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Opinion

Current Developments and the Potential for Automated Home-Based Music Listening Systems in Dementia Care

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Abstract

People with Dementia (PwD) in the earlier stages still living in their own home experience neuropsychiatric symptoms (NPS) such as stress, frustration and agitation, which affect quality of life and independence, as well as adding strain to carer relations. Listening to preferred or relaxing and calming music has been reported to help manage agitation and have a positive effect on other behavioural and psychological symptoms. This paper discusses current directions in the use of music for these purposes, and ways to deliver the right music to PwD when they need it most. An overall tendency is the development of adaptive technology for facilitating music playlist compilation and music listening that can alter arousal levels and help regulate neuropsychiatric symptoms. This is discussed in the context of supporting people living independently with dementia and potentially being able to remain in their home for longer.

There are several published methodologies for assisting in sourcing and compiling music likely to be personally meaningful and beneficial for PwD, with some helpful apps and online resources such as Playlist for Life that link to Spotify accounts. There is no existing music listening technology readily available that can be: 1. installed in the home environment of PwD, 2. easily located and heard with an effective speaker system, 3. used to alter the environment in order to reduce incidence of agitated behaviour and improve quality of life. Research in this area is required in order to determine whether such technology can be developed and made publicly available that would be effective in prolonging independent living.

Introduction

This article presents a selection of music listening research and related technology for assisting in the management of the symptoms of dementia. The article discusses areas where research and development might aid the implementation of music resources in order to optimise quality of life and help prolong independent living. According to World Health Organisation data, there are approximately 50 million people affected by dementia worldwide and 10 million new cases every year. Approximately £10,000 per-year in the UK is paid by people with dementia and their families either for unpaid care or private social care[1]. For people living with dementia (PwD), cognitive impairment, in particular memory and attention, are common symptoms that impact on their ability to perform vital daily tasks. Related neuropsychiatric symptoms include agitation, depression and anxiety. These combined effects have a significant impact on quality of life, relations with spouse and/or carers, and early admission into care homes. Even at the later stages of dementia, music induced emotions and memories are often preserved [1]. In populations without dementia, music has been shown to have an effect on various systems and functions, including arousal [2], anxiety, systolic blood pressure, and respiratory rate [3,4,5]. It has also been shown to aid psychophysiological recovery from stress. Listening to preferred music might also help to reduce pain, anxiety and depression in older people [6]. Calming and individualised music, played for 10 minutes, has been found to reduce agitation in the elderly, with effects sustained for one-hour post-listening [7].

PwD can experience problems managing neuropsychiatric symptoms such as agitation, aggression and anxiety, and would benefit from strategies and interventions to help reduce the need for psychotropic medicine, which commonly has side effects. These symptoms have been identified as the major contributing factor to early care home placement Dowson, Mcdermott and Schneider [8] and recent NICE guidelines advise against over use of psychotropic medicines. A systematic review reporting the clinical effectiveness of sensory, psychological and behavioural interventions for managing agitation in PwD, found a general benefit through listening to preferred or calming/relaxing music [9].

The effects of music interventions on non-biomedical symptoms, such as quality of life and apathy, affecting 50% of PwD, merits further research [8]. Interviews with PwD on their experiences of music (listening and active participation) suggest that it might enhance self-esteem and

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competence, promote feelings of independence and lessen the experience of social isolation [10]. Research into apathy with people with moderate to severe dementia comparing the effects of live music delivery with pre-recorded music and silence, found that there was significant engagement with the live delivery compared to the other conditions [11]. Positive engagement in pre-recorded music listening was not significantly greater than for silence, indicating that for people at this stage of dementia progression, when measuring effects on apathy, music listening might not be appropriate.

The listening environment may also play a part in how effective music listening is. Little is known about how to adapt home environments to optimise music listening benefits. Of 22 studies included in a systematic review of music therapy randomised controlled trials with people with dementia, none were conducted in private homes and only two were purely music listening. A further review included six studies, one of which examined the effects of music listening in the home environment through headphones on self-consciousness. The group that selected one song that was well-know to them, plus their favourite music, showed stabilized or increased self-consciousness questionnaire scores, compared to the control group with unfamiliar music whose scores deteriorated. One study reports on the setting but not the environment specifically, with findings indicating that music listening is more effective in the long-term for those living in a care home than for those in their own home. As regards musical experience and whether this might bring more benefits from music listening, the same study showed that it did not, but the care situation did, together with dementia etiology, severity and age.

Listening Trends in Older People

Researchers have examined listening niches, including technology used and music preferences, across a century of popular music, with nearly 1900 participants born between 1940 and 1999 [12]. Older listeners had the broadest tastes due to exposure to music across their lifespan from different niches. Personal memory associations with the songs presented from 10 decades were reported by 53.6% of participants [12]. What may be useful from the Krumhansl study when compiling music playlists, is that the decade in which participants were born had no effect on the percent of associated memories or their specificity. Associated memories with music were most strongly reported between the ages of 13-29 years of age. There was a positive association between incidence of personal memories and music that made listeners feel energised, happy, nostalgic and romantic, and a negative association with music that made them feel sad. Music listening appeared to be most strongly correlated with specific personal memories when the music had been listened to alone or with friends and peers. Participants rated how the music clips affected their mood. The younger birth cohorts, born in the 60s-90s- rated the music of all decades as making them feel sadder than was the case for the older birth cohorts. Other studies have found that there is a more prominent 'reminiscence bump' if the music is personally significant to the listener.

Creating Music Playlists for People Living with Dementia

Building music playlists for people living with dementia fits with the recommended person-centred approach to care, which aims at preserving the personhood of each individual and optimising each care plan due to an improved awareness in relatives and caregivers of the individual's personal needs. With short-term memory most affected in PwD and long-term, episodic memory more preserved, it might be the case that music associated with the recollection of memories is more pleasurable than stimuli in their current environment, which can be confusing and disorientating [13]. Some research has explored whether selecting classical music would suffice in helping to regulate agitation, but it was found that individualised music playlists were more effective [13].

Several studies have been conducted with PwD to measure the benefits of listening to their preferred music, one of which showed significant reductions in aggressive behaviours in severely cognitively impaired PwD during bathing [14]. The participants, residing in a nursing facility, listened to CDs of the music identified by them as preferred, which included hymns, classical, big band and old-time string music that was familiar to the demographic. The protocol developed and tested by Gerdner for assembling playlists [15] is now in its 5th published edition and has led to a similar study that resulted in significantly reduced anxious behaviours in older adults with dementia residing in a nursing home [16].

Using music playlists in a supported living facility for PwD has been evaluated, using the Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework [17]. This was conducted over eight months, showing benefits in mood, emotional expression and goal-directed activity (during listening), evaluated on the percentage of encounters where mood was observed to improve according to medical technicians. This system required weekly visits from two volunteer medical students, and bi-monthly playlist adjustment based on resident responses. A central iTunes account was used to provide music for all devices used by residents. Music was distributed by medication technicians, who helped residents with their daily activities and so were very familiar with each person. This was done at least twice per-week for 30 minutes. Medical technicians were able to decide the timings of music delivery, based on their knowledge of each resident's behaviour and routine. They were also encouraged to try and administer music at times when they knew that difficult behaviours occurred. This system clearly relies on the availability of a team of volunteers and permanent staff who know residents well, and can allocate time to adjust playlists according to how they are engaging and responding. Some research has been conducted in order to determine whether carers can deliver music listening to PwD, identifying emotionally and biographically important music, and how to apply it for different purposes, such as for relaxation or vitalisation. In order to help assimilate music listening into the home and everyday life, homework exercises were also implemented [18].

Music Listening and Playlist Compiling for Pwd Living in Their Own Home (or, Use of Music in Private Homes by Pwd Either Independently or with Their Carer)

Feasibility of delivering preferred music in individual sessions to people in the early stages of dementia has been explored for addressing depression and anxiety. One case study showed that playing familiar songs to a man, living at home with his wife, that were about travel or praising nature, helped him to tolerate traveling to a care home four times per week, which he was becoming increasingly resistant to. The songs were not chosen based on the man's preference, but a hypothesis that the musical style and subject matter might increase tolerance and adherence, and reduce behavioural symptoms, which they did [19].

Beyond Manually Compiled Music Playlists

Some researchers suggest that it is now possible for music streaming and mobile application technologies to converge and provide adjunct music-based therapy for affective disorders [20]. Based on reviewed evidence and scientific theory, they suggest that music can be mapped onto a plane of varying arousal, by measuring electrodermal activity (EDA) and/or electroencephalogram (EEG) activity in people whilst they listen to different music. This goes beyond existing music streaming services such as AllMusic, Amazon Prime Music, Apple Music, Google Play Music, iHeartRadio, Pandora, Spotify, or SoundCloud, which can recommend music based on unclear criteria for affective purposes, such as helping a person feel relaxed or energized.

Musicovery is a streaming service that uses an interface to help listeners select what mood of music they would like. The music is categorized using an arousal/valence plane, for example music in the

'Happy' category would contain elements such as major key, many instruments, electronic sounds, piano, percussive, compared to 'Relaxing', which would include music in a minor key with few instruments, that is quiet, slow and flowing [20]. Research using affective Brain Computer Music Interfaces (aBCMI) led to this development in the use of music listening for health. The aBCMI used EDA and EEG to record listeners' reported affective state and compare it with how the music had been categorized based on the researchers' arousal/valence plane. Matches were found to be 65% accurate, and developments continue in order to establish the best ways in which to move people to the desired or targeted affective state. This, they term the case-based reasoning system [21].

Playlist for Life, developed for PwD, enables music selection by date, linking with Spotify in order for the music to be selected based on the person's date of birth and age at which they were predicted to listen most frequently to music. The system does not use any system to map music onto an arousal/valence plane, and bio-data cannot be used to match music to the listener's current arousal level or alter it incrementally.

A computer program was developed by researchers to help participants select a suitable musical style that was also personally meaningful. Twenty-minute musical sequences were broken down into several phases that drew the listener into a state of relaxation. The researchers refer to this as the 'U' sequence method, which works on relaxation by gradually introducing a slower tempo, reduced orchestral arrangement and decreased volume. This appears to be similar in theory to the arousal/valence plane discussed earlier [20], and found significant treatment related reductions in depression and anxiety in a cohort of nursing home residents with mild to moderate Alzheimer's disease.

It has been suggested that X-System (not yet commercially available) is the only music listening application that predicts the level of excitement or relaxation of music based on a model of the musical brain and body. Heart rate variability [HRV] has been shown to be significantly impacted by music [22]. What is unique about this listening system compared to others, is that it uses an arousal/valence plane to categorise music, but the music is then selected based on each user's real-time heart rate data generated from their bio-bracelet. The listener can select the music of their choice, which is processed by the X-System and placed on the arousal/valence plane so that it is categorised based on parameters such as tempo, dynamic form and tonality, and can be used to achieve the state of arousal that the listener needs or would like (increase, decrease or maintain). Effects may include modulation and regulation of emotion, mood, bodily movement and autonomic and endocrine response. The automatic categorisation process is based on the Innate Neurophysiological Response to Music model (INRM) [23]. The model is concerned primarily with low and mid-brain processing of music in areas where responses are largely innate and 'universal'. Heart rate variability (HRV) is a good marker of the emotional state Fourie [24] and mental state Howells [25] of individuals and is also a good measure of performance anxiety [26].

What Existing Equipment and Technology is Commercially Available that Best Suits PwD for Music Listening, and Does Everything that they Need?

Some research findings indicate that the main reason for non-use of information and communication technology (ICT) by older adults is related to lack of interest or sense of need. Whilst there is an increasing trend in its use, possibly motivated by perceived usefulness, there is a need to support older people in accessing such technologies through simpler interface design, training provision, and, importantly, demonstrating that it can improve their quality of life [27]. Touchscreen tablets offer multimedia and multisensory stimulation, with intuitive interface operating system design, and have been used to facilitate interactions between PwD and their caregivers through the playing of music. Caregivers rated positive mood changes (P = <.001), demonstrating a potentially valuable tool to help improve quality of life whilst living in their own home [28].

Some music streaming service statistics reveal that users are predominantly under 30 years of age, specifically Spotify (62%) and Pandora (45%) [12]. Figures from this 2015 CivicScience report also show that 15% of Spotify users and 23% of Pandora users were over 45[2]. When growing up, people tended to listen to older music on older media, but used newer technologies in their teens and early twenties.

Different devices and an increasing array of music streaming services are commercially available to listen to almost every musical genre and spoken word recording, audiobook or podcast. Televisions are commonplace in homes around the world and can play radio, stream data and connect with other devices. Some people will still use separate radios, others have computers, tablets, mobile smart devices with which they stream anything that they want to watch or listen to. When looking at the development and implementation of different technology for playing music, research indicates that the appearance of the device must make it obvious, or as clear as possible to the PWD, that it is for listening to music. This is in order that they are prompted to turn it on and use it [10], via simple, easily navigable controls. The device needs to be positioned well in the home and possibly illuminated in order that users can more easily locate it.

The radio is a means of music listening familiar to the current age demographic of PwD. It offers a range of other listening material besides music, such as plays, comedy, sport, readings, news and discussion. Some studies have highlighted the need, expressed by experienced care home staff, to regulate the use of radio and music as it can exacerbate neuropsychiatric symptoms, depending on the nature of the music. One study reports on music listening in the home, with more participants using cassettes, CDs and records, and listening to music with others, than listening to the radio [10]. This might suggest that radio could be used as a platform or hub in the home throughout the day if adapted. For example, personalised diary announcements and preferred music could be integrated, interrupting the live broadcasts at appropriate times in order to remind the listener to complete daily tasks and enhance quality of life and independence. But the research also reported the use of music for reminiscence, and suggests that interactions with others as part of the music listening is an important part of the process and might help to optimise benefits. Music therapy with a definable protocol, delivered by a trained music therapist, has been reported in a systematic review as being more effective in decreasing agitation than music therapy that comprised of music listening [9]. The protocol included lots of interaction with the PwD, including a warm up and actively joining in with the music.

Beyond Manual Delivery of Music

Radios and stereo systems have long been available that can be programmed to switch on at certain times of the day, perhaps more commonly activating music as a morning alarm call, or turning off when in bed after 20 minutes or so, when it is hoped that sleep has been induced (Possibly seek references). Less common, might be programming music to come on at specific times in order to prompt an action or task and enhance engagement in it, as an appointment reminder, or to help 'get in the mood' for going out somewhere.

Widely available technology has been used in some instances to help provide reminders for PwD still living in their homes and to help prepare them for appointments and the journey to them. One study reports the case of a man, KS, who lived at home with his wife and was provided with an integrated circuit (IC) recorder. This is a small device into which anything can be recorded and programmed to play back at various points throughout the day [19]. When the voice reminders became ineffective and KS refused to attend a day centre, music was recorded into the IC recorder, to be played to him before going out to the day centre. This resulted in an increase in compliance, reduction in behavioral symptoms,

and less stress for his wife. A small study examined the use of music in song-task association using an app (Memory Tracks), which is available for free download. Staff caring for PwD on two care home sites used songs selected for their association with specific tasks such as washing and eating, in order to help engagement and completion [29]. One finding from the study, was that more needs to be done in the music selection process to improve the functionality of the app. Reminiscence therapy, using music and visual stimuli such as autobiographical photos and video, has been delivered remotely, but the equipment requires installation on-site before it can be used remotely [30,31].

Discussion

Although some research suggests that the public perception of music listening is as entertainment rather than for health and wellbeing [17], in dementia care music is becoming more widely recognised for these purposes. Current evidence, presented here, suggests that music listening might improve quality of life for PwD and help regulate arousal, thus assisting in the management of neuropsychiatric symptoms. Personal playlist creation may bring more benefits, and research has established how and where to source music likely to have personal meaning and to be linked to positive memories [15,16]. Without the need to gather autobiographical data, other than date of birth and the 'memory bump' period, it is possible to find and play music that a person will recognize and enjoy. Some research helps to identify where live music might be more engaging and effective than pre-recorded [11], which could inform on playlist delivery adaptations, for example where PwD and carer might sing along with the music to increase efficacy of arousal regulation. There are apps, linked to music streaming platforms, which allow easy access to familiar, personally meaningful music. It may, however, be difficult to access for PwD living independently, even with carer support.

For music to be used effectively in homes, potentially helping with the management of neuropsychiatric symptoms, and prolonging independent living with optimal quality of life, a system could be built into the user's home environment. This could be connected to a live stream of their biomedical data. These HRV, HR and/or EDA data could be calibrated to activate their preferred music when early onset of agitation or anxiety is detected, with the music mapped onto an arousal/valence plane that might help to reduce arousal level before a state of agitation is reached. Wearable and phone-based bio- and neurofeedback technologies may help in the screening of already-existing musical tracks, facilitating initial evaluation of their clinical utility [21,20].

The alternative is for the user to know what music to play and when. Even the notion of programming music for each person, at the point before a state of agitation is reached, and at times of the day when certain behaviours are consistently observed, would simply not be feasible or reliable. The RE-AIM study showed some efficacy due to the available staff, time and consideration, bespoke to each resident. But still there was great variability on frequency of use, ranging from two to three times per-week, to once a month [17]. Whether this would be feasible to implement for a carer or a person living independently in their own home is not known and appears unlikely.

Music systems need to be situated in a part of the home where they are easy to see, recognize, access and operate. One case study presented here demonstrated how the use of technology could help to reduce behavioral symptoms, with a handheld digital device which had to be carried and positioned in hearing distance at times in order that the music and voice recorded reminders could be heard and work effectively [19]. This highlights an area for further development, which is the arrangement and positioning of speaker systems to enable the user to hear the music throughout their home. Details of such systems have not been described in the literature reviewed here. The necessary and appropriate procedures for music selection have not yet been automated for implementation and use by a wider population of PwD, or any other population. There are no platforms for selecting and delivering music in this way, that can be used in care homes or private homes, either independently or by/with carers. Systems currently under development, such as X-System and Musicovery, might achieve these things if linked to HRV and/or EDA data collected from each user's bio-bracelet data.

Conclusion

People living with dementia benefit in terms of arousal regulation, reminiscence and improved mood when listening to music that they are familiar with, perhaps more so when the music has personal associations and is associated with positive feelings. Adapting the home environments of people living with dementia to enable automated music streaming in response to changes in their HR, HRV and EDA, which may help reduce incidence of neuropsychiatric symptoms and prolong living in their own home, has not been trialled. A system does not currently exist that would facilitate this, but evidence from associated research indicates that this is a worthy area for research, with potential benefits for sustaining independent living, improving quality of life and enhancing relations between PwD and their carer.

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