Spontaneous music listening in dementia: relationships between listening device and rumination but not depression, anxiety and listening frequency

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Spontaneous music listening in dementia: relationships between listening device and rumination but not depression, anxiety and listening frequency

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ABSTRACT

Music-based interventions are commonly used with persons with dementia, yet research exploring the technologies used for spontaneous music listening in dementia and its association with psychological factors was lacking. Persons with ($n = 55$) and without ($n = 66$) dementia/cognitive impairment completed a cognitive status interview, online self-report depression, anxiety and rumination scales, and reported their music listening device(s) and frequency of listening. Listening occurred most days and via music-related (i.e. radio) devices more often. Relationships were found between the number of music-related and multi-functional (e.g. laptop) devices used and rumination scores for persons with dementia/cognitive impairment, and between the total number of devices used and depression scores for persons without dementia/cognitive impairment. Cognitive-status scores had opposing relationships with device use for persons with and without dementia/cognitive impairment. To conclude, rumination and depression are associated with the technologies used for music listening by persons with and without dementia/cognitive impairment, respectively. Larger samples and longitudinal and/or experience sampling data could be collected to better understand the relationships identified in our data and their applications.

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Introduction

Music listening is a ubiquitous activity which can positively affect an individual's cognition, and psychological and physiological state (Baird & Samson, 2015; Bottiroli et al., 2014; Chan et al., 2011; Chanda & Levitin, 2013; Ito et al., 2022; Sakamoto et al., 2013; Särkämö, 2018; Särkämö et al., 2014; Satoh et al., 2015; Sihvonen et al., 2017; van der Steen et al., 2018; Vincenzi et al., 2022). Individual's listen to music for a variety of reasons (e.g. to self-regulate mood) and individual differences (e.g. mental health status or tendency to ruminate [e.g. repetitive negative thinking]) can affect the type of music that is listened to and its consequence (e.g. improving or worsening mood, and increased or decreased rumination) (Kanagala et al., 2021; Morizot et al., 2012; Schäfer et al., 2013; Thomson et al., 2014). Advances in technology (e.g. mobile devices) have provided increased accessibility to music. While older persons with and without dementia will engage with technologies, including unfamiliar devices to access music, research is scarce in terms of how psychological factors and individual differences may relate to the technology used for engaging with music (Creech, 2019; Davison et al., 2016; Krause & North, 2016; Lancioni et al., 2014).

Rumination has gained attention more recently for its potential to explain technology misuse (Eikey et al., 2021). Individuals may misuse technologies in the attempt to reduce negative affect or emotions, and rumination is suggested to be an intermediary factor in increased use (Elhai et al., 2019). For example, rumination has been shown to moderate the relationship between problematic mobile phone usage and attachment style, particularly for high ruminators, and account for the relationship between problematic mobile phone use and depression and anxiety severity in younger adults (Elhai et al., 2018; Liu et al., 2021). To the best of our knowledge, rumination levels have not been considered in research that focuses on older persons' technology use. For older persons, technology use has been found to moderate depressive symptoms (Elliot et al., 2014). However, the type of activity and how older persons engage in the activity determines whether technology use has a positive or negative relationship with depression and anxiety. For example, some activities have a positive association with depression and anxiety (e.g. checking in on individuals and looking at photos of others), while others have a negative association (e.g. leisure activities and checking status updates), and a higher risk of depression and anxiety can be seen in those who spend <1 h per day on electronic devices for socializing and entertainment compared to 1–4 h per day (Elliot et al., 2014; He et al., 2024; Hofer & Hargittai, 2024; Lifshitz et al., 2016).

In the current study, we focussed on music listening as research tends to focus on ruminators' responses to (sad) music and its consequences or the relationship between rumination and musicianship (e.g. musical ability)

(Garrido, 2009; Garrido, Eerola, et al., 2017; Jones et al., 2014; Larwood & Dingle, 2022) rather than technology use. Moreover, fewer studies focus on positive uses of technology, music interventions are commonly used with persons with dementia to relieve neuropsychiatric symptoms such as depression and anxiety, and research is lacking in regard to how older persons spontaneously engage with music (Bleibel et al., 2023; Garrido, Dunne, et al., 2017; Krause, 2020; Villamil & Heshmati, 2023). Older persons listen to music as it gives pleasure, can energise, calm/relax and reduce loneliness (Laukka, 2007). Depression, for example, is associated with reduced feelings of pleasure, low energy levels and loneliness, and rumination has a positive relationship with depression and anxiety (Brinker et al., 2013; Greenaway et al., 2024; Syed Elias et al., 2015). Taken together, we could have hypothesised that higher levels of depression, anxiety and rumination would be associated with more devices being used for music listening (to provide greater access), and more frequent listening occurring (i.e. listening to music most days) as there may be a greater need to regulate emotion. While individuals with depression and anxiety disorders can use music more for emotion modulation, they can also show no change in listening habits, use music less for emotion and arousal modulation, or stop listening to music (Gebhardt & von Georgi, 2015). Therefore, fewer/no devices would be used. Moreover, using a mobile device could reduce the need to use several devices as it can be moved around, and the presence of cognitive impairment may influence which devices are used (Wu et al., 2019). Analyses in the current study were conducted using the total number of devices used alongside device groupings—music-related devices (e.g. radio, CD and record players) which are less often investigated but may be more habitually used (Krause, 2020), and multifunctional devices (e.g. smartphone, tablet and laptop) which can be cognitively challenging (Wu et al., 2019) (see supplementary material for the devices in each grouping). Music listening frequency was explored in terms of participant group (cognitively impaired versus non-cognitively impaired), (2) rumination level (high versus low) and (3) gender as music, for example, may be used more for affective processing by females than males in younger populations (Boer et al., 2012; Habe et al., 2023).

Rumination as a response to depression (i.e. repetitive thoughts and feelings about a depressed or dysphoric mood which can be negative/maladaptive [depressive or broody] or relatively positive/adaptive [reflective]) was examined alongside rumination as a thinking style (i.e. a general tendency to ruminate involving repetitive, recurrent, uncontrollable and intrusive thoughts which can be positive, negative and neutral in nature) (Brinker & Dozois, 2009; Nolen-Hoeksema, 1991; Nolen-Hoeksema & Morrow, 1993). While these types of rumination are commonly explored, albeit separately, in regard to technology use in younger populations (Castro-Calvo et al., 2022; Elhai et al., 2018; Liu

et al., 2021), both types are important when examining rumination in relation to depression and anxiety for persons with dementia and can be reliably measured in this population (Greenaway et al., 2024). Moreover, different types of rumination may relate to technologies use to different extents. For example, Gao et al. (2022) found that brooding, and reflection to a lesser extent, was positively associated with problematic device use, with brooding mediating the association between depression and problematic device use while reflection did not.

In summary, rumination can be associated with device use for younger persons and has been studied in terms of music experience and practice, but the relationship between music and rumination in terms of technology use has yet to be explored. To this end, the aims of the current study were to identify the devices used by older persons with and without dementia/cognitive impairment to listen to music, and to explore how rumination, depression and anxiety levels may relate to the number and type of devices used for music listening, and the frequency of music listening.

Table 1. Group descriptive statistics information.

	PwCI			NoCI		
n	55 (F = 23, *M* = 32)			66 (F = 39, *M* = 27)		
Measures	Mean/ (Median)	*SD* (*IQR*)	Mean rank	Mean/ (Median)	*SD* (*IQR*)	Mean rank
Age	73	5	65	(71)	(9)	57
TICS* **	29	6	–	35	3	–
PHQ-9*	(3)	(6)	70	(2)	(3)	54
GAD-7**	(2)	(4)	71	(1)	(3)	53
RRS						
Total**	(35)	(11)	72	(29)	(10)	52
Brooding*	(8)	(4)	69	(7)	(2)	55
Reflection	(6)	(3)	65	(6)	(3)	58
RTSQ	(65)	(44)	66	(56)	(29)	57
Devices used						
Total	(1)	(1)	57	(2)	(1)	64
Music-related	(1)	(1)	60	(1)	(1)	62
Multi-functional	(0)	(1)	58	(0)	(1)	64
Music listening frequency		Percentage of group				
Never		13			18	
Rarely		20			14	
Some days		27			24	
Most days		40			44	

PwCI = persons with cognitive impairment (with diagnosis); NoCI = persons without cognitive impairment (no diagnosis); TICS = Telephone Interview for Cognitive Status; PHQ-9 = Patient Health Questionnaire 9; GAD-7 = Generalized Anxiety Disorder 7 scale; RRS = Ruminative Response Scale; RTSQ = Ruminative Thought Style Questionnaire.

* = <0.05.

** = <0.01.

*** = <0.001.

Table 2. Group depression and anxiety symptom status.

	n	
Symptom status	PwCI	NoCI
No depression or anxiety	32	55
Depression only	11	4
Anxiety only	1	2
Comorbid depression and anxiety	11	5

PwCI = persons with cognitive impairment (with diagnosis); NoCI = persons without cognitive impairment (no diagnosis); PHQ-9 = Patient Health Questionnaire 9; GAD-7 = Generalized Anxiety Disorder 7 scale.

No depression or anxiety = PHQ-9 < 5, GAD-7 < 5; Depression only = PHQ-9 ≥ 5, GAD-7 < 5; Anxiety only = PHQ-9 < 5, GAD-7 ≥ 5; Comorbid depression and anxiety = PHQ-9 ≥ 5, GAD-7 ≥ 5.

Materials and methods

Participants

Persons with cognitive impairment ([PwCI] $n = 55$) and persons without cognitive impairment ([NoCI] $n = 66$) were recruited via the Join Dementia Research platform (https://www.joindementiaresearch.nihr.ac.uk/) and community newsletter advertisements. The PwCI group (AD = 49, MCI = 6) were aged between 61 and 85 years old (see Table 1 for descriptive information). Participants in the PwCI group were classified as having no depression or anxiety (58%), depression only (20%), anxiety only (2%) and comorbid depression and anxiety (20%) (see Table 2 for group symptom status). The majority of participants ($n = 41$, 75%) were taking cognitive medication (Donepezil = 34; Rivastigmine = 3; Memantine = 3; Galantamine = 1), and few participants ($n = 5$, 9%) were taking anti-depressant medication. The NoCI group were aged between 60 and 88 years old (see Table 1 for descriptive information). The majority the participants in the NoCI group were classified as having no depression or anxiety (83%), depression only (6%), anxiety only (3%) and comorbid depression and anxiety (8%) (see Table 2 for group symptom status). All participants had at least 12 years education/technical training.

All participants provided written or verbal consent before the study commenced, and participants with cognitive impairment were also required to have a carer or representative provide written or verbal confirmation of the participant's ability to provide informed consent.

Procedure

Participants completed the Telephone Interview for Cognitive Status (TICS) (Brandt et al., 1988) and a music and technology survey during a phone call, and self-report depression, anxiety and rumination measures via Online surveys (https://www.onlinesurveys.ac.uk/). Participating took up to 1 h in total. The study was reviewed in accordance with the procedures of the

University of Reading's Research Ethics Committee and received a favourable ethical opinion for conduct (UREC 18/27).

Measures

Cognitive status

The TICS was used to assess memory, orientation, attention and language. A total score ranging from 0 to 41 can be generated from the summed scores from each of the 11 items, with a score of ≤30 being indicative of cognitive impairment. The TICS has comparable discriminative ability to the Mini Mental State Exam (Folstein et al., 1975; Seo et al., 2011).

Music and technology survey

Participants were asked to indicate how often they listened to music by selecting from the following responses, 'never', 'rarely', 'some days' and 'most days'. If they listened to music, they were then asked if they listened to music on a radio, mobile phone, tablet, laptop, desktop computer and any other devices. Prompts were provided if necessary (e.g. record player, MP3 and Alexa). A proxy was not used in the current study as no significant differences have been found between proxy and people with cognitive impairment's responses about their everyday technology use (Jakobsson et al., 2021).

Anxiety

The Generalized Anxiety Disorder 7 scale (GAD-7) (Spitzer et al., 2006) was used to screen for anxiety symptoms. A score of 0 (not at all) to 3 (nearly every day) is assigned for each of the 7 items, with 5–9 points representing mild, 10–14 moderate and ≥15 severe anxiety. The GAD-7 demonstrates high internal consistency ($\alpha = 0.89$), and a score of ≥10 is suggestive of generalized anxiety disorder (GAD) and other anxiety disorders (Löwe et al., 2008).

Rumination

The Ruminative Response Scale (RRS) (Nolen-Hoeksema, 1991) was used to measure participant levels of rumination as a response to depression. Items reflect depressive, brooding and reflective ruminative responses to depression. A score of 1 to 4 ('almost never' to 'almost always', respectively) is assigned for each of the 22 items, generating a totalled score ranging from 22 to 88. Higher scores indicate higher use of ruminative responding. The scale has excellent internal consistency, adequate convergent and predictive validity for persons without dementia and excellent internal consistency and

adequate test–retest reliability for persons with dementia (Greenaway et al., 2024; Nolen-Hoeksema et al., 1993, 1994).

The Ruminative Thought Style Questionnaire (RTSQ) (Brinker & Dozois, 2009) was used to assess rumination as a style of thinking. Respondents rated each of the 20 items in terms of the statements' self-descriptiveness ranging from 'not at all descriptive of me' to 'describes me very well' (1 to 7, respectively). The RTSQ has shown adequate test–retest reliability and high internal consistency for persons with and without dementia (Brinker & Dozois, 2009; Greenaway et al., 2024; Tanner et al., 2013).

Data analysis

The median rumination score was used to classify participants as low (below median score) and high (above median score) ruminators (Watkins & Mason, 2002).

Effect size (ES) were calculated for significant bivariate correlations by squaring the correlation coefficient (r^2).

Results

Participant characteristics

The groups did not significantly differ in age, in their use of rumination as a reflective response to depression nor as a thinking style, and the total number of devices, music-related nor multi-functional, used for listening to music (see Table 1 for descriptive data and supplementary data for non-significant test information). The PwCI group was significantly more cognitively impaired, $t(73) = 7.27$, $p < .001$), depressed, $U(N_{\text{PwCI}} = 55,\ N_{\text{NoCI}} = 66) = 2{,}281.50$, $z = 2.46$, $p = .01$, and anxious, $U(N_{\text{PwCI}} = 55,\ N_{\text{NoCI}} = 66) = 2{,}347.00$, $z = 2.86$, $p = .004$, than the NoCI group. The PwCI group used rumination as a response to depression total, $U(N_{\text{PwCI}} = 55,\ N_{\text{NoCI}} = 66) = 2{,}414.00$, $z = 3.12$, $p = .002$, and brooding, $U(N_{\text{PwCI}} = 55,\ N_{\text{NoCI}} = 66) = 2{,}237.50$, $z = 2.23$, $p = .03$, significantly more than the NoCI group.

There were no within-group significant differences between males and females in age, cognitive ability, depression, anxiety and rumination scores, nor the total number of devices, music-related nor multi-functional, used for listening to music for the PwCI group (see supplementary data for demographic and non-significant test information). This was also evident for the NoCI group except in the use of reflection as a response to depression, with males using reflective rumination significantly less than females, $U(N_{\text{Female}} = 39, N_{\text{Male}} = 27) = 342.50$, $z = -2.50$, $p = .01$.

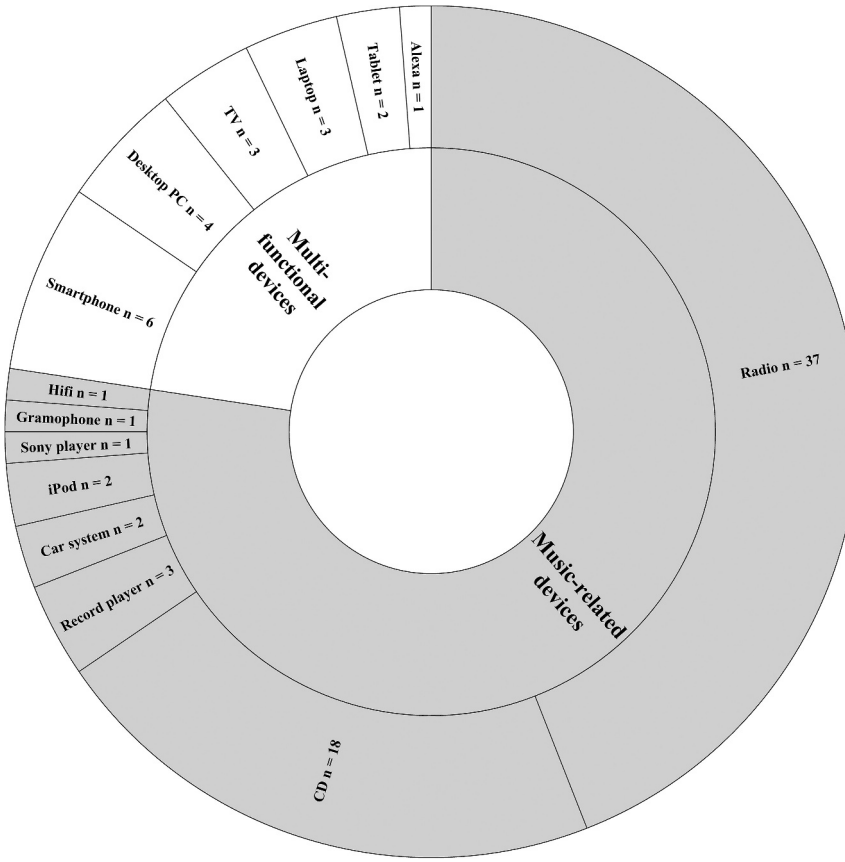

Figure 1. Chart showing the music listening devices used by persons with cognitive impairment (PwCI) ($n = 49$).

Devices used for listening

Participants could use up to five devices to engage with music, with music-related devices (e.g. radio) being used more than multi-functional devices (e.g. smartphones) for both the PwCI and NoCI groups (see Figures 1 and 2). No significant relationships were found between the number of devices used for listening to music and anxiety for both groups, and with depression for the PwCI group (see supplementary data for non-significant/further correlation information). Using more devices to listen to music was associated with higher depression scores, $r_s(64) = .28$, $p = .02$, 95% CI [.04, .49], with small effects (ES, $r^2 = .08$) for the NoCI group. In regard to rumination, using more music-related devices to listen to music was associated with less rumination as a thinking style, $r_s(53) = -.30$, $p = .03$, 95% CI [−.53, −.03], and using more multi-functional devices to listen to music was associated more rumination as

Figure 2. Chart showing the music listening devices used by persons without cognitive impairment (NoCI) ($n = 63$).

a response to depression total, $r_s(53) = .28$, $p = .04$, 95% CI [.01, .51], and reflection, $r_s(53) = .31$, $p = .02$, 95% CI [.04, .53], with small effects (ES, $r^2 = .09$, $r^2 = .08$ and $r^2 = .10$, respectively) for the PwCI group. No significant relationships with rumination were found for the NoCI group (see supplementary data for non-significant correlation information).

Music listening frequency

Although a higher percentage of participants in both groups and high ruminators (except rumination as a response to depression for the NoCI group) listened to music most days, there was no significant associations between the listening frequency and group, rumination level, nor gender (see Tables 1 and 3 for listening frequency data and supplementary data for non-significant test information).

Table 3. PwCI and NoCI groups' high and low ruminator's listening frequency.

	Rumination			Listening frequency			
Group	Type	Level	*n*	Never	Rarely	Some days	Most days
PwCI	RRS	Low	26	6%	16%	14%	16%
		High	24	6%	6%	14%	22%
	RSTQ	Low	27	4%	9%	20%	17%
		High	27	9%	9%	7%	24%
NoCI	RRS	Low	26	10%	7%	8%	25%
		High	24	5%	8%	19%	17%
	RSTQ	Low	33	11%	11%	11%	18%
		High	32	6%	3%	14%	26%

PwCI = persons with cognitive impairment (with diagnosis); NoCI = persons without cognitive impairment (no diagnosis); RRS = Ruminative Response Scale; RTSQ = Ruminative Thought Style Questionnaire.

Sub-groups

To better understand how specific listening choices may relate to depression, anxiety and rumination levels, the PwCI and NoCI groups were then divided into four sub-groups consisting of those who did not listen to music on any devices (No-Devices), only music-related (Music-related), only multi-functional (Multi-functional) and both music-related and multi-functional devices (Both-types).

PwCI participant characteristics

The PwCI sub-groups did not significantly differ in age, cognitive ability, depression, anxiety, rumination as a reflective response to depression nor as a thinking style (see supplementary data for non-significant test information). There was a significant difference between the sub-groups in their use of rumination as a response to depression total, $\chi^2(3, N = 55) = 8.216$, $p = .04$ and brooding $\chi^2(3, N = 55) = 11.567$, $p = .01$. Pairwise comparisons showed that the PwCI Multi-functional sub-group used rumination as a response to depression total significantly more than the Music-related subgroup, $U(N_{\text{Multi-functional}} = 7, N_{\text{Music-related}} = 31) = -19.11$, $z = -2.85$, $p = .004$, with this comparison remaining significant after Bonferroni correction ($p = .03$). The PwCI Multi-functional sub-group also used rumination as a response to depression brooding significantly more than the No-Devices, $U(N_{\text{Multi-functional}} = 7, N_{\text{No-Devices}} = 6) = -20.76$, $z = -2.36$, $p = .02$, Music-related, $U(N_{\text{Multi-functional}} = 7, N_{\text{Music-related}} = 31) = -21.70$, $z = -3.29$, $p = .001$, and Both-types, $U(N_{\text{Multi-functional}} = 7, N_{\text{Both-types}} = 11) = 22.16$, $z = 2.90$, $p = .004$, sub-groups, with the latter comparisons remaining significant after Bonferroni correction ($p = .006$ and $p = .02$, respectively).

Devices used for listening

The PwCI No-Devices sub-group was not entered into computations as no devices were used. There was a significant difference between the PwCI sub-groups in the number of devices used to listen to music, $\chi^2(2, N = 49) = 19.30$, $p = <.001$. The Both-types sub-group used significantly more devices than the Music-related, $U(N_{\text{Both-types}} = 11,\ N_{\text{Music-related}} = 31) = -19.98,\ z = -4.32,\ p = <.001$, and the Multi-functional, $U(N_{\text{Both-types}} = 11,\ N_{\text{Multi-functional}} = 7) = -19.08,\ z = -2.99,\ p = .003$, sub-groups, with these comparisons remaining significant after Bonferroni correction ($p = <.001$ and $p = .01$, respectively). A significant relationship was found for the PwCI Both-types sub-group (see supplementary data for non-significant/further correlation information). Using more music-related devices and more devices in total to listen to music was associated with less rumination as a thinking style, $r_s(9) = -.72$, $p = .01$, 95% CI [−.93, −.12] and $r_s(9) = -.75$, $p = .01$, 95% CI [−.94, −.20], respectively, with moderate effects (ES, $r^2 = .52$ and $r^2 = .56$, respectively).

NoCI participant characteristics

The NoCI sub-groups did not significantly differ in age, depression, anxiety and use of rumination (see supplementary data for non-significant test information). There was a significant difference between the NoCI sub-groups in their cognitive ability, $\chi^2(3,\ N = 66) = 8.28,\ p = .04$. Pairwise comparisons showed that the Both-types sub-group was significantly more cognitively impaired than the Music-related sub-group, $U(N_{\text{Both-types}} = 22,\ N_{\text{Music-related}} = 36) = 13.87,\ z = 2.69,\ p = .01$, with this comparison remaining significant after Bonferroni correction ($p = .04$).

Devices used for listening

The NoCI No-Devices sub-group was not entered into computations as no devices were used. There was a significant difference between the NoCI sub-groups in the number of devices used to listen to music, $\chi^2(2, N = 63) = 26.21$, $p = <.001$. The Both-types sub-group used significantly more devices than the Music-related sub-group, $U(N_{\text{Both-types}} = 22,\ N_{\text{Music-related}} = 36) = -23.59,\ z = -5.12,\ p = <.001$, with this comparison remaining significant after Bonferroni correction ($p = <.001$). A significant relationship was found for the NoCI Music-related sub-group (see supplementary data for non-significant/further correlation information). Using more devices in total to listen to music was associated with more depression, $r_s(34) = .34,\ p = .04$, 95% CI [.002, .61], with small effects (ES, $r^2 = .12$).

Age, cognitive ability and device use

Although age was not a primary focus of the study, the only significant relationship found was for the NoCI Both-types sub-group. Using more multi-functional devices and devices in total to listen to music were

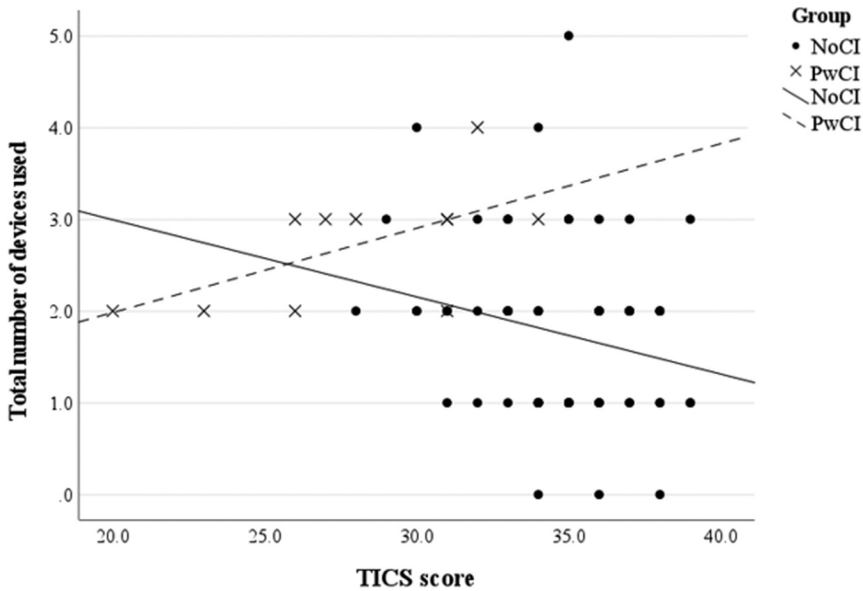

Figure 3. Graph showing the total number of devices used for music listening against TICS scores for the PwCI Both-types sub-group ($n = 11$) and NoCI participants ($N = 66$).

associated with being younger, $r_s(20) = -.59$, $p = .004$, 95% CI [−.82, −.19] and $r_s(20) = -.43$, $p = .04$, 95% CI [−.73, −.01], respectively, with small effects (ES, $r^2 = .35$ and $r^2 = .18$, respectively).

While our focus in terms of cognitive ability related to participant and device groupings, significant relationships were for the PwCI and NoCI participants. Using more devices in total to listen to music was associated with less cognitive impairment (i.e. higher TICS score), $r_s(9) = .63$, $p = .04$, 95% CI [−.01, .91], with moderate effects (ES, $r^2 = .40$) for the PwCI Both-type sub-group, and using more multi-functional devices to listen to music was associated with having more cognitive impairment (i.e. lower TICS scores), $r_s(64) = -.30$, $p = .02$, 95% CI [−.51, −.05], with small effects (ES, $r^2 = .09$) for the NoCI group (see Figure 3).

Discussion

The aims of the current study were to identify the devices used by persons with and without dementia to spontaneously listen to music, and to explore listening frequency and how depression, anxiety and rumination levels may relate to device use. We found that music-related devices (e.g. radio and CD players) were used to engage with music by more participants than multi-functional devices (e.g. smartphones and computers), music was listened to more often than not (67–68% some/most days versus 32–33% rarely and

never), and that the factors associated with technology use differed between the groups. For persons with dementia/mild cognitive impairment, only rumination was associated with device use (i.e. multi-functional devices at group level, and music-related devices at both group and [Both-types] sub-group level), whereas for persons without dementia/mild cognitive impairment, only depression was associated with the total number of devices used at both group and [Music-related] sub-group level. Cognitive ability was associated with device use in opposing directions for persons with and without dementia/mild cognitive impairment, and these relationships involved the use of multi-functional devices in some manner (i.e. both multi-functional *and* music-related device use, and just multi-functional device use for persons with and without dementia/mild cognitive impairment, respectively). It is possible that with increasing cognitive impairment (i.e. TICS scores lowering from 41 points), individuals use more multi-functional devices for music listening. With further increasing levels of cognitive impairment (e.g. TICS scores below 26 points), less multi-functional devices are used (as demonstrated in Figure 3). TICS scores between 21 and 25 and ≤20 points fall within the mildly and the moderately to severely impaired ranges, respectively (Chappelle et al., 2023). With higher levels of cognitive impairment (i.e. individuals with mild cognitive impairment/dementia), multi-functional devices may be perceived as harder to use and used less (Hedman et al., 2015). In contrast, multi-functional devices could be perceived as easier to use for individuals with lower levels of/no cognitive impairment, and therefore, more of these devices could be used for music listening if desired.

Of note, our measurement of two forms of rumination and device groupings allowed us to observe differing associations, a negative relationship between rumination as a thinking style and music-related device use, with those who listen via music-related *and* multi-functional devices (Both-types sub-group) possibly underlying this finding, and a positive relationship between rumination as a response to depression (total and reflection scores) and multi-functional device use (group level). Although rumination is thought to be (positively) associated with problematic not general technology use, it is typically investigated in terms of problematic smart device/internet-based use, and findings may not be generalisable for older persons nor directly comparable given that we examined the use of several devices for a specific purpose (i.e. music listening) rather than single device use (e.g. smartphone) or use for a specific purpose (e.g. social media use and gambling) without interest in the device being used (Castro-Calvo et al., 2022; Elhai et al., 2018; Kircaburun et al., 2019). The negative relationship between rumination as a thinking style and music-related device use found in the current study is interesting from an experimental and/or interventional standpoint. For example, will an individual engage in less ruminative thinking if they increase the number of music-related devices they use for music

listening (without increasing listening frequency and duration)?. Given that rumination is a risk factor for depression and anxiety and music interventions are used to manage these symptoms, it would be advantageous to know whether particular devices may be better for music engagement than others.

However, other factors (e.g. type of music, duration of listening, and/or perceived ease of use) could be mediating these relationships (Elliot et al., 2014; Gold et al., 2009; He et al., 2024; Malinowsky et al., 2017) and causational relationships need to be explored. Moreover, other activities (e.g. using social media) also need to be considered when examining these relationships. For example, the Engagement in the Good with Technology framework (Villamil & Heshmati, 2023) suggests that three domains, seeing good (e.g. viewing positive content), feeling good (e.g. engaging in music) and doing good (e.g. posting positive content) are interconnected with technology engagement for good (e.g. emotional regulation). And given the positive relationships between reflective rumination and the number of devices used for music listening by persons with dementia/mild cognitive impairment in the current study, the extent to which trait rumination (as measured here) *and* the device contributes to reflection could be explored. For example, the Reflection, Rumination and Thought in Technology scale (Loerakker et al., 2024) allows for an assessment of how technologies may support types of ruminative thinking.

Limitations and future studies

Limitations of our study include the non-collection of perceived ease of use and further socioeconomic information (e.g. financial status) as these factors can impact technology use by older persons. Due to the cross-sectional nature of our study, the causational relationship between psychological factors and technology use could not be explored. Additionally, retrospective accounts were provided. Longitudinal and/or experience sampling data could be collected to explore the dynamics of these relationships and how the duration of music listening on different devices may impact results. Our sample size limited the type of analyses that could be conducted. Future larger samples are required to examine moderating and mediating factors in these relationships. The motivation for listening device selection (e.g. listening location and music track accessibility) could also be ascertained and factored into analyses.

Conclusion

Our findings indicate that older persons listen to music more frequently than not and that rumination and depression are associated with the technologies used for music listening by older persons with and without dementia/

cognitive impairment, respectively. While our study represents the first step in the inclusion of older persons/with dementia in studies exploring rumination and technology use, more information and larger samples are required to better understand the relationships identified in our data and their applications.

Recommendations

A holistic approach should be taken when investigating or using music as an intervention for managing depression and anxiety symptoms. Based on the literature, music type (e.g. valence), preference, dosage and listening location, as well as the individuals' ruminative tendency and pre-/symptomatic relationships with music should be taken into consideration (Franěk & Režný, 2024; Garrido, Dunne, et al., 2017; Gebhardt & von Georgi, 2015; Gold et al., 2009; Knox & MacDonald, 2016). The type of device being used by persons with dementia may be of particular importance given the effect size of the association between music-related devices and less rumination (as a thinking style) found in the current study and thus should also be considered.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

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