Health (NIMH, 2016) strongly recommended that attention be paid to the development of effective and easily disseminated psychological interventions to prevent anxiety.

The influence of music listening on affective states is well known (e.g., Juslin & Sloboda, 2010; Zentner, Grandjean, & Scherer, 2008). Listening to music evokes a wide range of emotions (joy, Koelsch & Skouras, 2014; wonder, Choppin et al., 2016), modulates brain activity (Koelsch, 2014) and cardiac output (Sumpf, Jentschke, & Koelsch, 2015). Moreover, in the last decade, there has been a growing interest in an evidence-based approach to studying the impact of music listening on anxiety, as measured by self-report measures (subjective reactions toward a stressful situation) or psychophysiological markers (objective indicators of anxiety, such as increasing heart rate). Listening to music has been a component of several psychological intervention protocols used in the domain of anxio-depressive symptoms, such as post-traumatic stress disorder (Bensimon, Amir, & Wolf, 2012) and depression (Fachner, Gold, & Erkkilä, 2013). The findings from reviews of the beneficial impact of music listening on clinical patients have shown that music may decrease blood pressure, heart and respiration rates (e.g., Pittman & Kridli, 2011). Scholars suggest that the type of music determines its beneficial effects. However, this hypothesis has not been explored systematically. Findings from studies of the effects of listening to music on healthy populations have revealed that music listening may decrease anxiety when different stressful situations are manipulated (e.g., Burns et al., 2002). Nevertheless, in some cases it seems to have no impact at all (e.g., Robb, 2000). As a whole, research on the impact of music listening on anxiety suggests that music may reduce both self-reported and psychophysiological measures of anxiety; however, this evidence has barely been quantified. Moreover, it remains unclear what factors underlie the beneficial impact of music listening on anxiety (Juslin, 2013).

Thus, the main aim of the current study is to present a meta-analysis of available randomized controlled trials (RCTs) run on the effects of music listening on anxiety in healthy adults. The rationale for that target population is in line with the notion of the preventive application of music listening for anxiety regulation. We will also attempt to determine when music is actually producing beneficial effects on anxiety so that the discussion of complex music-based interventions can be suggested.

Method

Literature research and eligibility criteria

The articles were obtained through a search of English reports in PsycINFO, Cochrane Library, PubMed, and Web of Knowledge databases; the reports were published from the first available year to January 2016. The search used the following keywords in combination: *music*, plus *stress* or *anxiety*. Studies were selected in accordance with the following inclusion criteria: (a) *dependent variables*: self-reported anxiety and/or psychophysiological measures of anxiety; (b) *design*: RCTs; (c) *procedure*: music listening group or condition, with a control group or condition; (d) *study aim*: anxiety or stress regulation; (e) *population*: healthy adults; and (f) *results*: means and standard deviations for each group or condition.

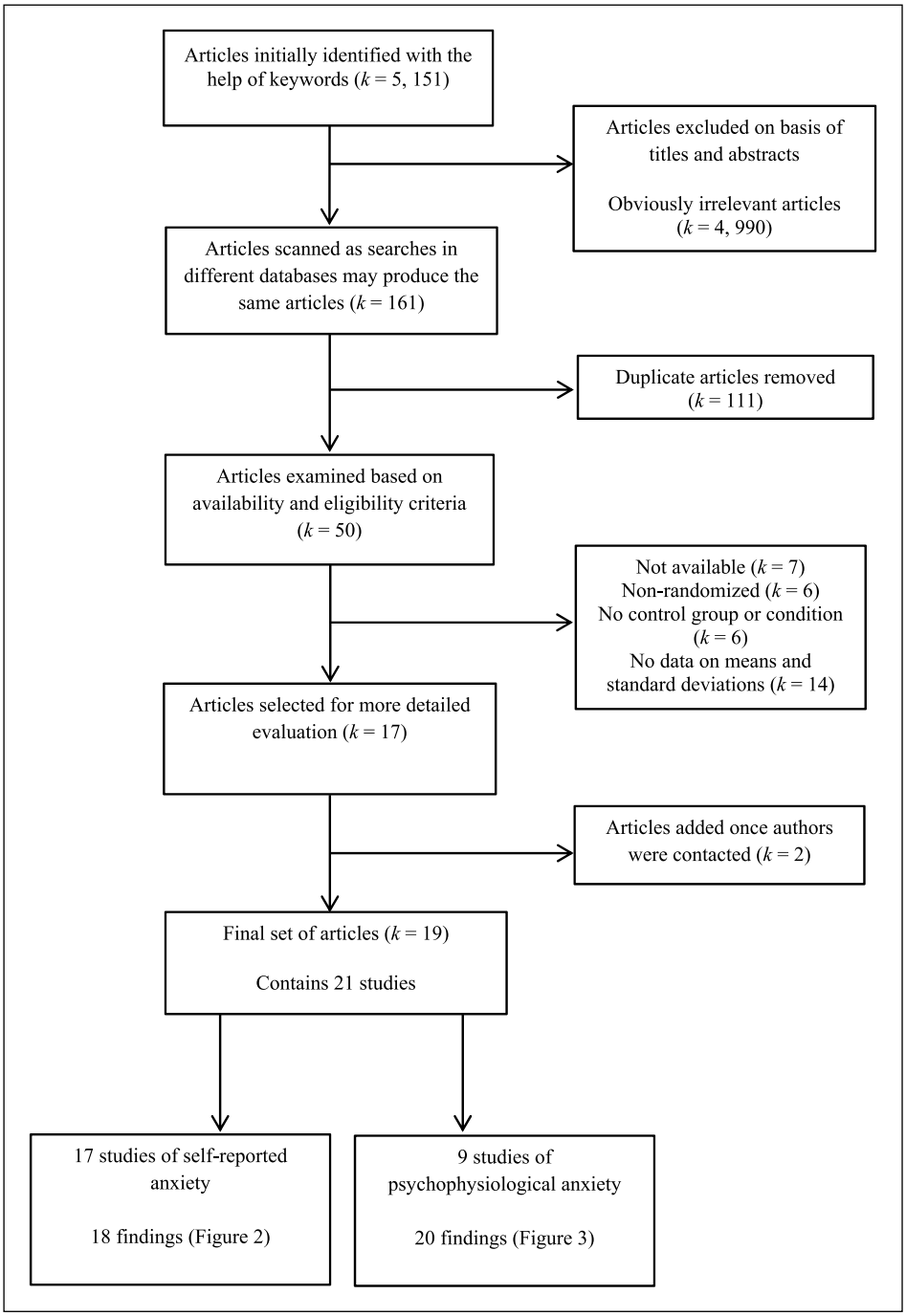


Figure 1. Flow diagram of publications selection process.

As described in Figure 1, the search yielded a total of 5,151 articles. An initial examination of their titles and abstracts revealed the majority of these references ($k = 4{,}990$) to be irrelevant for our meta-analysis. The remaining articles ($k = 161$) were identified as potentially meriting

further assessment. Out of this set of articles, the majority ($k = 111$) were set aside as they turned out to be duplicates that appeared in more than one database. The remainder ($k = 50$) were examined in accordance with the above-described eligibility criteria. Authors of unavailable articles ($k = 14$) were contacted via email to request a copy of their publications. They were also contacted in case of missing data on means and standard deviations (SDs). Once articles were added on the basis of the authors' replies, the final set of articles retained ($k = 19$) was subject to a thorough examination. As some publications (Plante, Marcotte, Manuel, & Willemsen, 1996; Smith & Morris, 1977) compared two different populations, in Table 1 they are considered to represent different studies. Some studies (e.g., Lai, Li, & Lee, 2011) provided several anxiety measures (e.g., cortisol, heart rate and mean blood pressure) and were therefore counted more than once in our meta-analysis (18 findings for self-reported anxiety, see Figure 2, and 20 findings for psychophysiological anxiety, see Figure 3).

Analyses were stratified by outcome measures and, within each outcome, we calculated the overall effect, and the standardized mean difference by music tempo, mode, presence of lyrics and music selection. To assess the methodological quality of the reviewed articles, we referred to the "gold standard" for evaluating non-clinical samples, namely, the Consolidated Standards of Reporting Trials (CONSORT; Bourton, Moher, Altman, Schulz, & Ravaud, 2008). In order to make it more relevant to music intervention, we have further developed a scale in line with previous research in grading papers (Kocsis et al., 2010). Twenty-four different dimensions applicable to the intervention were left (e.g., "Outcome and estimations – For each outcome, a summary of results for each group and the estimated effect size and its precision") and assessed on a 3-point scale (good evidence; partial evidence; no/poor evidence). Out of the total 456 judgments, the coders agreed on 87.94% ($n = 401$). Intercoder reliability was calculated with Kendall's tau coefficient, with 0 representing no agreement and 1 absolute agreement. The intercoder agreement was found to be strong, $\tau = .886$, $p < .001$. Divergences were resolved by discussion to reach consensus.

The effect size of music on anxiety was obtained with the pooled estimate of Cohen's *d* using the inverse variance weighting method with a random effect model. Heterogeneity was estimated with I^2, which was used to establish the proportion of variance due to heterogeneity among studies. I^2 values larger than 50% were considered indicators of large heterogeneity (Deeks, Higgins, & Altman, 2011; Higgins, Thompson, Deeks, & Altman, 2003). The magnitude of the effect sizes was interpreted in accordance with Cohen's (1988) recommendations: Cohen's *d*s of .2, .5, and .8 are considered, respectively, small, medium, and large. The estimated Cohen's *d* for each study was displayed in forest plots, along with its associated confidence interval, the weight given to each study in the meta-analysis, and the overall pooled effect size.

Results

Characteristics of studies

Table 1 summarizes the main characteristics of the 21 studies retained in the meta-analysis. Overall, the study group represents a total sample of 1,144 participants (69% females). Most studies (86%, $k = 18$, $N = 1{,}032$) applied a between-subject design allowing them to compare the effect of music listening to a control group or condition. Eighteen studies (86%, $N = 976$) used at least one passive control condition in which participants were invited to rest quietly for the same amount of time as the other group spent listening to music. Three studies (14%, $N = 168$) compared music listening to a muscle relaxation task or an aerobic exercise. Participants were exposed to a stressful event in 13 studies (62%, $N = 682$). Seventeen studies (81%, $N = 849$) assessed the effects of music listening with self-report measures of anxiety, and nine

Table 1. Characteristics of studies.

Study	*N* (female)	Cell *n* (No. of cells)	Population	Stress induction	Outcome measures	Out-come	Type of control
1. Burns et al. (2002)	60 (48%)	16*/18/13/13* (4)	students	mental task	STAI-S EMG HR	↓ – ↓	silence
2. Burns, Labbé, Williams, & McCall (1999)	56 (57%)	ND (4)	students	none	EMG HR	– –	silence
3. Choi (2010)	32 (68%)	8*/8/8/8* (4)	caregivers	none	STAI-S	↓	silence
4. Elliott, Polman, & Taylor (2014)	72 (39%)	26*/24/22* (3)	students	motor task	CSAI-2R HR	– –	silence
5. Gupta (2005)	80 (0%)	40/40 (2)	students	none	STAI-S	↓	silence
6. Hatta & Nakamura (1991)	52 (54%)	13*/13/13/13* (4)	students	none	SACL	↓	silence
7. E. Labbé, Schmidt, Babin, & Pharr (2007)	56 (73%)	ND (4)	students	mental task	HR Resp SC	– ↓ –	silence
8. Lai et al. (2008)	38 (100%)	38 (1)	students	examination	STAI-S PR	↓ –	silence
9. Lai et al. (2011)	54 (100%)	54 (1)	nurses	none	VAS-S Cortisol HR MAP	↓ ↓ ↓ ↓	silence
10. Lai, Liao, Huang, & Peng (2013)	60 (100%)	20*/20/20 (3)	nurses	mental task	HR MAP	– –	silence
11. Macone, Baldari, Zelli, & Guidetti (2006)	27 (48%)	14/13 (2)	students	treadmill exercise	STAI-S	–	silence
12. Plante et al. (1996)	34 (0%)	11*/7/9*/7 (4)	students	videotaped intelligence test	MAACL	↓	aerobic exercise
13. Plante et al. (1996)	26 (100%)	4*/8/6*/8 (4)	students	videotaped intelligence test	MAACL	↓	aerobic exercise
14. Radstaak, Geurts, Brosschot, & Kompier (2014)	123 (93%)	31*/32/34/25* (4)	students	mental task	DBP HR SBP	– – ↑	silence

(Continued)

Table 1. *(Continued)*

Study	*N* (female)	Cell *n* (No. of cells)	Population	Stress induction	Outcome measures	Out-come	Type of control
15. Robb (2000)	60 (ND)	ND (4)	students	none	STAI-S VAS-A	– –	silence
16. Smith & Morris (1976)	66 (ND)	22*/22/22* (3)	students	examination	worry	–	silence
17. Smith & Morris (1977)	30 (ND)	15/15 (2)	students	mental task	worry	–	silence
18. Smith & Morris (1977)	30 (ND)	15/15 (2)	students	mental task	worry	–	silence
19. Stoudenmire (1975)	108 (100%)	54/54 (2)	students	none	STAI-S	–	muscle relaxation
20. Szabo, Ainsworth, & Danks (2005)	20 (100%)	20 (1)	students	none	STAI-S	–	silence
21. Thoma et al. (2013)	60 (100%)	20*/20/20* (3)	students	psychosocial stress test	STAI-S Alpha-A Cortisol HR	– – – –	silence

Note. Alpha-A = salivary alpha-amylase; CSAI-2R = Revised Competitive Sport Anxiety Inventory-2 (R. H. Cox, Martens, & Russell, 2003); DBP = diastolic blood pressure; EMG = muscle tension; HR = heart rate; MAACL = Multiple Affect Adjective Checklist (Zuckerman, Lubin, & Robins, 1965); MAP = mean arterial pressure; ND = not defined; PR = pulse rate; Resp = respiration rate; SACL = Stress Arousal Checklist (T. Cox & Mackay, 1985); SBP = systolic blood pressure; SC = skin conductance; STAI = Spielberg State-Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); VAS-A/S = Visual analogue scale for anxiety/stress; * = groups of interest for our meta-analysis; Cell = *N* for each group or condition.

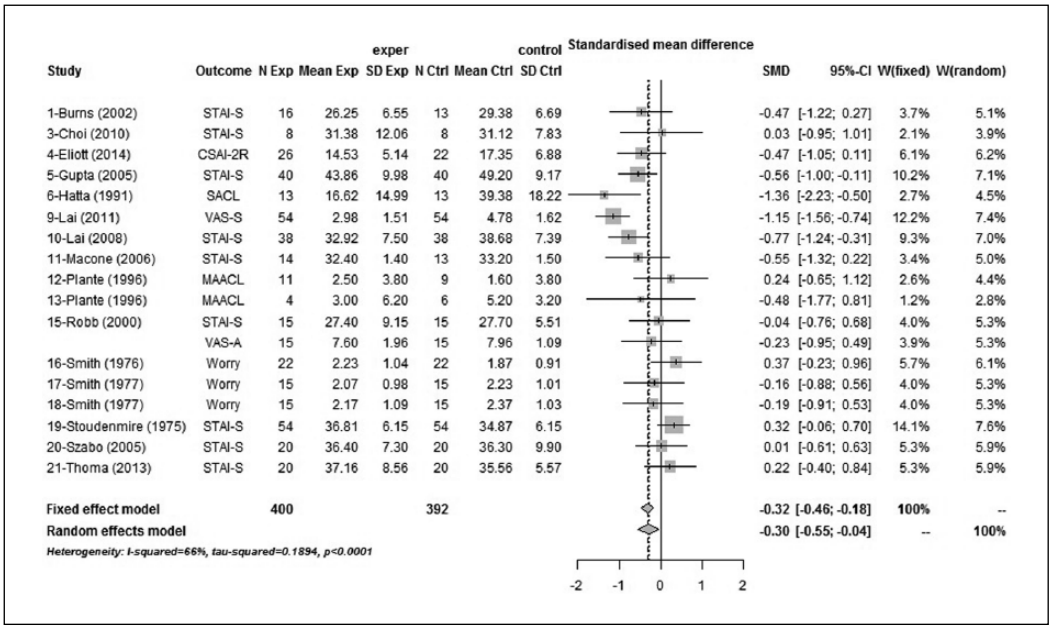


Figure 2. The effect of music on self-reported anxiety. CSAI-2R = Revised Competitive Sport Anxiety Inventory-2 (R. H. Cox et al., 2003); MAACL = Multiple Affect Adjective Checklist (Zuckerman et al., 1965); SACL = Stress Arousal Checklist (T. Cox & Mackay, 1985); VAS-A/S = Visual Analogue Scale for Anxiety/Stress.

studies (43%, $N = 579$) applied psychophysiological measures of anxiety. The mean length of music listening was 22 minutes overall ($SD = 9.86$) and 25 minutes ($SD = 8.45$) in studies showing a beneficial effect on anxiety.

The effect of music on self-reported anxiety

Figure 2 describes the pooled effect sizes of music listening effects on self-report measures of anxiety. The general pooled effect size for those studies was significant ($d = -0.30$, 95% CI [–0.55, –0.04]. The heterogeneity across the studies was relatively high ($I^2 = 66\%$, $\tau^2 = 0.19$, $p < .001$). A significant pooled effect size was obtained from 10 studies (48%, $N = 352$) that experimentally induced stress, while it did not prove significant for seven studies (33%, $N = 334$) that did not apply a stressor ($d = –0.26$, 95% CI [–0.47, –0.05] and $d = –0.37$, 95% CI [–0.83, 0.09], respectively). A significant pooled effect size was obtained for 16 studies (76%, $N = 659$) with slow music ($d = –0.28$, 95% CI [–0.55, –0.01]). The pooled effect for studies that specified their choice of music as classical ($k = 5$, 24%) and the mode of the music as major ($k = 5$, 24%) did not reach significance. It is important to note that the abovementioned results were obtained from music listening groups/conditions where the music sets were prepared by the experimenter.

The effect of music on psychophysiological anxiety

Figure 3 describes the pooled effect sizes of music listening on psychophysiological markers of anxiety. The pooled effect size of music listening on the overall psychophysiological reactions, assessed through the various psychophysiological measures, was not statistically

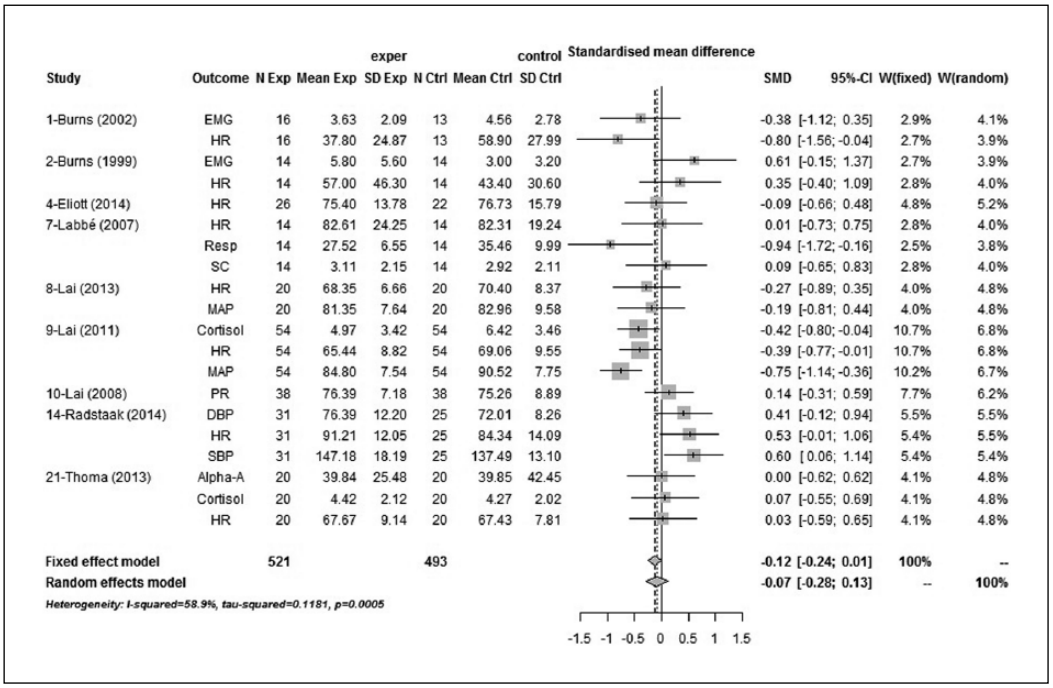


Figure 3. The effect of music on psychophysiological anxiety. EMG = measure of muscle activity; DBP = diastolic blood pressure; HR = heart rate; MAP = mean arterial pressure; PR = pulse rate; Resp = respiration rate; SBP = systolic blood pressure; SC = skin conductance.

significant ($d = -0.07$, 95% CI [–0.28, 0.13]). In addition, the heterogeneity across studies was high ($I^2 = 58.9\%$; $\tau^2 = 0.12$, $p < .001$). Additional analyses did not detect any groups of studies (e.g., studies measuring heart rate) that revealed a significant pooled effect size.

Methodological quality of articles

Table 2 describes the methodological quality of different dimensions of the final set of publications. In section 1, *Title and abstract*, the abstract was often incomplete (e.g., regarding results or conclusions). In section 2, *Introduction*, few articles described the theoretical framework explaining the impact of music on anxiety. In section 3, *Method*, few articles explicitly stated the eligibility criteria for participants or determined the sample size on the basis of power analysis. In section 4, *Results*, few articles presented a participant flowchart or defined the recruitment periods. Finally, in section 5, *Discussion*, very few studies discussed the generalizability of their findings.

Discussion

The current study represents the first meta-analysis on the beneficial effects of music listening on anxiety in healthy adults. The data gathered from the 19 selected articles suggested that listening to music decreases overall self-reported anxiety. Only in certain instances, though, does it congruently modify psychophysiological markers previously

Table 2. Methodological qualities in accordance with CONSORT guidelines as coded by the two independent coders.

Section	Dimension	Evidence quality [median value]
Title & Abstract	Summary of an article	1
Introduction	Scientific background	1
Method	Participants	1
	Interventions	1
	Standardization of interventions	1
	Adherence to protocols	0
	Objectives and hypothesis	1
	Outcomes	2
	Sample size	0
	Randomization sequence generation	0
	Allocation concealment	0
	Blinding	0
	Follow-up	0
	Statistical methods	0
Results	Participant flow	1.5
	Recruitment	0
	Baseline data	0
	Number analyses	1
	Outcomes and estimations	1
	Ancillary analyses	0
Discussion	Interpretation	1
	Generalizability	0
	Overall evidence	1
	Limitations	1

Note. 2 = good evidence; 1 = partial evidence; 0 = poor or no evidence. Guidelines adapted from Bourton et al. (2008).

found to be associated with stress reactions. The overall decrease in subjective anxiety is consistent with previous findings that reviewed the effects of music listening in patients (e.g., Bradt, Dileo, & Potvin, 2013). It seems that the type of music (classical or other) and the mode of music (major or minor) do not particularly influence the beneficial outcome of music listening. It is highly likely that other processes, such as autobiographical memories, underlie these outcomes (Belfi, Karlan, & Tranel, 2016). Thus, the role of underlying processes should not be neglected when exploring the impact of music listening on anxiety. The lack of support for the overall effect size on psychophysiological markers of anxiety can be explained by the great heterogeneity of studies' outcomes and assessment procedures – an argument highlighted in previous reviews (e.g., Chanda & Levitin, 2013; Koelsch & Jäncke, 2015). In addition, the small number of studies included in the meta-analysis compromised statistical power and any attempts to further stratify effects as a function of different psychophysiological markers.

New longitudinal studies should be conducted to ascertain whether the effects of listening to music described in this meta-analysis correspond to a transitory change in state

anxiety or whether they may correspond to changes that can also be measured in follow-up studies. The repetition and related training regulation strategies during music listening in those studies might also help us to better understand the phasic and sustained effects of music listening on the different components of stress and anxiety. Recommendations for further studies on music listening are summarized in the Appendix. A theory-driven approach combined with more stringent empirical study protocols would be expected to reach cutting-edge conclusions (Juslin, 2013).

The results of the current meta-analysis must be considered in light of several limitations. First, the great diversity of work in the area caused us to focus on articles that explicitly mentioned the use of music listening to reduce anxiety. Studies in which anxiety reduction was a secondary outcome were omitted. That choice limited the number of articles selected for this paper. Second, our analysis of the quality of the evidence provided so far, based on the CONSORT guidelines (Bourton et al., 2008), indicates that the most rigorous standards are still not being consistently applied. Therefore, further empirical research should be based on RCTs, with standardized procedures, and clear study aims. This will improve our understanding of music listening interventions in accordance with good research practice guidelines (Medical Research Council, 2012).

The perspectives in the domain of music and emotional regulation are huge (Lamont, 2012). For instance, low-intensity psychological interventions aiming to promote resilience, the cognitive ability to cope with stressful events (Ceschi, Heeren, Billieux, & Van der Linden, 2015), definitely have a comfortable margin to be developed. The complex nature of such interventions may involve: (1) engagement with music (dancing, singing) to boost subjective well-being (Weinberg & Joseph, 2016); (2) mental imagery to project positively in future (Pictet, Jermann, & Ceschi, 2016); (3) playing a musical instrument to express the personality (Nadyrova, 2012), discover hidden feelings (e.g., while improvising), and to show emotions that may be difficult to express verbally (C. Labbé, Glowinski, & Grandjean, 2016). Moreover, new technological developments allow non-musicians to produce music through corporal expression (by moving) while using interactive multimodal applications (Glowinski et al., 2014). The impact of those movements on emotions has not been explored yet. However, it has been shown that participants' emotional states changed congruently with their own vocal expressions, when these were manipulated experimentally (Aucouturier et al., 2015). Thus, new technologies are enlarging the scope of the potential use of music in psychological interventions by enabling participants to maintain a more active attitude and a greater physical engagement. This paves the way for inspiring new research and intervention avenues.

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Appendix

Best Practices for Conducting a Study of Music's Influence on Anxiety, inspired by the CONSORT guidelines (Bourton et al., 2008).

In the introduction

1. Describe the evidence of the beneficial effects of music listening on anxiety and suggest at least one explanation for each effect described.
2. Justify the choice of sample.
3. Formulate study aims and hypotheses.

In the method

1. Describe the eligibility criteria for participants and demonstrate how the sample size was calculated.
2. Give detailed information on the music excerpts used (e.g., tempo, mode); if possible, use pre-validated music excerpts that induce positive emotions (e.g., "Shallow Grave" from the Jyväskylä dataset; Eerola & Vuoskoski, 2011).
3. Use explicit measures of anxiety with well-established psychometric qualities (e.g., STAI-S; Spielberger et al., 1983).
4. According to previous studies that documented a beneficial effect of music on anxiety, the overall music duration should be 25 minutes (SD = 8.45).
5. A single music listening session might be sufficient to produce an effect. However, the music dose effect should be explored in further studies.
6. Given the average effect size described in our meta-analysis (cf., Figure 2; d = .30), in order to obtain a 90% chance of detecting a decrease in self-reported anxiety, test at least 95 participants (G*Power; Faul, Erdfelder, Lang, & Buchner, 2007).
7. To claim an effect on psychophysiological anxiety, use at least three different measures.
8. Control the baseline anxiety level to avoid ceiling effects.
9. To improve effect interpretation, use multiple suitable control groups or conditions (instead of a silence control condition/group only).
10. To evaluate the stability of music effects, run longitudinal studies with follow-up anxiety measures at 1, 3 and 6 months.
11. To increase ecological validity, consider the possibility of inducing a state of anxiety (e.g., by having participants view movies or images inducing stress and anxiety; International Affective Picture System, IAPS; Lang, Bradley, & Cuthbert, 2001; Schaefer, Nils, Sanchez, & Philippot, 2010) while listening music.
12. To disentangle the direct effects of music on anxiety and the indirect effects on resilience to stressful events (effect on vulnerability to anxiety), consider inducing a state of anxiety (e.g., by having participants solve very demanding tasks) after music listening.
13. Provide a flowchart showing participants' trajectory through the study.

In the results

1. State the number of participants in each group or condition.
2. Provide means and standard deviations for each group or condition.

In the discussion

1. Indicate to what extent your findings could be generalized to other populations, music types or contexts.
2. Discuss the clinical implications of the findings for anxiety interventions and stress prevention (resilience).
3. Discuss study limitations.