Effects of Music Listening on Cognition and Affective State in Older Adults

A Systematic Review and Meta-Analysis

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Abstract: This systematic review and meta-analysis examined whether and how music listening impacts cognition and affect in healthy older adults, specifically considering the emotional connotations of music (happy- or sad-sounding music) and its presentation modality (background or prior to the tasks). Based on the PRISMA guidelines and preregistering in PROSPERO (CRD42022366520), we searched the Scopus, PsycInfo, and Web of Science databases. Out of 2,675 articles, 27 met the inclusion criteria. The synthesized findings on cognition (23 studies) revealed an uncertain influence of music type and presentation modalities on memory outcomes. In contrast, happy-sounding music seems to support executive functioning (2 out of 4) and processing speed (1), when presented in the background, and facilitate language processes (2 out of 3), when given prior to the task. However, the high heterogeneity and inconsistency in the music type and presentation modalities, as well as in the cognitive outcomes considered, prevented us from drawing clear conclusions on the effect of music listening on older adults' cognition. For affective outcomes, a narrative synthesis of the findings on mood (12 studies) and arousal (7 studies) outcomes showed that, regardless of music presentation modality, happy- and sad-sounding music increase or decrease mood/valence and arousal, respectively. Results from meta-analysis showed no significant cognitive benefits from music listening (SMD = 0.09, [95% CI: −0.17, 0.35], p = 0.51) and suggest a positive effect of happy-sounding music on arousal (SMD = 0.44 [95% CI: 0.13, 0.74], p = 0.005), but not on valence (SMD = 0.79 [95% CI: −0.25, 1.84], p = 0.14). The methodological shortcomings of the extant literature call upon the need for further studies adopting more rigorous and consistent approaches that better elucidate the potential benefits of music listening on cognitive and affective outcomes among older adults.

Keywords: music listening, cognition, affect, older adults, systematic review, meta-analysis

Aging is a complex, multidimensional phenomenon characterized by a coexistence of decline, stability, and growth trajectories across different domains of functioning (Baltes, 1987). At the cognitive level, it has been well documented that fluid intellectual abilities – such as memory, executive functions, processing speed, and reasoning – are sensitive to age-related changes and show a turning point towards a decline in adulthood. In contrast, crystallized intellectual abilities linked to accumulating experiences and expertise, such as verbal and numeric ones, even show increments across adulthood and older age or little or no decrements before old age (Craik & Salthouse, 2011). At the same time, with aging comes a more resilient affective and emotional functioning: as stated by the socioemotional selectivity theory (SST; Carstensen, 2006, 2021), notwithstanding various difficulties arising from the aging process, motivational shifts and perceived time constraints lead older adults to prioritize positive emotional meaning and to display a greater functional affective regulation compared to younger adults while preserving psychological well-being (e.g., Carstensen, 2021). Successful cognitive and emotional functioning prompt autonomy, everyday functioning, quality of life, and healthy aging among the older adult population. It is therefore paramount to identify factors and/or cost-effective techniques that not only support and enhance older adults' cognitive functioning but also favor an adaptive process against challenges of late adulthood as emotional functioning.

Over the years, there has been great interest in examining the effects of music listening on various psychological functions of listeners (Schäfer et al., 2013). Previous evidence has shown that music listening can modulate

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individuals' cognitive performance (Schellenberg, 2012); however, the effects of music listening on healthy older adults' cognition have been less thoroughly examined and appear heterogeneous.

Some studies have shown the positive effects of music listening on older adults' performance for cognitive tasks involving memory (e.g., source memory: Reaves et al., 2016; memory encoding: Ferreri et al., 2014; episodic memory: Bottiroli et al., 2014; Ward et al. 2021; working memory [WM]: Vincenzi et al., 2022), as well as executive functioning, attention, processing speed (Bottiroli et al., 2014; Fernandez et al., 2019), and reasoning (Padulo et al., 2020). Other studies, however, have reported adverse or negative effects of music listening on older listeners' WM performance (Hirokawa, 2004; Giannouli et al., 2019), executive functions (Giannouli et al., 2019), and attention/inhibition (Cloutier et al., 2020).

These inconsistencies may arise from various factors influencing responses to music listening, such as a failure to distinguish the music-listening presentation modality adopted, that is, studies using background music) – heard while participants complete cognitive tasks – from those examining performance after music listening – that is, prior to the task (see Schellenberg, 2012). Among older listeners, background music was shown to have either positive (e.g., long-term memory: Ferreri et al., 2014; executive functions and processing speed: Bottiroli et al., 2014; executive functions: Mammarella et al., 2007) or negative (long-term memory: El Haj et al., 2014; Reaves et al., 2016) effects on cognitive performance. Music listening can also positively (WM: Vincenzi et al., 2022; long-term memory: Ward et al., 2021) or negatively (WM: Giannouli et al., 2019) influence older adults' performance on subsequent cognitive tasks.

Another key, essential aspect that merits consideration is the affective response elicited by the music that is heard: the effects of music listening on cognition, according to the prominent and well-established arousal and mood hypothesis (Thompson et al., 2001), would stem from changes to listeners' mood and/or arousal states that, in turn, influence cognitive performance. Happy-sounding music (i.e., fast tempo and major mode) increases arousal and feelings of pleasantness (Husain et al., 2002), whereas sad-sounding music (i.e., slow tempo and minor mode) decreases arousal and induces feelings of sadness (Gabrielsson & Lindström, 2001). Both mood and arousal elicited by music listening influence cognition, with optimal arousal and positive moods appearing to be most beneficial for cognitive performance (e.g., Schellenberg et al., 2007). How the affective (mood and/or arousal) states elicited by music listening impact older adults' cognitive performance is unclear; however, previous studies have shown that happy-sounding music can enhance long-term memory (Bottiroli et al., 2014; Ferreri et al., 2014) but seems to have a null effect on WM (Borella et al., 2014); sad-sounding music can also have positive (e.g., executive function: Bottiroli et al., 2014; recognition: Moltrasio et al., 2022) or null effects (e.g., executive function: Vincenzi et al., 2022; WM: Borella et al., 2014) on older listeners' cognitive performance.

It is worth mentioning that there have been relatively few attempts to examine the affective outcomes (emotional reactions) that music listening exerts on older listeners. For example, some findings have shown that (a) older adults are more accurate in decoding happy emotions compared with others expressed by music than young adults (Vieillard, Didierjean, & Maquestiaux, 2012), and (b) that older listeners report stronger emotional reactivity, mainly assessed with self-assessment scales for happy-sounding music, report a decreased responsiveness to sad- and scary-sounding music, and, more likely, falsely recognize happy music compared to younger listeners (Vieillard & Gilet, 2013). These results, in line with the SST, reflect the well-known "positivity bias" occurring with aging in emotional functioning as a potential strategy to preserve a high level of psychological well-being in later life, which also seems to be true in older adults' response to music. Thus, there is an interest in clarifying the role of music listening on the affective state of older listeners to further understand whether music could represent a valuable method to prompt emotional functioning among older adults, as well as its complex interplay with cognition.

Overall, in a heavily mixed and heterogeneous picture, the extent to which older adults benefit from music listening when cognitive and affective outcomes are considered deserves clarification. Given that the presentation modalities (prior to a task or background) and the type of music (happy- or sad-sounding music) could provide different but complementary information regarding the influence of music listening on cognitive and affective state outcomes in older adults, these aspects warrant specific consideration.

This review aimed to address this gap in the literature by evaluating the effects of music listening on age-sensitive cognitive domains (e.g., memory, executive functioning) and affective outcomes (mood/valence and arousal ratings) in healthy older adults (aged 60 years and older). The effects of music listening were also synthesized by specifically considering the two most common modalities of music presentation (i.e., prior to the task and background) and the types of music excerpts categorized by emotional connotation into happy- and sad-sounding music (see Schellenberg et al., 2008; Vincenzi et al., 2022). In addition, to quantitatively synthesize the effects of listening to music on older adults' cognitive and affective outcomes, meta-analytic models focused on effect size estimates derived from comparisons between music conditions and control groups.

Methods

This study was conducted according to the Preferred Reporting items for Systematic Reviews and Meta-Analysis guidelines (PRISMA; Moher et al., 2015). The review protocol (CRD42022366520) was preregistered with the PROSPERO (Booth et al., 2012). Inclusion/exclusion criteria were as follows: (a) Population: Healthy older adults aged 60 years and older. We excluded all studies including older adults with health conditions, dementia (such as Alzheimer's or Parkinson's disease) other neurological or psychiatric and mood disorders, and professional musicians. (b) Intervention/exposure: Experimental condition(s) involving listening to music. We excluded all studies involving pharmacological and nonpharmacological interventions, music therapy, or music training. (c) Comparison: Comparison of the music listening condition(s) to control condition(s), including white noise, silence, or other auditory stimuli. (d) Outcomes: Assessment of cognitive measures such as memory, processing speed, and executive functions, as well as affective state measures such as mood/valence and arousal ratings. Outcomes that did not relate to older adults' cognitive and affective functioning were excluded. (e) Study design: Inclusion of quasi-experimental or randomized controlled trials published in research articles. Grey literature was assessed through conference abstracts, and official reports in peer-reviewed journals at any time, in English, Italian, Portuguese, or Spanish. We excluded articles not published in these languages, case studies, qualitative studies, books, commentaries, meta-analyses, and reviews (see Electronic Supplementary Material, ESM 1, Table E1).

Search Strategy for Study Identification

The comprehensive literature search was conducted for relevant peer-reviewed articles in October 2022 using three electronic databases: Scopus, PsycInfo, and Web of Science. There was no limitation on the date of publication (up until October 2022). Three authors (MV, ES, and EB) first constructed the search strategy and then refined it with the other authors. The choice of search terms was based on the target population of interest (older adults), music listening, and the outcomes of interest (i.e., cognitive, and affective outcomes). We used the following terms: ("aging" OR "older adults" OR elderly OR "older people") AND ("music" OR "music listening" OR "listening to music" OR "music therap*") AND ("cognit*" OR "visuospatial" OR "visuo-spatial" OR "memory" OR "working memory" OR "intelligence" OR "reasoning" OR "executive funct*" OR "attention" OR "emotional state" OR "affect" OR "mood"). The complete search algorithm with the keywords for each database is available from the authors on request. Eligible studies were identified and then deduplicated (i.e., removal of identical records retrieved from selected databases).

The literature search in the databases was conducted by two authors (ES, MV). Then, two reviewers (MV and MR) independently screened the titles and abstracts of the articles retrieved for eligibility. If they disagreed, one of the other authors (ES, EB, EC) was consulted to reach a final decision.

Data Collection, Synthesis of the Findings

The extraction form was designed to gather information related to the sample characteristics (age, gender, sample size), study design, type of music (determining if happy-sounding or sad-sounding, according to the musical characteristics of the piece, i.e., the mode and the tempo of the excerpts), music listening presentation modality (prior to the task or in background), control group (e.g., white noise, silence), outcomes (cognitive and affective – mood and arousal), and key findings (ESM 1, Table E2). Data extracted from the included studies were recorded by the first author within a standardized extraction form, and revised by the other two authors (ES, ET) to ensure precision. We also grouped the included studies into two main categories: cognitive outcomes (encompassing memory, executive functioning and processing speed, spatial visualization and spatial learning, attention, and reasoning) and affective outcomes (mood/valence, arousal) (see Table 1). Finally, we summarized the evidence at the outcome level by including the study design, the modality of the music listening presentation modalities (prior to the task or in the background), the duration of music exposure, the methodological quality of the study (refer to the risk of bias assessment below), directionality of effects, and a summary of the findings and quality of evidence (Table 1).

In an exploratory manner, we gathered data from the reviewed studies to perform a meta-analysis on the effects of listening to music on cognitive and affective outcomes in older adults. We examined the presentation modality of music listening (prior to the task and background) and the types of music (happy-sounding and sad-sounding) as potential moderators of the effect size for each outcome using meta-regression. The effect sizes of interest were standardized mean differences (SMDs) for cognitive and affective outcomes. Only studies with a control group were included in the meta-analysis (see ESM 1 for details).

Table 1. Qualitative synthesis of the findings grouped by domains of interest

Outcome of interest	Studies	Music modality of presentation	Type of music condition	Direction of music effect	Overall risk of bias	Summary of the findings
Cognitive outcomes						
Memory	Borella et al., 2014	*Prior to the task*	Happy-sounding Sad-sounding	⇒⇐ ⇒⇐	Some concerns	Although most studies examining the effects of music on memory tasks reported performance improvements, some studies' results were complex and mixed. The certainty of evidence was evaluated with methodological concerns, including heterogeneity in music presentation modality.
	Bottiroli et al., 2014	*Background*	Happy-sounding Sad-sounding	⇑ ⇑	Some concerns	
	El Haj et al., 2014	*Background*	Happy-sounding	⇓	Some concerns	
	Ferreri et al., 2014	*Background*	Happy-sounding	⇑	Some concerns	
	Giannouli et al., 2019	*Prior to the task*	Happy-sounding	⇓	Some concerns	
	Hirokawa, 2004	*Prior to the task*	Self-selected	⇒⇐	Some concerns	
	Mammarella et al., 2007	*Background*	Happy-sounding	⇑	Some concerns	
	Moltrasio et al., 2022	*Prior to the task*	Happy/stimulating Relaxing	⇒⇐ ⇓	Some concerns	
	Narme et al., 2016	*Prior to the task*	Happy-sounding Sad-sounding	⇑ ⇒⇐	Some concerns	
	Palumbo et al., 2018	*Background*	Happy-sounding Sad-sounding	⇑ ⇑	Some concerns	
	Parks and Clancy Dollinger, 2014	*Prior to the task*	Positive valenced (pleasant) Negative valenced (unpleasant)	⇑ ⇒⇐	Some concerns	
	Reaves et al., 2016	*Background*	Self-selected	⇓	Serious concerns	
	Silva et al., 2020	*Prior to the task*	Fado (preferred-music) and hip-hop (non-preferred music)	⇒⇐	Some concerns	
	Vieillard and Bigand, 2014	*Prior to the task*	Happy-sounding Sad-sounding	⇑ ⇒⇐	Some concerns	
	Vincenzi et al., 2022	*Prior to the task*	Happy-sounding Sad-sounding	⇑ ⇒⇐	Some concerns	
	Ward et al., 2021	*Prior to the task*	Happy-sounding Sad-sounding	⇑ ⇑	Some concerns	
Executive functioning	Bottiroli et al., 2014	*Background*	Happy-sounding Sad-sounding	⇑ ⇑	Some concerns	Evidence emerged regarding background music, but the limited number of studies on the effect of music listening on executive functioning did not provide clear evidence. These studies were evaluated with methodological concerns.
	Cloutier et al., 2020	*Background*	Stimulating-sounding Relaxing-sounding	⇒⇐ ⇑	Some concerns	
	Fernandez et al., 2019	*Background*	Happy-sounding Sad-sounding	⇑ ⇒⇐	Some concerns	
	Giannouli et al., 2019	*Prior to the task*	Happy-sounding	⇓	Some concerns	
	Mammarella et al., 2007	*Background*	Happy-sounding	⇑	Some concerns	
	Vincenzi et al., 2022	*Prior to the task*	Happy-sounding Sad-sounding	⇒⇐ ⇒⇐	Some concerns	

(Continued on next page)

Table 1. (Continued)

Outcome of interest	Studies	Music modality of presentation	Type of music condition	Direction of music effect	Overall risk of bias	Summary of the findings
Other cognitive outcomes						Overall, potential benefits of music listening on various cognitive domains among older adults emerged. However, due to the paucity of evidence, weak methodological quality of studies, and heterogeneity in music presentation modality, the overall certainty of evidence is considered low.
Processing speed	Bottiroli et al., 2014	*Background*	Happy-sounding Sad-sounding	⇑ ⇒⇐	Some concerns	Increased performance accuracy in visual processing speed
Lexical processing	Ferraro et al., 2003	*Prior to the task*	Happy-sounding Sad-sounding	⇑ ⇑	Some concerns	No improvements were found in arithmetic ability.
Language comprehension,	Liu, 2021	*Prior to the task*	Happy-sounding Sad-sounding	⇑ ⇑	Some concerns	Increased text comprehension ability.
Semantic categorization	Mairal, 2015	*Background*	Sad-sounding	⇒⇐	Some concerns	No improvements were found in semantic categorization.
Perceptual reasoning	Padulo et al., 2020	*Prior to the task*	Happy-sounding	⇑	Some concerns	Improvements were found in the reasoning tasks with happy-sounding music.
Auditory target identification	Vieillard & Bigand, 2014	*Prior to the task and background*	Happy-sounding Threatening-sounding	⇑ ⇓	Some concerns	Shorter reaction times were found for target identification for happy-sounding music than for other types of music.
Arithmetic ability	Vincenzi et al., 2022	*Prior to the task*	Happy-sounding Sad-sounding	⇒⇐ ⇒⇐	Some concerns	No improvements in arithmetic ability.
Affective outcomes						

(Continued on next page)

Table 1. (Continued)

Outcome of interest	Studies	Music modality of presentation	Type of music condition	Direction of music effect	Overall risk of bias	Summary of the findings
Mood and valence	Padulo et al., 2020	*Prior to the task*	Happy-sounding	⇑	Some concerns	The majority of studies reported improvements in mood and valence. The certainty of evidence could be biased by some methodological concerns about the study quality.
	Bottiroli et al., 2014	*Background*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		
	Vieillard et al., 2012	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇒⇐		
			Threatening-sounding	⇒⇐		
			Peaceful-sounding	⇒⇐		
	Vieillard & Bigand, 2014	*Prior to the task and background*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇒⇐		
			Threatening-sounding	⇒⇐		
			Peaceful-sounding	⇒⇐		
	Vieillard et al., 2020	*Prior to the task*	Threatening-sounding	⇓	Some concerns	
	Vincenzi et al., 2022	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		
	Liu, 2021	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		
	Cloutier et al., 2020	*Background*	Stimulating-sounding	⇑	Some concerns	
			Relaxing-sounding	⇑		
	Ferraro et al., 2003	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		
	Parks and Clancy Dollinger, 2014	*Prior to the task*	Positive valenced (pleasant)	⇑	Some concerns	
			Negative valenced (unpleasant)	⇓		
	Pearce & Halpern, 2015	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		
	Groarke & Hogan, 2019	*Prior to the task*	Self-selected	⇓	Some concerns	
Arousal	Padulo et al., 2020	*Prior to the task*	Happy-sounding	⇑	Some concerns	Increased arousal ratings emerged. The certainty of evidence could be biased by the moderate risk of bias.
	Hirokawa, 2004	*Prior to the task*	Self-selected	⇑	Some concerns	
	Vieillard et al., 2012	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Threatening-sounding	⇓		
	Vieillard et al., 2020	*Prior to the task*	Threatening- sounding	⇑	Some concerns	
	Vincenzi et al., 2022	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		
	Cloutier et al., 2020	*Background*	Stimulating-sounding	⇑	Some concerns	
			Relaxing-sounding	⇓		
	Pearce & Halpern, 2015	*Prior to the task*	Happy-sounding	⇑	Some concerns	
			Sad-sounding	⇓		

Note. ⇑ = Positive and significant effect of music listening; ⇓ = Negative and significant effect of music listening; ⇒⇐ = No significant effects of music listening.

Quality Assessment (Risk of Bias)

The methodological quality of each eligible study was assessed using the following standardized and valid tools: the revised Cochrane risk of bias tool for randomized trials (RoB 2, Higgins et al., 2019), and the ROBINS-I (Sterne et al., 2016) to assess nonrandomized and quasi-experimental studies. The following sources of bias were examined: selection bias, randomization process (if any), bias due to the deviations from intended intervention/exposure, missing outcome data, bias in measurement of outcomes, and overall methodological bias. Studies with a low risk of bias are considered high quality, those with some concerns are classified as moderate quality, and studies with a high risk of bias are evaluated as low quality. Two authors (MV, AV) rated each reviewed study. When they disagreed, a third reviewer (ES) rated the study in question.

Results

A total of 2,675 records were identified. Once duplicates were removed, 1,790 records were screened for relevance using titles and abstracts. Cohen's kappa k of .84 indicated an almost perfect agreement between the reviewers (see Landis & Koch, 1977). Next, 42 papers were retained for full-text screening, 27 of which met our inclusion/exclusion criteria (see Figure 1) and were included in our review.

Participants and Study Design

Table E2 in ESM 1 provides details of the 27 studies included in the review, involving 1,365 older adults (with sample sizes ranging from 12 to 227; mean age [±SD] across all studies: 70.20 [±5.73]). Eight studies were randomized controlled trials (RCTs), whereas 19 adopted a quasi-experimental design. Furthermore, a subset of 10 studies provided available data for meta-analysis, with the experimental groups totalling 1,086 participants (experimental group, n = 980; control groups, n = 696; see ESM 1, Table E2). The studies were conducted on several continents around the world: 19 in Europe, 6 in North America, one in South America, and one in Asia.

Risk of Bias of the Reviewed Studies

Eight studies were RCT and were considered to have "some concerns", indicating a moderate overall quality. The majority of these studies (six out of eight; 78%) had concerns about the randomization process of participants: the allocation of participants into the experimental condition and control group was not clearly defined, and only two studies provided adequate details about the randomization process (Mairal, 2015; Groarke & Hogan, 2019).

All the studies reported some concerns in the selection of the reported results, as they did not provide adequate details in the pre-specified analysis plan before unblinded outcome data were available. Although all studies provided adequate details about the availability of outcome data for all or almost all randomized participants, they all reported some concerns regarding the selection of reported results. However, the studies provided consistent information on how the outcome variable was measured, indicating a low risk of bias due to inadequate measurement of the outcome (Figure 2a).

Among the 19 studies with quasi-experimental design, 18 (95%) were found to have a moderate risk of bias, while only one study (Reaves et al., 2016) was evaluated as having a serious risk of bias. The primary sources of bias were the lack of adequate details in measuring the outcome variable (i.e., moderate risk of bias due to inadequate measurement of the outcome) and in the selection of reported results (e.g., inadequate details about the pre-specified analysis plan before outcome data were assessed). Although only one study showed a moderate risk of bias due to missing outcome data and inadequate participant selection, all studies provided adequate information on controlling confounding effects and intervention details and showed a low risk of bias for other sources. Further information on the methodological quality of each study is provided in ESM 1 (Figures E1 and E2).

Characteristics of the Music-Listening Condition

The included studies varied in terms of music presentation modality: 10 of them included music while the participants performed the cognitive task (i.e., background), whereas 18 presented the music and afterward asked the participants to complete cognitive tasks (i.e., prior to the task).

The studies included pieces from various musical genres and periods (ESM 1, Table E2). In 18 studies, the experimenters categorized the music types based on the music's happy-sounding, "positive," or "activating" characteristics, such as major mode and fast tempo. The most frequently used happy-sounding excerpt was the first movement of Mozart's *Sonata K 448* (four studies). In 14 studies, the researchers categorized the music listening types based on the music's sad-sounding or "negative" or "relaxing" characteristics, i.e. minor mode and slow tempo. The most used excerpts were Albinoni's *Adagio* (four studies) and Mahler's *Adagietto* (three studies). In five studies, the researchers used unreleased music excerpts or pieces previously used in the same context. Film music was also used in two studies. In two studies, the experimenters selected the music excerpts from their personal collections, and in two studies, the researchers asked the participants to provide their music piece(s).

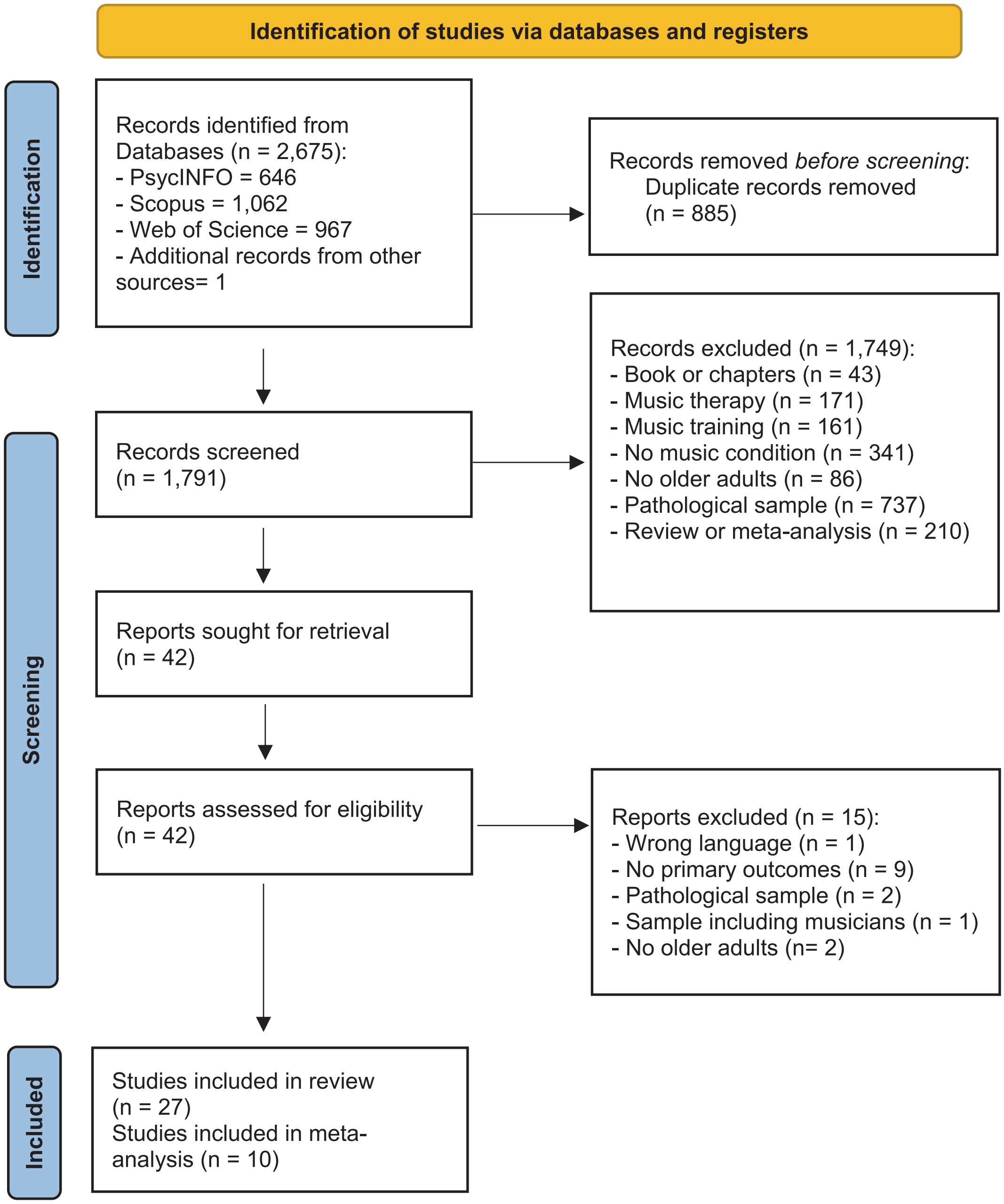

Figure 1. Overview of the study selection process.

Characteristics of the Control Groups

Of the studies examined, 17 involved at least one control group that was compared with the experimental listening condition: five studies used a silence condition, four employed white noise, two used spoken-word recordings, and one utilized a radio documentary, whereas five employed two control conditions with sound conditions (white noise, environmental sounds, musical rain, relaxation instructions, or street noise) and silence (see ESM 1, Table E2).

Nine studies did not include any type of control condition. These latter studies used a within-subject experimental design, where participants served as their own control by providing baseline scores across different conditions.

Synthesis of the Findings Grouped by Outcomes of Interest

Music-listening effects were observed across diverse cognitive and affective outcomes, with considerable

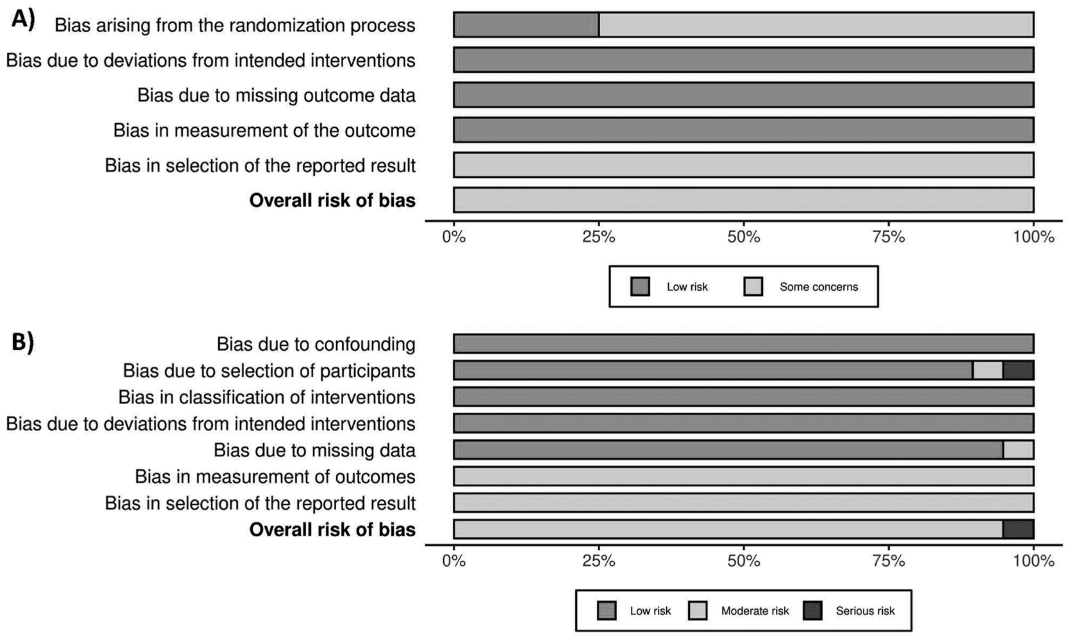

Figure 2. Summary of authors' judgments result in percentage (%) for each source of bias of (A) the Rob-2 tool for randomized trials (Higgins et al., 2019), and (B) the ROBINS-I (Sterne et al., 2016) for non-randomized and quasi-experimental studies.

heterogeneity in music type and presentation modality. Authors (MV, ES) categorized study results based on their outcomes of interest (see Table 1), with all reported statistical indicators (e.g., effect sizes or differences in sum scores on performance measurements) included in ESM 1, Table E2.

Cognition

In total, 23 studies examined the effects of music listening on cognitive functioning, including different cognitive outcomes. Seven were RCTs, and 15 used quasi-experimental designs. Eight studies implemented a control group, whereas 15 adopted control groups. Among them, four studies utilized a silence condition, four used white noise, two employed spoken-word recordings, and five used various sound conditions (including white noise, street noise, relaxation instructions, environmental sounds, and musical rain) alongside silence conditions.

As for the modality of music presentation, in some studies, the experimenters proposed listening to music during task performance (i.e., background; 9), the majority used the prior-to-the-task music presentation modality (16), and one study included both modalities.

As for the type of music, based on the excerpt's emotional connotation, which could vary in the degree of positive/happy or negative/sad emotional connotation elicited, the studies included happy/positive (20) or sad/negative sounding music (15), as well as relaxing (two) and stimulating (one) music, participant-selected songs (one), experimenter-selected songs (one), film music (one), and traditional songs (one). A wide range of musical genres from various historical periods have been adopted in the reviewed studies, ranging from classical compositions to film music and contemporary songs.

Memory Performance

In 16 studies (see Table 1), various memory tasks were used to assess memory performance in different memory systems (e.g., short-term memory, WM, and long-term memory; see Table E2, ESM 1).

Positive effects of listening to happy-sounding music on WM and short-term memory tasks were observed in some studies. Ward et al. (2021) asked 48 young and 48 older adults to listen to happy-sounding music (J. S. Swaine by Franco et al., 2014) prior to completing the Backward Digit Span task and found significant improvements in WM performance when the musical emotion matched the mood of the listener. Vincenzi et al. (2022) assigned 132 older adults to three different prior to the task listening conditions: older adults listening to happy-sounding music (Mozart's sonata K 448 in D major), sad-sounding music (Albinoni *Adagio*), or control (spoken-word) condition. Older adults in the happy-sounding music condition showed increased visuospatial WM performance (Backward Corsi block task) compared to the sad-sounding music and control conditions. Mammarella et al. (2007) found increased short-term memory performance (Forward Digit Span) among 24 older adults who listened to background happy-sounding music (Vivaldi's *Four Seasons*) than those listening to white noise.

Positive effects on verbal long-term memory tasks were also observed. Bottiroli et al. (2014) found increased episodic memory (word list recall) in 65 older adults listening to happy-sounding background music (Mozart's *Eine Kleine Nachtmusik*) compared to silence or white noise. Ferreri et al. (2014) found that happy-sounding music (S. Bechet, *If you see my mother*) benefited source memory performance: 16 older adults remembered words encoded when they listened to happy-sounding music in the background better than those encoded with silence. Ward et al. (2021) also reported that older adults who listened to happy- and sad-sounding music prior to the task increased memory recall for happy and sad images, respectively, in the mood-matching condition (when the musical emotion matched the mood of the listener). Palumbo et al. (2018) compared 144 older and 144 young adults and found that happy- (Mozart's *Eine Kleine Nachtmusik, Divertimento #136*) and sad-sounding (Mahler, *Adagietto*) background music increased source memory (of valenced images) in both age groups, especially when the affective content matched the valence of the background music. Moltrasio et al. (2022) observed a decrease in delayed false recognition of valenced pictures in 44 older adults listening to relaxing music (e.g., Pachelbel's *Canon* in D major) prior to the task execution compared to activating music (e.g., Joseph Haydn's *Symphony No. 70* in D major) and white noise.

Three studies reported significant positive effects of listening to happy-sounding music on subsequent song-recognition tasks using unfamiliar musical stimuli. Narme et al. (2016) examined emotionally-valenced music excerpts in 53 older and 60 young adults prior to the task, finding that happy-sounding music increased recognition compared to other conditions (peaceful, sad, and fearful) in both age groups. Parks and Clancy Dollinger (2014) compared 54 young, 40 middle-aged, and 41 older adults who listened to emotionally-valenced music excerpts before the task, noting increased recognition of happy-sounding, positively valenced excerpts compared to sad-sounding ones in middle-aged and older adults. In Vieillard and Gilet (2013), 18 young and 18 older adults listened to musical stimuli divided into four emotion categories prior to completing a recognition memory task, and older adults were more likely to falsely recognize happy-sounding music.

Negative effects of music listening were also observed. Reaves et al. (2016) compared 53 young and 50 older adults, finding that background music (selected by the experimenters) as well as musical rain (control condition) decreased associative memory (face-name recognition) only in older adults, compared to silence. Giannouli et al. (2019) examined short-term memory performance (Forward Digit Span task) in both 227 older and 240 young adults after listening to happy-sounding classical, baroque, or minimalistic music compared to silence. They found that listening specifically to happy-sounding baroque music (Vivaldi *Concerto for harpsichord Op.4 n° 10*) decreased subsequent short-term memory performance in both age groups. Three other studies reported significant negative effects of music listening on long-term visual memory task performance. El Haj et al. (2014) found that background happy-sounding music (Vivaldi's "Four Seasons") decreased source memory performance compared to street noise and silence in both 35 older and 41 young adults. Similarly, Moltrasio et al. (2022) observed that older adults who listened to "relaxing" music compared to "activating" music and white noise showed impaired subsequent memory performance, with an increase in the number of false recognitions of valenced pictures.

Finally, some studies yielded null results. Borella et al. (2014) found no effects of happy- (Mozart's sonata K 448) or sad-sounding music (Albinoni, *Adagio*) on WM measured with the Affective Operation Working Memory Span Test (OSPAN) in 92 older and 63 young adults. Similarly, Hirokawa (2004) reported no significant effects of self-selected songs listened prior to the task on verbal WM (Reading Span task) in 15 older adults. Moltrasio et al. (2022) found no significant effect of happy- and relaxing-sounding music listened prior to the task on visual memory (Rey Complex Figure Test) in older adults. Silva et al. (2020) found no significant effects of listening to different music genres (fado and traditional local music vs. hip-hop) prior to the task on subsequent verbal long-term memory (word lists recall) in 12 older adults, compared to the control conditions (environmental sounds or silence).

Executive Functioning

Six studies assessed executive functioning using tasks that measured verbal fluency and cognitive inhibition. Four studies included control groups, with one using white noise, two using silence, and one using a spoken word recording. One study employed only a music-listening condition.

Background music was used in three studies, whereas two used music presented prior to the task.

As for verbal fluency, two studies found positive effects when music was played in the background: Mammarella et al. (2007) observed a significant increase in performance with happy-sounding music, and Bottiroli et al. (2014) reported a significant improvement in performance with both happy- and sad-sounding music on verbal fluency tasks, with both studies comparing music conditions to control conditions (silence and white noise).

On the contrary, two other studies played music prior to the task and yielded contrasting results: Vincenzi et al. (2022) found no significant effects on verbal fluency performance for either happy- or sad-sounding music compared to the control conditions, whereas Giannouli et al. (2019) observed a significant and negative impact of happy-sounding music on verbal fluency performance in older adults compared to young adults.

As for cognitive inhibition, Fernandez et al. (2019) compared 19 young and 33 older adults and found that listening to happy-sounding instrumental classical music (e.g., Delibes: *Coppélia. Ballet in 3 Acts*. 1st act, *Prelude-Mazurka*) reduced reaction times in the modified ANT flanker task compared to sad-sounding music (e.g., Bach, J.S., *Musical Offering*, BWV 1079. *Canon a 2 per augmentationem*) and silence. In contrast, Cloutier et al. (2020) investigated "relaxing" (*Suite Bergamasque*, *Clair de Lune* composed by Debussy) and "activating" music (e.g., *William Tell Overture: Final*, composed by Rossini) but found no significant effects on reaction time performance in the Eriksen flanker task compared to silence in the 21 young and 19 older adults.

Other Cognitive Processes

Seven studies investigated the effects of music on various cognitive aspects, each considered by only one study and thus categorized into a miscellaneous category. Four studies adopted the prior-to-the-task modality, two employed background music, and one study utilized both modalities. Among these, four studies included control conditions: one with silence, one with white noise one with both silence and white noise, and one with spoken-word recordings.

Regarding processing speed, Bottiroli et al. (2014) found that happy-sounding music increased older adults' performance accuracy in the Symbol Digit Modalities Test compared to the sad-sounding music or white noise condition.

As for processes linked to language, Ferraro et al. (2003) explored the impact of happy- (e.g., Mozart, *Eine Kleine Nacht Musik*, Divertimento #136) and sad-sounding music (Mahler's *Adagietto*) on lexical processing in 50 young and 25 older adults, finding faster responses to emotionally congruent words for both age groups. Liu (2021) compared 30 young and 30 older adults and found that happy-sounding music (Bach Brandeburg Concerto No. 3), compared to sad-sounding music (Prokofiev, *Russian Under the Mongolian Yoke*), increased language comprehension (facilitated sentence processing) in older adults. Mairal (2015) found no significant effects of sad-sounding music on semantic categorization tasks in 22 young and 18 older adults.

Vieillard and Bigand (2014) found decreased response times for auditory target identification with happy-sounding music (from Vieillard et al., 2008) in 27 older adults compared to 30 young adults. Padulo et al. (2020) investigated perceptual reasoning in 85 older adults, showing the positive effects of music listening on reasoning performance, measured with the block design task (Wechsler Adult Intelligence Scale).

Finally, Vincenzi et al. (2022) examined arithmetic abilities using the AC-FL task but did not find significant effects of music listening prior to the task.

Affective State

Thirteen studies investigated the effects of music listening on mood/valence (12) and arousal (seven). Four studies employed RCT designs (with two focusing on arousal), and nine used a quasi-experimental design (with eight focusing on mood/arousal and only one on arousal). Six studies lacked a control group (two addressing both mood/valence and arousal), one used white noise (for both mood/valence and arousal), one employed spoken-word recordings (for both mood/valence and arousal), one used both white noise and silence (for mood/valence), one utilized a radio documentary (for mood/valence), and one employed relaxing instructions and silence (for arousal).

As for music presentation modality, nine studies utilized a prior to the task modality (five focusing on both mood/valence and arousal, four on mood/valence, and one on arousal), three employed background music (for both mood/valence and arousal), and one study used both modalities (for mood/valence; see Tables 1 and ESM 1, Table E2).

For the type of music, six studies utilized both happy- and sad-sounding (four for mood/valence and two for both mood/valence and arousal), one employed multiple music conditions (i.e., happy, sad, threatening, and peaceful-sounding; for mood/valence), two focused on relaxing and stimulating music (for both mood/valence and arousal), one study employed threatening music (for both mood/valence and arousal), one utilized positive- and negative-valenced music (for mood/valence), and two utilized self-selected music (one for mood/valence and one for arousal).

Mood/Valence

All 12 studies showed significant effects of music listening on mood and valence ratings, leading to matched positive or negative changes in emotional experiences, based on the type of music. Three studies, with background music, revealed the positive effects of happy-sounding music on valence, measured using the Self-Assessment Manikin (SAM). Two of them reported increased valence ratings in older adults listening to happy-sounding music (Liu, 2021; Vincenzi et al., 2022), and another one reported increased valence in both young and older adults (Padulo et al., 2020). In addition, Parks and Clancy Dollinger (2014) used an ad hoc valence rating (from negative [low] to positive [high]) and found that happy-sounding music produced more positive valence in middle-aged and older adults.

Four studies asked participants to rate the intensity of emotions felt after listening to music stimuli (Vieillard et al., 2012; Vieillard & Gilet, 2013; Vieillard & Bigand, 2014; Vieillard et al., 2020) and consistently showed that happy-sounding music increased emotional intensity in older adults (samples from 18 to 34) compared to young adults (samples from 18 to 35), whereas sad- and scary-sounding music decreased sadness and fear levels in older adults compared to younger adults.

In addition, Cloutier et al. (2020) asked 21 young and 19 older adults to listen to stimulating (e.g., Rossini, *William Tell Overture: Final*) and relaxing-sounding (e.g., Debussy, *Clair de Lune*) and showed that only relaxing-sounding music increased pleasantness in both age groups. Ferraro et al. (2003) measured mood using the Depression Adjective Checklist (Lubin, 1965) and found that sad-sounding music induced higher sadness scores in both younger and older adults compared to happy-sounding music. Groarke and Hogan (2019) reported that self-selected music led to a greater reduction of negative affect compared to the control. Bottiroli et al. (2014) observed differences in mood ratings based on the type of music, with Mozart's music rated happier than (sad) Mahler's music, which was comparable to white noise. Finally, Pearce and Halpern (2015) used the Geneva Emotional Music Scale 9 (Zentner et al., 2008) and compared 22 young adults with 15 older adults, finding that happy-sounding music increased positive valence ratings in both age groups.

Arousal

Seven reviewed studies evaluated the effects of music listening on older adults' arousal. Two studies reported significant positive effects of listening, prior to the affect outcomes, to happy-sounding music in increasing arousal levels measured with the SAM in older adults (Padulo et al., 2020; Vincenzi et al., 2022).

Cloutier et al. (2020) reported that listening to stimulating-sounding background music increased older adults' arousal measured with the VAS compared to young adults. In Pearce and Halpern (2015), fearful and then happy music was rated as more arousing, whereas sad and tender music was rated as the least arousing by older adults on the GEMS-9; however, older adults gave less extreme scores compared to young adults.

Meta-Analytic Effects of Listening to Music

We analyzed cognitive outcomes using data from 10 studies, which involved a total of 82 effect sizes, including 13 control groups, 20 treated groups, and 24 group comparisons (see ESM 1 for details).

The estimated meta-analytic effect showed an SMD of 0.09 [95% CI: −0.17, 0.35], p = 0.51, with significant and large heterogeneity (Q(81) = 969.94, $p < 0.001$; I^2 = 84.36%). None of the moderators here considered – music listening presentation and music types – or their interactions reached significance.

As for affective outcomes, only one study (Vincenzi et al., 2022) reported effects on valence and arousal as affective outcomes. As for valence, a meta-analysis of eight effects ranging from 0.00 to 2.75 yielded a pooled estimated SMD = 0.79 [−0.25, 1.84], p = 0.14, with substantial heterogeneity (I^2 = 94.10%, τ = 1.04). Regarding arousal, effect sizes ranged from −0.95 to 0.53, resulting in an overall pooled estimate of SMD = −0.09 [−0.73, 0.55], p = 0.78, with large heterogeneity (I^2 = 86.21%, τ = 0.61).

Discussion

In this systematic review, we aimed, for the first time to our knowledge, to summarize the existing evidence of the effects of listening to music on the cognitive and affective outcomes in healthy older adults; specifically, the music presentation modality (prior to the task or background) and the emotional connotation – mainly categorized as happy- or sad-sounding – were considered.

Our review included 27 studies that assessed different cognitive and affective outcomes (23 and 13 studies, respectively).

In terms of cognitive outcomes, a substantial focus was directed towards examining music-listening effects on older listeners' memory performance (16 out of 23; 70% of the studies). The literature appeared to include memory tasks from a variety of memory subsystems (e.g., short-term memory, long-term memory, and WM), with a high inconsistency in terms of music type and presentation modality across the memory subsystems examined. Music listening prior to the task completion was the modality adopted by the majority of the studies using WM and short-term memory outcomes (83% of the studies), whereas background music was the modality adopted by the majority of the studies presenting long-term memory tasks (63%). Thus, the role of the music presentation modality in relation to the memory domains examined is inconclusive.

A mixed and unclear pattern of findings also emerged when the type of music being listened to is concerned: both across and within memory subsystems, listening to happy-sounding music was found to either improve, impact or have a null effect on older listeners' memory performance; similarly, it also emerged that sad-sounding music could either facilitate (especially when musical emotion matched the mood of the listener or the emotional content of the to-be-remembered stimuli) or have detrimental or null effects on memory performance.

A more consistent finding was discovered for the memory of valenced music excerpts, with positively valenced music excerpts eliciting better memory recall than negatively valenced ones (Narme et al., 2016). Such evidence, which merits further study, suggests that healthy older adults seem to prioritize the processing and recall of positive music information, which extends the SST (Carstensen, 2006, 2021) to the processing of music excerpts.

The other cognitive domains were examined by a limited number of studies. In particular, 65% (13 out 20) of the studies considered executive functions (six studies), processing speed (one study), perceptual reasoning (one), arithmetic ability (one), identification of auditory (music) targets (one), and language (one study on lexical processing, one on language comprehension and one on semantic categorization).

As for older adults' executive functioning – as measured by verbal fluency and inhibition tasks – and processing speed, it appeared that happy-sounding music presented in the background, but not prior to the task, sustained these processes. Such a pattern of results aligns with the notion that fast and major background melodies could facilitate performance in tasks involving shifting, updating, and inhibitory processes – like verbal fluency ones – that might benefit from a more alert, focused, and less-prone-to-interference mood and state elicited by this type of music (Kiss & Linnell, 2021; Masataka & Perlovsky, 2013). Background happy-sounding music might also facilitate synchronization between auditory rhythms of music and motor-tracking processes that are involved in processing speed tasks (e.g., Bottiroli et al., 2014). Music listening seems also to facilitate cognitive skills that are known to be spared by age-related cognitive decline: In line with evidence linking music to language (Temperley, 2022), older adults benefit from listening to music in tasks entailing language processes, such as lexical processing and predictive sentence processing, at least when music listening occurs prior to the task completion. However, null effects were observed for tasks involving semantic processing or arithmetic abilities (Mairal, 2015, Vincenzi et al., 2022), and no clear conclusions can be made on the effect of the type of music being listened to. Overall, given the paucity, or unique/single studies examining the abovementioned cognitive outcomes as well as the mixed findings that emerged – for attentional (inhibitory) tasks –, ours are only speculations and merit further investigation. Therefore, it is too premature to draw any conclusions on the role of music on cognition in aging, as also highlighted by the tentative meta-analysis conducted. In fact, our meta-analytic models revealed a small and statistically nonsignificant overall effect on cognitive performance as well as nonsignificant effects of both music type and presentation modality.

The clearest pattern emerging here is that the extant literature displays poor methodological quality, large heterogeneity, and inconsistency in terms of choice of music and control conditions, experimental procedures, and coverage of cognitive domains (with some domains being examined in only one study). There was also an uncertain categorization of tasks considering the underlying processes/mechanisms involved (e.g., forward digit span was categorized as a WM task instead of short-term memory; see ESM 1, Table E2) and a high heterogeneity in the demands and to-be-processed stimuli (e.g., verbal, visuospatial, emotional) of the tasks used across the reviewed studies. As a result, the meta-analytic effect was small and characterized by large heterogeneity. Such a heavily inconsistent picture hinders any interpretation of the true effects of music listening on the reviewed cognitive functions in healthy older adults. Therefore, further research is required to understand more clearly the potential impact of music listening as well as the effect of the type of music and its presentation modality on cognitive functions in healthy aging older adults.

A slightly different picture emerged when considering the effects of listening to music on older adults' affective outcomes. The included studies revealed a clear influence of listening to music on mood/valence and arousal outcomes, which consistently varied based on the emotional connotation of the music. Our review in fact highlighted that, regardless of the music presentation modality, listening to happy-sounding music increases positive valence, improves mood, and heightens arousal, whereas sad-sounding music is associated with decreased valence, heightened negative emotions, and reduced arousal. These results seem to be partially supported by our quantitative synthesis (however, based only on the Vincenzi et al., 2022 study), showing that listening to happy-sounding music appeared to enhance mood/valence in older adults more than listening to sad-sounding music, though the moderator analysis results did not reach statistical significance, and that music with happy-sounding emotional content significantly increased arousal, whereas sad-sounding music significantly decreased it. This pattern of results aligns with the well-documented relationship between music and emotions (e.g., Schäfer et al., 2013) and confirms and extends it to healthy older adults: Certain features of music (e.g., tempo, mode, pitch, timbre) are known to more or less evoke and arouse positive affective states in listeners (Juslin, & Sloboda, 2010]); thus, they do have these effects on older adults. However, older adults display a specific pattern of affective experience and reactions to musical stimuli, as compared to young adults (Ryczkowska, 2023), so they have more positive affective responses and assessments of music, greater preference for happy-sounding musical stimuli, and less-intensive affective responses to negatively valenced music, as well as less-extreme and less-differentiated affective responses to music fragments of different emotional expressions. Therefore, much like other emotional information, older adults display the well-known "positivity effect," even when facing musical stimuli. To note, despite intriguing findings on older adults' affective states, our reported effects are based on several studies lacking control groups, with only one study allowing for a meta-analytic estimate on mood and arousal, thus no clear conclusions can be drawn. It is also worth mentioning that the majority of the reviewed studies, including mood and arousal outcomes, were adopted prior to the task modality, so further research is needed to understand the potential interplay between the emotional aspects of music and the music presentation modality. Nonetheless, music listening could be a promising approach, alongside other classical ones (e.g., use of valenced images or words), to facilitate older adults' advantage in regulating their emotional functioning.

Notwithstanding these promising results, caution is required in the interpretation of the reviewed findings. Methodological divergence was observable in terms of experimental design as both studies assessed the music effects on cognitive and affective outcomes (ESM 1), which underscores the dual emphasis on upholding methodological rigor in conducting the research and exploring more flexible settings to assess the effects of music listening on cognitive performance among older adults. However, most of the RCTs reported methodological weaknesses in participant randomization processes, potentially impacting the outcomes' internal validity and generalizability. Detailed information regarding the randomization process was adequately provided only in two studies (see ESM 1). In non-randomized studies, an overall moderate risk of bias was observed, with one study exhibiting a serious risk. Detected sources of bias included inadequacies in outcome measurement and a lack of transparency in result reporting, indicating potential vulnerabilities in methodology and reporting. To improve the quality of future studies, researchers should prioritize rigorous methodologies, transparent reporting of analysis plans, and comprehensive descriptions of outcome measurement procedures.

Another methodological weakness relates to the comparison conditions adopted. Few studies (around 59%) included a control condition, displaying a wide heterogeneity (ranging from silence [absence of music] and white noise to ambient sounds and relaxation instructions). This methodological weakness in the experimental design highlights the potential for bias (e.g., the presence of confounding variables), hindering the observed effects' clarity and true direction and undermining the findings' validity and generalizability.

Furthermore, in most of the studies, music excerpts were used without considering individuals' music preferences. It is in fact well known that music familiarity (a listener's prior experience of listening to, or knowledge about, a piece of music) is interconnected with arousal and emotional valence (see Ho & Loo, 2023). However, our results showed that a minority (3%) of studies examined the influence of the level of music familiarity (Cloutier et al., 2020; Groarke & Hogan, 2019; Pearce & Halpern, 2015), and no significant role of the degree of familiarity emerged across the studies. The majority (73%) of the studies only checked that the music stimuli were unfamiliar to the participants, without further exploring this aspect (see ESM 1, Table E2). In addition, although the listener's degree of control (i.e., whether the music was experimenter- or self-selected) may have an impact on the effects of music on liking (with more pronounced effects for self-selected music; see Krause & North, 2017), this aspect could not be considered here (ESM 1, Table E2). Here, again, further evidence is necessary to examine how music preferences influence older listeners' cognitive and affective responses. Other music characteristics (e.g., vocal versus instrumental music, music genre, exposure duration), not considered here, should be accounted for. Evidence suggests that vocal music (rather than instrumental; e.g., Wipplinger, 2007) and certain music genres (songs with lyrics; Souza & Barbosa, 2023) may have a distracting/negative effect on cognitive performance. However, most studies in our review utilized instrumental music (with only two using vocal music) and the classical music genre, limiting further exploration (see ESM 1, Table E2). Future studies should further investigate these factors as potential moderators of music effects among older adults. Furthermore, most music excerpts are typically classified based on emotional ratings by young adults rather than older ones. However, age-related changes in emotional processing and regulation, associated with age-related brain changes (Stretton et al., 2022), occur also in normal aging (e.g., Carstensen, 2021). Given that these changes may also affect responses to musical stimuli (Vincenzi et al., 2022), researchers should consider evaluating musical excerpts rated by older adults to better understand how music listening impacts their cognitive performance and affective states.

Some limitations of this review process should also be acknowledged. First, the reviewed studies did not extensively explore the potential role of mood and arousal mediation in the relationship between music listening and cognition, despite the presence of the arousal and mood hypothesis (Schellenberg, 2012; Thompson et al., 2001). This issue needs to be expanded and confirmed in future aging studies. To address these limitations and enhance our understanding, researchers should consider music rated by older adults and consistently include measures of emotional ratings and psychophysiological measures to provide a more comprehensive review of how music listening affects older adults' cognitive performance and affective states as well as their interplay. Here we focused on specific aspects of music (music presentation modality and its emotional connotation), not considering other important music features (e.g., genres, exposure duration), as well as listeners' characteristics (e.g., music familiarity and preference, current mood, gender, personality), that deserve further analysis in aging studies in order to clarify the link between music listening, cognition, and affective states.

In conclusion, the evidence in this field has produced some initial evidence regarding the effects of happy-sounding music in positively increasing mood and arousal and of sad-sounding music in decreasing arousal in older listeners. The same cannot be said when considering the effects of music listening on older adults' performance in memory or other outcomes. The identified methodological weaknesses call upon the need to study more "systematically" and strictly the music-listening effects on cognitive performance in older adults. Nonetheless, our results offer some insights for the applied field, in particular in designing interventions or protocols to sustain, using music – particularly happy-sounding –, affective states in healthy aging.

Electronic Supplementary Materials

The following electronic supplementary material is available with this article at https://doi.org/10.1027/1016-9040/a000533.

ESM 1. Parts 1-4: Literature search criteria, details of the reviewed studies, risk of bias assessment, details of meta-analysis.

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