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Review Article

How does music aid sleep? literature review

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ABSTRACT

With the growth of interest in using music to treat insomnia, there is a need to collect and evaluate the literature. This paper reviews disparate literature and assesses the various kinds of assertions and hypotheses made by researchers about music's efficacy in assisting sleep. Six main researcher proposed reasons (RPR) for how music aids sleep were identified in the literature: (1) relaxation, where music encourages physiological or psychological relaxation; (2) distraction, where music acts as a focal point to distract from inner stressful thoughts; (3) entrainment, synchronization of biological rhythms to beat structures in music; (4) masking, obscuring noxious background noise with music; (5) enjoyment, listening to preferred, emotionally relatable or pleasant music; and (6) expectation, individuals cultural beliefs around music. We evaluated each RPR in terms of the evidence available in the extant literature. Masking RPR was identified as having support for improving sleep. Relaxation, distraction and enjoyment RPR had mixed levels of support. Expectation RPR had possible support. Entrainment had mixed possible support. The paper discusses interactions between RPRs, and a call is made to turn research attention to sequencing the RPRs and possible RPR mediators, with relaxation being a likely mediator of several RPRs.

1. How does music aid sleep? Literature review

The prevalence of insomnia is of critical concern with estimates nearing one in three individuals experiencing a sleep disorder [1]. Insomnia is associated with medical, psychiatric, personal and societal consequences [2,3]. Music is a sleep solution with no know side effects [4–7]. Moreover, using music to promote sleep has found support in surveys of the public [8]. Meta-analysis of music and sleep-related studies [9–11], including a Cochrane review [7] showed a positive effect of music as an intervention on sleep quality. Summary of meta-analyses and Cochrane review are shown in Table 1 with negative standard mean difference (SMD) indicating improved sleep quality (eg, reduced Pittsburgh Sleep Quality Index (PSQI) score) in favour of the music intervention to control.

In the meta-analyses, the reasons why music may aid sleep are not clearly addressed. Feng, Zhang [11] suggested that music may aid sleep by stimulating interactions between perception and action systems citing research unrelated to sleep. De Niet et al. [9], and Wang et al. [10], did not specify the process by which music may aid sleep. The Cochrane review identified two reasons why music may aid sleep: relaxation and distraction. However, as will become evident in the present research, the restriction of reasons for music aiding sleep to just these two might be overly conservative, particularly given the nascent state or research in the area. The strict inclusion criteria for Cochrane reviews will produce robust results but may omit studies because the hypothesis investigated have simply been understudied or inadequately designed rather than due to any necessary rejection of hypotheses. The aim of this paper, therefore, is to collate a broader literature review concerned with music and insomnia and from this literature present a comprehensive but plausible set of what we shall refer to as ‘researcher proposed reasons’ (RPRs) for how music may aid sleep. These RPRs come directly from the beliefs, hypothesis and mechanisms proposed by authors in their research papers. They are not our interpretations but proposed by the authors who attempt to explain the results of their research.

2. Method

2.1. Inclusion criteria

The studies were included in the review if they involved empirical investigation with reference to participants listening to an audio stimulus as a sleep aid. This audio stimulus is not limited to strict or conventional definitions of music but includes noise [12] and combinations of music and noise [13], as defined by the

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Table 1
Overview of meta-analysis of music for sleep.

Author	Review (n)	Epidemiology	Intervention	Total Population (Intervention/Control)	Measure	SMD[a] (95% CI[a])	RPR
De Niet, Tiemens [9]	17	Sleep problems	Music-assisted relaxation	–	PSQI, RCS	−0.74 [−0.96 to −0.46]	None
Feng, Zhang [11]	20	Primary insomnia	Music-assisted relaxation and other (ie, exercise, acupuncture, language induction and stimulus control)	684/655	PSQI	−0.61 [−1.01 to −0.20]	None related to sleep
Jespersen, Koenig [7]	5	PSQI>5 or complaints of insomnia	Music listening	134/130	PSQI	−2.80 [−3.42 to −2.17]	Relaxation Distraction
Wang, Sun [10]	4	Acute sleep disorder acute	Music	–	PSQI, RCSQ, VAS, VSH	−0.74 [−1.13 to −0.34]	None
Wang, Sun [10]	6	Chronic sleep disorder	Music	–	PSQI	−0.55 [−0.99 to −0.11]	None

SMD – Standardized Mean Difference.
CI – Confidence Interval.
PSQI – Pittsburgh Sleep Quality Index.
RCSQ – Richards-Campbell Sleep Questionnaire.
VAS – Visual Analogue Scale (VAS).
VSH – Verran and Synder-Halpern (VHS).
[a] Negative values indicating in favour of the intervention not the control.

researchers. The studies needed to have an identifiable RPR on how music impacts on participant sleep quality or sleep onset latency. A broad approach was taken which included papers regardless of group background characteristics (age, health, and sleep quality), measures (including physiological and self-report), audio (music, white noise and tones), experiment type (including descriptive, not strictly experimental), additional relaxation measures (such as massage or progressive muscle relaxation) and listening process (eg duration, time of day, the listening device etc.). Studies measuring wakefulness rather than sleep [14,15] were excluded from this review.

2.2. Search strategy

We systematically searched several online databases, including PubMed, Science Direct, The Cochrane Library and Google Scholar, from 1995 up to February 2019 using the search terms “music” and, “insomnia” or “sleep” in keywords, titles, abstracts and content for studies published in English. After the searches were completed, reference lists from, and citations of identified studies were examined to find additional studies that met the inclusion criterion.

2.3. Data extraction and categorization

Each paper was screened for an RPR concerned with music aiding sleep. The evidence presented in each paper was then assessed using three categories of support. The categorisation was necessarily qualitative because we consciously avoided conducting a meta-analysis to allow as many explanations of how music could aid sleep as possible, rather than only those studies with rigorous methodological and analytic approaches. Each study was therefore categorised as either:

- Support: The study found evidence to support the RPR for music aiding sleep.
- Possible support: The study found evidence of improved sleep which the author attributed to the RPR without direct testing.
- No effect: The study found no evidence of the RPR for music aiding sleep.
- Possible no effect: The study found no evidence of improved sleep which the author attributed to the RPR without direct testing.
- Opposing: The study found evidence was in contrast to the RPR for music aiding sleepie, the opposite effect.
- Possible opposing: The study found evidence of deteriorated sleep which the author attributed to the RPR without direct testing.

The papers were further broken-down into a physiological measures of sleep onset latency (PMSOL); a self-report measure of sleep onset latency (SMSOL); a physiological measure of sleep quality (PMSQ); and a self-report measure of sleep quality (SMSQ).

3. Results and discussion

One hundred and one peer-reviewed studies were identified as being related to the topic of music and sleep, but after consideration of inclusion criteria and other factors, as detailed in Fig. 1, 15 studies were retained for analysis. Six RPRs were identified in the literature to explain why music aids sleep quality or sleep onset latency (SOL): relaxing characteristics, distraction, entrainment, masking, enjoyment, and expectation. Each RPR is explained, and an overview of the evidence presented. Summary information of the retained studies are shown in Table 2 and then organized by RPR degree of support in Table 3.

3.1. Relaxation RPR

Sedative music can encourage physiological and psychology relaxation which may then lead to sleep. Su et al. [16], compared silence and music on sleep quality. The music group had improved sleep quality both using polysomnography (PSG, measuring sleep quality through a combination of electroencephalogram, electrooculogram, electromyogram and electrocardiogram) and self-report measures (Verran and Synder-Halpern Sleep Scale which assesses participant reported sleep quality). Relaxation indices of heart rate, arterial blood pressure and respiratory rates improved in the music group but not the silence group. The absence of an active control is a weakness in the design of the study, however, the improvement of sleep and increased relaxation in the music group, compared to the silent group supports the relaxation RPR for both self-report and physiological indices of sleep quality.

Jespersen and Vuust [17] measured participant sleep quality using the Pittsburgh Sleep Quality Index (PQSI). They compared music which participants had reported as relaxing on a scale

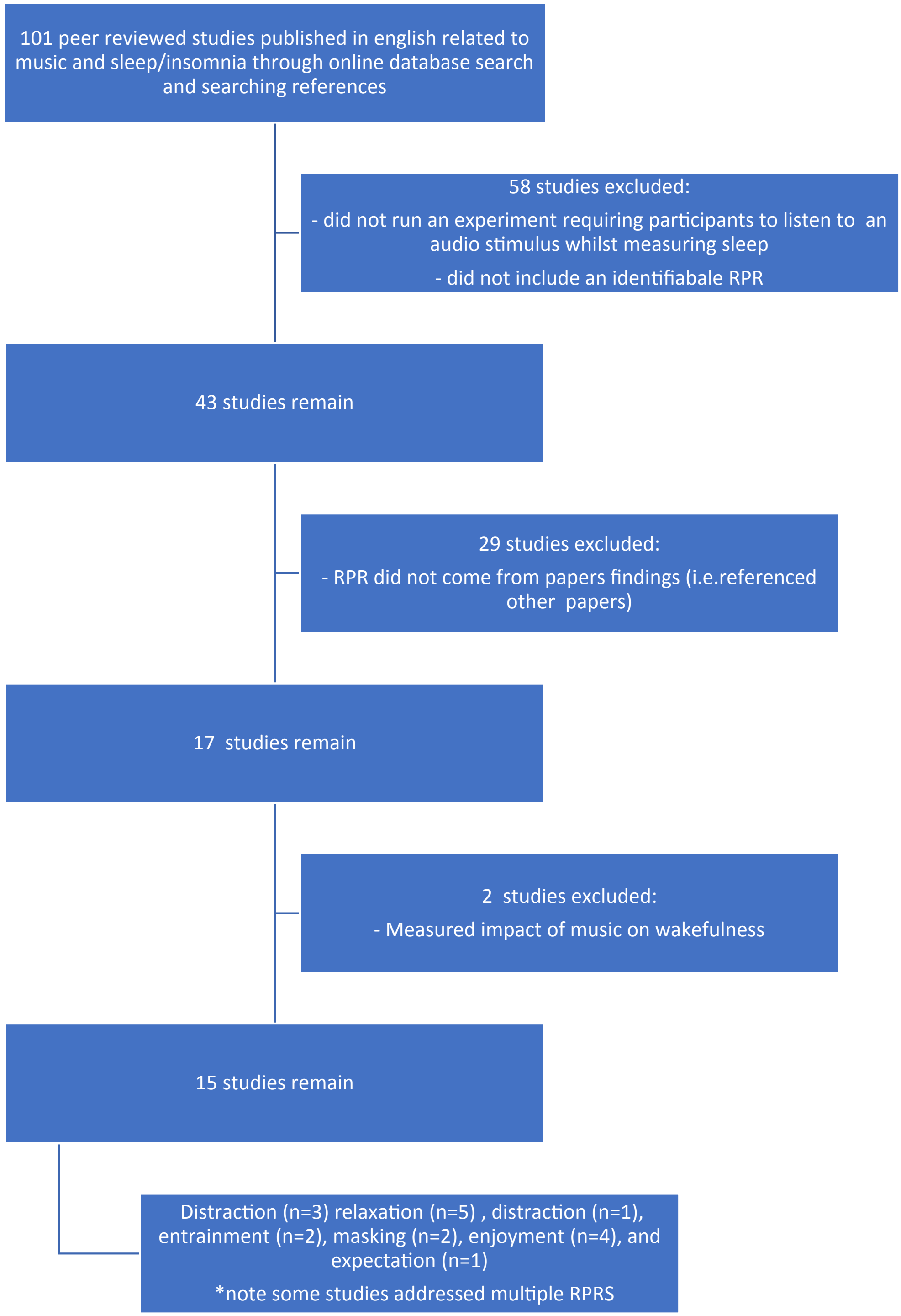

Fig. 1. Flow chart of selection of literature.

from 1 very relaxing to 7 very activating, with music. The music group had improved sleep quality compared to the control. Jespersen and Vuust [17] showed the effectiveness of music on relaxation and sleep but did not measure the impact of no music on participant-reported relaxation. Jespersen and Vuust [17] provide possible support for the relaxation RPR for subjective sleep quality due to lacking a comparison of relaxation between the music and control.

Harmat et al. [18], compared music, audiobooks and no intervention on sleep quality, choosing audiobooks as an alternative relaxing activity. Music improved sleep quality as measured by PSQI where audiobooks and no intervention did not. The authors suggested that music has additional qualities to aid sleep, different from the audiobook. However, they [18] did not explicitly measure subjective or objective relaxation which begs the question of whether the RPR was directly tested. This paper is classified in the

Table 2
Summary of literature.

Author	N	Sample	Epidemiology	Dependant Variable	Sleep Measure	Findings	RPR
Ansfield, Wegner [30]	101	University students	–	High/Low cognitive load music and High/Low sleep urgency	Sleep diary (self-assessed sleep onset latency)	Music ↑ and ↓ self-assessed sleep onset latency.	Distraction
Chang, Lai [22]	50	Paid volunteers	PSQI > 5 for 1 month	Preferred music/Researcher selected music/Control	Polysomnography VAS	Music ↓ N2 and ↑ REM. NS* sleep quality for researcher and preferred music.	Enjoyment
Gitanjali [40]	8	Individuals unfamiliar with raga	–	Sleep raga/Control raga	Polysomnography VAS	NS* sleep quality.	Expectation
Harmat, Takács [18]	94	University Students	PSQI > 5	Music/Audio books/Control	PSQI	Music ↑ PSQI.	Relaxation
Hernández-Ruiz [25]	28	Abused Women	Mean PSQI ≈ 11	Music with PMR/Control	PSQI (modified)	Music ↑ PSQI.	Distraction
Hu, Jiang [38]	50	Cardiac ICU patients	Mean PSQI ≈ 8	Earplugs + mask + music/Control	RCS (modified)	Intervention ↑ sleep quality.	Masking
Jespersen and Vuust [17]	15	Traumatized refugees	PSQI > 5	Music/Control	PSQI	Music ↑ PSQI.	Relaxation
Lazic and Ogilvie [19]	10	University Students	Mean PSQI ≈ 6	Music/Tones/Control	PSQI Polysomnography VAS	Music ↑ delta during sleep onset. NS* sleep quality.	Relaxation Enjoyment Entrainment
Mornhinweg and Voignier [26]	25	Elderly Community Based	Sleep complaints	Classical/New Age/Control	Self-report daily logs	96% of participants reported ↑ sleep.	Distraction
Ogata [23]	8	Volunteers	Normal sleepers	Classical music/Sim-music	EEG, EOG, ECG VAS	Sim-music ↑ delta in N2.	Enjoyment
Picard, Bartel [5]	20	Patients with fibromyalgia	JSS 17.5	Music (no control)	JSS VAS	↑ JSS score.	Entrainment
Ryu, Park [13]	58	Cardiovascular disease ICU patients	Satisfied with sleep	Music + earplug + mask/ Earplug + mask	VSH (modified) Sleep efficiency survey	Music ↑ sleep quality.	Masking
Stanchina, Abu-Hijleh [12]	4	Medical community	No sleep problems	Baseline/ICU recording/ICU recording + noise	Polysomnography	ICU recording ↓ sleep quality. White noise NS*.	Masking
Su, Lai [16]	28	ICU patients	Mean VSH = 511.43	Music/Control	VSH Polysomnography	Music ↓ N2 and ↑ N3.	Relaxation
Talbot, Hairston [21]+	56	Individuals with bipolar disorder and healthy individuals	No sleep problems	Neutral music/Happy music/Sad music	Polysomnography Sleep Diary (self-assessed sleep onset latency)	Happy and sad music ↑ self-assessed sleep onset latency. NS* sleep quality.	Relaxation. Enjoyment,

PSQI – Pittsburgh Sleep Quality Index
VAS – Visual Analogue Scale of subjective response of sleepiness
RCS – Richard-Campbell Sleep Questionnaire
JSS – Jenkins Sleep Scale
Polysomnography – electroencephalogram, electrooculogram, electromyogram and electrocardiogram
VSH – Synder-Halpern Sleeping Scale
NS* – Non Significant
PMR – Progressive muscle relaxation
↑ – Improved (for PSQI ↑ indicates improved sleep quality ie lower PSQI score)
↓ – Diminished
Sleep stages – Stage N1 is the first sleep stage and indicator of sleep onset, Stage N2 representing deeper sleep, Stage N3 is indicated by slow brain wave activity as very deep sleep and Stage R (REM) where rapid eye movement is present [43].

Table 3
Level of Support for each of the six Research Proposed Reasons (RPRs) for music aiding sleep.

RPR	Measure	Opposing	Possible Opposing	No effect	Possible no effect	Possible Support	Support
Relaxation	PMSQ			Lazic and Ogilvie [19]++	Talbot, Hairston [21]+		Su, Lai [16]
	SMSQ			Harmat, Takács [18] b		Jespersen and Vuust [17] b Talbot, Hairston [21]+	Su, Lai [16]
	PMSOL			Lazic and Ogilvie [19]++		Talbot, Hairston [21]+	Su, Lai [16]
	SMSOL			Lazic and Ogilvie [19]++			
Enjoyment	PMSQ	Ogata [23] c		Talbot, Hairston [21] Lazic and Ogilvie [19]++ Chang et al [22] c			
	PMSOL			Lazic and Ogilvie [19]++			Talbot, Hairston [21]
	SMSOL			Lazic and Ogilvie [19]++			Talbot, Hairston [21]
Entrainment	PMSQ			Lazic and Ogilvie [19]			
	SMSQ					Picard, Bartel [5] b	
	PMSOL			Lazic and Ogilvie [19]			
	SMSOL			Lazic and Ogilvie [19]			
Distraction	SMSQ					Hernández-Ruiz [25] a Mornhinweg and Voignier [26] a	
	SMSOL	Ansfield, Wegner [30]+++				Mornhinweg and Voignier [26] a	Ansfield, Wegner [30]+++
Masking	PMSQ						Stanchina, Abu-Hijleh [12]
	SMSQ						Ryu, Park [13] Hu, Jiang [38]
Expectation	PMSQ					Gitanjali [40] d	
	SMSQ					Gitanjali [40] d	
	PMSOL					Gitanjali [40] d	

+From Talbot, Hairston [21] in enjoyment RPR section.
++From Lazic and Ogilvie [19] in entrainment RPR section.
+++Only listening to low cognitive load music under high urgency to sleep improved sleep onset latency, all other combinations of sleep urgency and cognitive load music hindered sleep onset latency.
* Some papers are reported more than once in the table because they addressed more than one RPR.
PMSOL = physiological measure of sleep onset latency.
SMSOL = self-report measure of sleep onset latency.
PMSQ = physiological measure of sleep quality.
SMSQ = self-report measure of sleep quality.
a Participant qualitative feedback only.
b Did not measure RPR for control and intervention.
c Did not compare measures for RPR with a statistical test.
d Did not test RPR.

no effect category for self-report sleep quality. Lazic and Ogilvie [19] (see entrainment RPR) found that participants reported music as being relaxing and soothing compared to tones but found no difference in sleep for either stimulus. Their study found no effect for the relaxation RPR for self-report and physiological measures of sleep onset latency, and no effect for physiological measures of sleep quality.

Relaxation from music can improve sleep, and music can alter physiological and psychological indices of relaxation. Relaxation appears to be a fundamental criterion for promoting sleep, and so the capacity of music to induce relaxation provides an obvious, self-evident RPR [20].

3.2. Enjoyment RPR

Music can be an enjoyable experience which positively impacts on mood. Talbot et al. [21], compared happy, sad and neutral music and mood state at bedtime on sleep quality of healthy and bipolar individuals. A manipulation check confirmed the music inducted the intended mood states through participant response to an affect grid (pleasure by arousal). Both happy and sad music improved self-assessed and PSG measures for SOL in healthy individuals compared to neutral music but mood did not influence sleep quality (based on REM latency and density). Talbot et al. [21], stated the sad mood state decreased arousal and the happy mood state facilitated sleep. These findings provide support that the enjoyment RPR improves self-report and physiological measures of SOL but does not provide physiological support for sleep *quality*. The sad mood may act through the relaxation RPR described above and provides possible support for self-report and physiological measures of SOL and possible no effect for physiological measures of sleep quality.

Chang et al. [22], compared the effect of preferred music, the researcher selected music and no music on sleep quality using PSG. Compared to no intervention, the music interventions decreased the duration of stage 2 sleep, and increased REM duration, and participant self-reported ‘feeling rested’. Sleep quality did not differ between participants who used preferred music and participants who used researcher selected music. Participants rated likability of preferred music and researcher selected music on a visual analog scale from 1 (not at all) to 10 (very much). However, Chang et al. [22], did not compare likability ratings for preferred and researcher selected music. Erring on the side of the author's interpretation, this paper is classified in the no effect category. Ogata [23] explored the effect of simulated white noise and music on sleep quality. The participants were required to complete the Kwansei Gakuin Scale (a translated version of the Standford Sleepiness Scale) in a questionnaire to measure participant subjective consciousness and sleepiness. In the questionnaire, some participants described the white noise as making them feel unpleasantly weary while they described the music as pleasantly relaxing or comforting with no indication for dislike. In that study, they [23] measured participant sleep quality using PSG. In stage 1 sleep the unpleasant white noise increased delta power (associated with deeper sleep) but the music did not. The study fits the opposing category.

Lazic and Ogilvie [19] found that participants reported music as being comforting and pleasant compared to tones but found no difference in sleep for either stimulus. Their [19] study, therefore, found no effect for the enjoyment RPR for self-report and physiological measures of SOL, and physiological measures of sleep quality.

The enjoyment RPR is supported with music to induce a happy mood state decreasing SOL compared to neutral music but this did not occur for sleep quality. While it may seem intuitive that enjoyable music would not hinder sleep, the absence of compelling evidence may indicate that should the RPR be implicated in aiding sleep, it may be due to the facilitation enjoyment creates upon other RPRs such as relaxation and distraction from cognitive activity that is otherwise hindering sleep. For example, Pelletier [24] found that preferred music resulted in greater alleviation of stress.

3.3. Distraction RPR

Engaging music can distract the listener from ruminating on stressful thoughts. If stressful, ruminating thoughts are responsible for interfering with sleep, this application of music may prove beneficial. Hernández-Ruiz [25] found that 20 minutes of silence was unpleasant for some abused women suffering anxiety and poor sleep quality. The participants reported the experience as “stressful”, “unbearable” and “annoying”, and sometimes “made [their] minds run with stressful thoughts” [25]. The women who listened to 20 minutes of participant self-selected relaxation music instead had reduced participant reported anxiety (State-Trait Anxiety Inventory) and improved sleep quality (PSQI). The author proposed that music reduces anxiety by providing a focal point of attention (ie, distraction). These qualitative findings provide possible support for the distraction RPR. Similar qualitative findings come from a study by Mornhinweg and Voignier [26] where elderly people were required to listen to baroque, new age music and silence. A repeated comment from participants occurred in the study describing the music as having the ability to “turn my head off” and 96% of the subjects felt their sleep problems reduced by the music (ie, ability to fall asleep, return to sleep, sleep longer) [26]. Additionally, their [26] study used qualitative measures only and thus is classified as possible support for the distraction RPR.

Both studies involved participants listening to ‘relaxing music’ and distraction from stressful thoughts, and so there may be a relationship between the distraction RPR and relaxation RPR. For example, Johnson [27] suggested music could distract from the frustration and dread associated with insomnia, while Chan et al. [28], suggested that music could distract from general stressful thoughts to encourage relaxation. Distraction may also influence secondary insomnia (eg, insomnia caused by medical problems, medication or other substances); for example, Lai and Good [29] suggested that selective attention towards music can distract listeners from a noxious input, and inhibit pain.

Ansfield et al. [30], found that for new age music (assumed to be ‘low cognitive load music’ - LCLM), when participants were asked to ‘fall asleep as fast as you can’ (high urgency to sleep – HUTS) had shorter SOL than ‘falling asleep when desired’ (low urgency to sleep – LUTS). The contrary was shown for marching music (high cognitive load music - HCLM) with longer SOL for HUTS than LUTS (Fig. 2). The SOL for HUTS was lower for LCLM than HCLM but there was no significant difference in SOL for LUTS between music styles. Compared to normal sleep, HUTS & LCLM had significantly lower SOL, whilst all other combinations (LUTS + LCLM, LUTS + HCLM, HUTS + HCLM) had significantly longer SOL than normal sleep. Distraction and pleasantness appear to be modulated by the listener urgency to sleep. Participants listening to HCLM reported feeling less rested than participants listening to the LCLM. Iwaki et al. [31], conducted a similar study that involved music participants who had previously used music to aid sleep. Music decreased SOL for the LUTS music group compared to no music but increased SOL for the HUTS music group compared to no music. A similar pattern was found in PSG measures for sleep quality. Latency to stage 2 sleep decreased in the LUTS music group compared to no music but increased in the HUTS music group. Music was rated as significantly more pleasant than the control by the participants. Iwaki and colleagues suggested that distraction might be mediated by enjoyment (distraction from rumination, anxiety etc by a stimulus we enjoy) aiding sleep in the LUTS group and that familiar music reduced cognitive load. The study supports Ansfield et al's [30] findings that music can be impacted by urgency.

In this subsection, five variables were discussed which may impact music's influence on SOL: distraction, cognitive load, sleep urgency, pleasantness and familiarity. The relationship between these variables is not entirely clear and includes opposing findings.

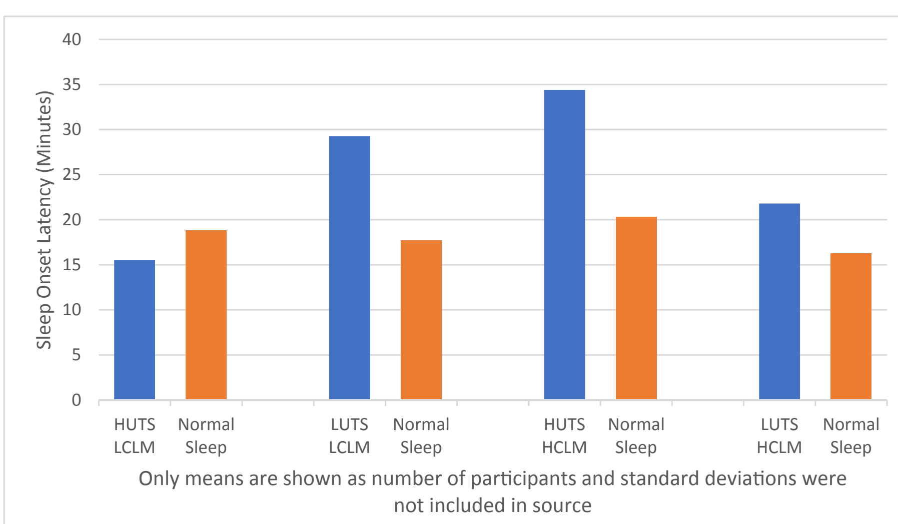

Fig. 2. The interaction between low/high urgency to sleep and kind of music to normal sleep onset latency in the study by Ansfield et al., [30].

For example, music previously used for sleep improved SOL under low urgency in Iwaki et al. [31], but did not in Mornhinweg and Voignier [26]. Only low cognitive load music benefited participants SOL in high urgency for Mornhinweg and Voignier [26].

3.4. Entrainment RPR

Rhythmic entrainment is the synchronization of the listener's low-frequency neural activity or heart rate to the rhythmic structure or tempo of an auditory stimulus (eg, music) [32]. Taken by some researchers has been to exploit the low wavelength brain waves emitted during certain stages of sleep, but which are absent during wakefulness. The driver of the entrainment RPR is that these low-frequency waves may be activated by an external stimulus that has a commensurate beat structure to which the low-frequency waves can entrain, hence encouraging the activation of the endogenous, sleep correlated waves [33,34].

Lazic and Ogilvie [19] explored music embedded with a pulse between the 0.5–3.5 Hz range. This is a similar frequency range to delta brainwave activity which is associated with deep sleep [35]. The exogenous stimulus was associated with increased delta power in the right hemisphere only during the sleep onset period for the music condition but not for tones or silence. No significant difference was found for any of the PSG measures during sleep. Participants' response to VAS on whether an intervention "helped sleep" resulted in no significant difference between the tones and music. The delta embedded music encouraged brainwave entrainment but did not improve self-report or physiological measures of SOL, or physiological measures of sleep quality compared to control or tones. The Lazic and Ogilvie [19] study therefore provide no evidence for the entrainment RPR. The participants rated the music statistically significantly higher for relaxing, comforting, pleasant and soothing scales compared to tones. Their [19] study, therefore, provides no effect of relaxation or enjoyment either.

Picard et al. [5], compared music embedded with 2 Hz binaural beats to no music on sleep as measured by the Jenkins Sleep Scale. The music improved sleep quality compared to no intervention. While this finding appears to support the entrainment RPR, it is important to note that the study did not confirm that exogenous wave generation locked into the beat of the music or binaural beats. Entrainment was not measured in music or control, thus the entrainment RPR was not isolated but has possible support for self-report sleep quality.

With limited support for neural entrainment, other forms of entrainment that may influence sleep should be considered. Bernardi et al. [36] found music with rhythmic phrases similar to cyclic changes in arterial blood pressure entrained cardiovascular autonomic variables (heart rate, respiration rate, blood pressures, middle cerebral artery flow velocity, and skin blood flow). However, Bernardi et al. [36], did not measure the impact of entrainment on sleep but for relaxation which may influence sleep (see relaxation).

3.5. Masking RPR

The continuous playing of music at relatively loud intensity can drown out or minimize the impact of noxious external background noise/s. One example is masking low volume undesired background noise with music at a louder volume. Another example is where the listener habituates to the volume level of the music (increasing the sensory threshold) and then perceives intermittent noxious background sounds as less disruptive due to the masking effect.

Stanchina et al. [12], studied the impact of intensive care unit (ICU) recorded noise on sleep, finding that recordings of ICU noise increased participant brain cortical activations. Auditory evoked cerebral cortical activations impact on sleep quality [37]. However, when the researchers combined ICU noise with white noise masking, the number of activations decreased and increased deep sleep (stage 3–4 NREM). In relation to music Ryu et al. [13], found in hospital care that listening to music through earphones with an eye mask improved self-report sleep quality (measured using a modified Verran and Synder-Halpern sleeping scale) compared to eye mask and earphones only. In a similar study, Hu et al. [38], found that ICU patients' perception of night time noise decreased and self-report sleep quality (based on results of the Richards-Campbell Sleep Questionnaire) increased when participants listened to music compared to silence. All three studies provide support for the masking RPR.

The masking RPR is most distinct from other RPRs because it hinges on external input (ie noxious background sounds). Although there is evidence of the utility of masking for aiding sleep, it is necessarily a relative effect because it works only when the external sleeping environment is degraded (noisy) to some extent.

3.6. Expectation RPR

The review of the literature identified a single study that did not fit into any of the above RPRs but demonstrated a coherent RPR. We present this RPR as being concerned with the individual's cultural belief systems. These systems are tied, in part, to expectations that arise from exposure to the norms of a culture, but could also be seen from a psychological perspective as relating to the satisfying expectation of what should or should not help an individual sleep [39]. In effect, the music acts as a placebo rather than an active process. For example, an individual may find that particular music they believe to aid sleep is alone sufficient regardless of other RPRs.

Gitanjali [40] compared Indian sleep ragas to Indian non-sleep ragas to individuals unfamiliar with classical Indian Karnatic music. No significant difference was found for any measure between the ragas in terms of total sleep time, REM time, non-REM time, slow wave sleep time, SOL, REM onset latency and self-report sleep quality (using a VAS). This study involved individuals unfamiliar with Indian Karnatic music to prevent bias and Gitanjali [40] suggested that individuals who regularly listen to these styles or were exposed to the ragas as a child at bedtime may have differed in sleep quality. The expectation RPR requires the individual to be familiar with in this case Karnatic music. However, data collected from the individuals unfamiliar with the genre did not provide evidence of an expectation effect. Deshmukh et al. [41], found Indian Karnatic music could improve sleep quality but did not identify the participant's familiarity with the music. Gitanjali's [40] study fits the possible support category because it does not include participants who may be influenced by the expectation RPR.

Considering the impact of placebo and expectation in other sedative treatments [42] the expectation RPR may be a plausible explanation for how music aids sleep under certain circumstances. But research has yet to fully disentangle this RPR from others, such as relaxation. That is, the expectation RPR may well be subsumed by relaxation, and should be considered an RPR more for completeness than its explanatory utility.

3.7. Summary of RPR findings

In sum, 15 studies and six RPR were identified in the literature (Table 2). Studies varied by participant health, music intervention, measure of sleep and RPR. Two studies [19,21] addressed more than one RPR. The six RPRs: relaxation,

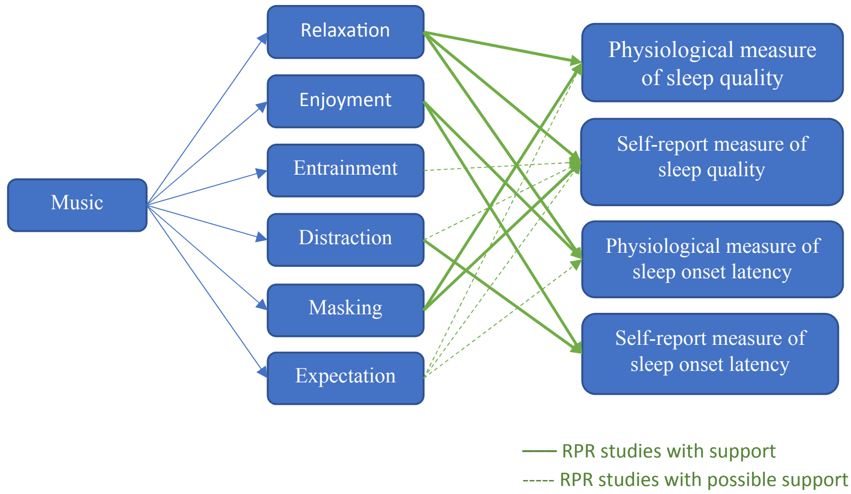

Fig. 3. Chart of Support for RPRs. Chart showing frequency of support in the literature for RPR regarding music aiding four broad indices of sleep based on Table 3.

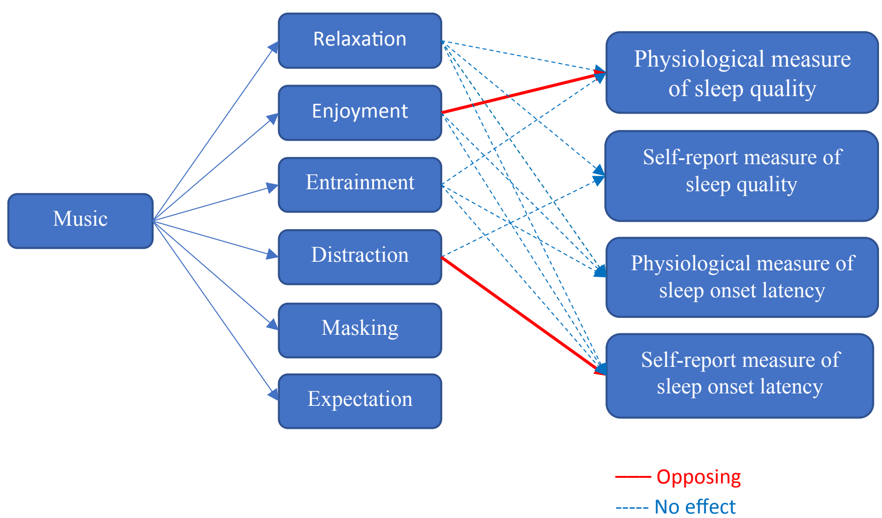

Fig. 4. Chart of Does Not Support for RPRs. Chart showing frequency of opposing support and no effect in the literature for RPR regarding music aiding four broad indices of sleep based on Table 3.

enjoyment, entrainment, distraction, masking and expectation varied by level of support (Table 3). Level of support was grouped into (1) opposing: the study found evidence of RPR hindering sleep; (2) no effect: the study found no evidence of RPR impacting sleep; (3) possible support: the study had limited evidence of RPR aiding sleep; and (4) possible support: the study had limited evidence of RPR aiding sleep; and (4) support: the study found evidence of RPR aiding sleep. The RPR with only possible support were frequently speculations from the authors of the studies and shouldn't be disregarded but instead should be further investigated. The overall support, opposing and no effect for each RPR is displayed in Figs 3 and 4 for physiological and self-report measures of sleep quality and sleep onset latency. Of the six RPR, only masking has clear supporting evidence. Relaxation has evidence both supporting and no effect. Distraction and enjoyment have evidence both supporting and opposing. Expectation has evidence of possible support only. Entrainment has evidence of possible support and no effect. Differences in the studies (Table 2) and altering the RPR in the studies (eg, distraction Ansfield et al. [30]) may explain the mixed evidence for many of the RPR.

4. Conclusions

This literature review attempted to identify the researcher proposed reasons for how music could possibly influence sleep quality and sleep onset latency by deliberately taking a broad look at the available literature, so as to include reasons that may have been excluded due to inadequate testing, rather than lacking in utility. Six RPRs were identified by building on Jespersen et al. [7], and a reanalysis of the literature. Table 3 shows how the included studies can be organised according to the sleep measures (physiological and self-report measures within each RPR and sort them according to the strength of evidence based on the interpretations of the authors. We found support for the masking RPR for improved PMSQ and SMSQ. The relaxation RPR had mixed levels of support ranging from support to no effect for measures of sleep quality and sleep onset latency. Enjoyment and distraction varied from opposing support (ie, inhibiting rather than supporting sleep) to a statistically demonstrable positive relationship. Expectation had possible support across physiological and self-report measures. Entrainment varied from possible support to no effect.

4.1. Future directions

Several studies exhibit design weaknesses that may limit our understanding of how music impacts on sleep. The most common problem identified is the assumptions about music being relaxing, entraining, or creating expectations without confirming that these assumptions were plausible. Another issue that emerged was the presence of interactions and mediators, with many studies being unclear on whether an RPR can wholly explain why music leads to improved sleep. For example, we identified RPRs that are likely to operate in tandem with others, such as enjoyment or distraction being mediated by relaxation. It is important to present this broad, and simple set of potential explanations for how music can aid sleep because it reflects the (somewhat limited) state of the research and sets a broad set of possibilities that may lead to more focused research without sacrificing credible RPRs that have yet to be tested through methodologically well-grounded research.

Ethical approval

None.

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Conflict of interest

The authors declare no conflict of interest, but accept that they might be a perceived conflict because author GTD has created the Android and iPhone app "Can't Sleep" that uses music to improve listener sleep quality (www.cantsleepapp.com).

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.05.016.

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