A proof of concept personalized music player for persons with Alzheimer's Disease

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ABSTRACT
Numerous studies have shown that persons diagnosed with mild to severe Alzheimer's disease exhibit positive reactions when listening to familiar music. Results show that the disease spares musical memory in comparison to other memory parts of the brain until very late stages of Alzheimer's. This project explores the potential of a minimal user-interface design prototype for smart devices that relies upon simple user interactions, i.e. browsing and skipping, to identify and retrieve familiar and preferred music. We report on the results of a small Wizard of Oz study that provides support for the initial design concept and input to the next round of the design cycle. Most participants were able to interact with the device and to quickly identify preferred music that provided a useful starting point for collaborative filtering-based recommendations.

Keywords
music information retrieval, Alzheimer's, dementia, memory recollection, personalized music.

INTRODUCTION
A number of studies have demonstrated that persons diagnosed with mild to severe Alzheimer disease show signs of positive reactions when listening to familiar music (Cuddy & Duffin, 2005; Cuddy et al., 2012; Halpern & O'Connor, 2000). Dementia patients can benefit from listening to individualized music during music therapy by becoming less agitated, depressed and stressed, by remembering personal facts, becoming approachable and responsive, among other outcomes (Clement, Tonini, Khatir, Schiaratura, & Samson, 2012; Cooke, Moyle, Shum, & Murfield, 2010; Gerdner, 2010).

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However, current approaches to identifying the music preferences of dementia patients are burdensome, including the use of questionnaires and interviews with patients, family members and care givers (Gerdner, 2010). Motivated by research by Lancioni et al (2014), showing that simple technology aids can be used by individuals with Alzheimer's disease, we undertook the design of a personalized music application that would provide a lightweight approach to identifying and retrieving familiar music.

Such an application would be useful for caregivers and family members, and as an ultimate goal, be suitable for personal use by Alzheimer's Disease (AD) patients as a means to listen to their favorite music. The autonomy afforded by the application would make it a cost-effective supplement to therapy and medical treatment, and would be beneficial for AD patients as well as their families, spouses, and caregivers (Buettner et al., 2010). The goals of the study reported here were to investigate the factors that must be taken into consideration in the design of such an application and to establish proof of concept. Therefore, this study proposes and tests a minimal user-interface design prototype for smart devices that relies upon simple user interactions, i.e. browsing and skipping, to identify and retrieve familiar and preferred music.

PREVIOUS RESEARCH
Previous studies in the fields of neuropsychology, neurology, music therapy, music information retrieval, computer science, digital humanities and psychogeriatrics have examined the effects of listening to familiar music on AD patients'. For example, work by Cuddy et al. (2005, 2012) shows that long-term familiarity with melodies is prevalent across levels of dementia, including the severe stage for some individuals. Persons with mild, and some with moderate, dementia detected melodic distortions within the normal performance range of older adults. To see whether the exposure to music can actually enhance the production of self-defining memories, i.e. memories that contribute to self-discovery, self-understanding, and identity, Haj, et al. (2015) played specific music to study participants. They found that autobiographical recall is enhanced in AD patients when they are exposed to

personalized music in comparison with silence or music chosen by the researcher.

In considering the design of a music player system for AD patients, there is an extensive body of relevant research on music retrieval and recommender systems, including collaborative and content-based systems that filter based on skipping behavior and body movement. For example, Pampalk and Widmer (2005) propose a filtering system that builds a profile based on user feedback gathered by a "skip" button and Hoashi et al. (2003), propose content-based filtering that retrieves songs based on the user's genre preferences and relevance feedback. Technology design for AD patients presents challenges; however, research by Lancioni et al. (2014) supports the notion that they are capable of using specially designed technology to independently select and listen to preferred music. A similar study by Topo (2004) found that participants could use a multimedia system to identify and listen to music. Our approach builds on this previous work by proposing and testing a lightweight tablet-based music player that identified music preferences implicitly, based on user interactions.

METHODS

Design of Prototype

The prototype for this study was implemented on an Apple IPad 4 device using customizable, open source code (HTML, CSS & Java Script) for a music player[1]. The overall design concept was to keep the interface visually appealing, but as simple as possible with respect to content and interaction design. All unnecessary text, such as name of the artist and music track was deleted. The interface (Figure 1) shows the CD cover art of the music track that is currently playing and the edges of the previously played (left) and upcoming (right) songs. Covers showing images of the musician/s were selected when possible to serve as a secondary memory cue. The current selected song can be played and paused by touching anywhere on the full-sized cover; pressing on the left or right cover edge will play the previous or next song. Swiping allows for backwards and forward scrolling.

The playlist used for the music player application consisted of 40 songs, of which 25 were popular, 10 classical and 5 North American folk songs. The songs were selected because research on Alzheimer's patients shows that the symptoms of Alzheimer's disease commonly occur at age 67 and higher. Research shows that songs, especially those from the patients' childhood and adolescence years, are mostly remembered even until severe stages of Alzheimer's disease (Jacobsen et al., 2015; Cuddy et al., 2012; Fukui & Toyoshima, 2008; Cuddy & Duffin, 2005).

Participants and Recruiting

Participants were selected through a purposive sampling method from a pool of patients with age-related memory loss living at a special-needs, assisted-living care facility. These individuals were not suffering from Alzheimer's disease, but were considered to be an appropriate proxy sample for the early stages of interface testing. Participants of age 60 and above who were considered capable of participating in the study were identified with the help of facility staff, invited, and voluntarily consented to take part. In keeping with the recommendation of Nielson and Landauer (1993), we recruited 5 participants (3 females, 2 male, aged 62 to 69). All five study participants indicated that they had no previous experience in handling a tablet or a similar device.

Figure 1: Music Player Prototype

Procedures

This cross-sectional study was conducted in a "Wizard of Oz" style simulation (Kelly, 2009) in a quiet room in the assisted-living facility with the researcher, the participant and one care-giver present. The first step of the study presented participants with the music player application on a tablet. They received a brief tutorial, were given headphones and asked to use the system. The participants browsed and listened to songs included in the playlist and decided when to play, forward or replay a song previous heard. Based on the participant's preferences with the music player, the researcher then used Spotify, a commercial music streaming platform, to obtain recommendations and play additional songs. This was followed by a very brief interview including basic demographic questions (age, experience with technology, favorite music) and questions about the participants' experiences of using the system and of listening to the music. Sessions were brief: on average 12 (range 8.5 to 16) minutes.

Data was collected through direct observation, audio recording, and screen capture. The largely qualitative data was analyzed thematically to identify patterns of activity and to extract instances of positive and negative experiences with the prototype.

[1] Source: www.codepen.io

RESULTS

Music Recommendations

The study showed that, in most cases, the pre-generated playlist in combination with collaborative-filtering on Spotify allowed for a quick, interactive personalization and determination of the participants' music taste. Each participant independently showed an emotional reaction to some degree (singing along, smiling, remembering childhood events, etc.) to one or several music pieces. For example, Participant 1 reacted to Al Jolson – Swanee after listening to it for a few seconds by saying out loud the artist's name. After further listening he exclaimed, "I go for this for a while" and he recalled a movie he had seen about Al Jolson. After listening to several songs, he said, "It is so soothing. I am a very anxious person. That relaxes me." Using the artist Al Jolson as a search query in Spotify resulted in several artists similar to Jolson, and Participant 1 enjoyed listening to those, saying that they were familiar, although he did not remember the artist's name.

Participant II clearly enjoyed listening to the rockabilly songs included in the pre-generated playlist: Elvis Presley's Jailhouse Rock and Bill Hailey's Rock Around the Clock. He fully listed to both of these in contrast to several others he skipped after listening to only a few seconds. Bill Hailey was used in Spotify as a search query and the similar artists recommended played to Participant II resulted in a positive reaction in which he remembered events in his life. "Sure. Great Music. Oh Johnny Be Good. Who is it? .... Chuck Berry. Sure. I saw them live once…".

Results were similar for Participants III and V who both skipped through several songs to find two songs they listened to almost completely. Participant III reacted to the Hallelujah chorus from Handel's Messiah with memories from childhood and recollected "we always played this in our family on Christmas time. Oh, it gives me thrills" and "Christmas time was a special time for us children seeing my dad playing Beethoven, Mozart and Bach". Participant V reacted strongly to Procol Harum – A Whiter Shade of Pale and started to sing the lyrics along with the song. In Part 2 of the session, the recommended artists and songs created reactions such as "Yeah, yeah I like that one. Teacher never leave us alone" and "Yes. It is fantastic".

The case with Participant IV was somewhat different, as she rejected the playlist after moving quickly through three songs, saying she wanted to listen to folk songs from Germany, as she was born and grew up there. When we played German folk songs on Spotify, she reacted with excitement and started to hum the melody energetically. She laughed and asked in German: "Are we going to dance?"

Interaction Design

All five participants had, to their own account, never used a tablet and several issues were observed with the functionality of the music player. The swiping and tapping functions were challenging for participants. All participants tapped the touchscreen slowly and left their finger on the touchscreen to select an action. Several interventions by the researcher and the care giver slowly resulted in the correct motion of tapping the touchscreen and four of the five participants were capable of using the application independently by the end of the session.

Other issues observed included a lack of understanding of the backward scrolling function of the player, using the previous CD-Cover image, even after several attempts to clarify. However, using the current CD-Covers as the main selectors was quickly understood by participants. Also, the stand-by mode of the tablet created confusion several times as the display suddenly turned off during the process of listening to a song. Despite these issues, participants expressed comfort and interest in using the application in the post session interviews. One participant stated: "I sure would enjoy listening to music with this, because I can't remember the artists name but I can remember the tune."

DISCUSSION

Findings suggest that it may be possible to identify individualized music for dementia patients quickly and easily without the use of interviews and questionnaires. Despite widely varying musical tastes, participants quickly found music they enjoyed and, while listening, showed signs of emotional wellbeing (Clement et al., 2012), singing along to familiar melodies, and even episodic memory (Cuddy et al., 2012). This was a very limited study that included participants with age-related memory loss rather than Alzheimer's disease, so the results are merely suggestive. However, we consider the results promising and we intend to develop the next iteration of the music player that would incorporate a user profile derived from interaction with the initial playlist and a recommendation engine.

Study results suggest that the interface design can be simplified further by removing the option to scroll back. Given that there are only a small number of songs in the playlist loop, users can scroll forward only and still relocate songs. Further testing is needed to adjust the sensitivity of the touch interface, which may need to be reduced for optimal handling by this population. Results suggest that patterns of listening and skipping behavior could be used to as input to a filter or personalization profile (Pamplak & Widmer, 2005). Looking forward we are investigating implicit interaction methods such as reading body movement (Godoy & Jensenius, 2009) or facial expressions. (Kumari et al., 2015) A built-in camera could read facial expressions such as anger, disgust or happiness and a recognition filter could determine whether a song should be skipped or not. Accordingly, an in-built camera could read body movements such as calm or agitated based upon which a filter decides to skip or keep playing a song. This type of approach would have the most potential value for AD patients in the severe stage who may be unable to use even the simplest of direct interaction techniques.

One observed limitation of the current prototype is its cultural bias, as the selection playlist is based on the North American "top hits" lists. An interesting design challenge for such systems is a culturally neutral means of eliciting music preferences. However, the simplest approach in the meantime may be to develop a range of pre-generated playlists to accommodate the cultural diversity of the user population.

CONCLUSION

This preliminary study showed that a music player application with a minimal user-interface has the potential to be used independently by dementia patients. In general, study participants showed eagerness to learn the application and enthusiasm for listening to music with it. Further, the study showed that without asking study participants, care givers or family members, it was possible to determine their musical preferences based solely upon their interactions with a brief, predetermined music playlist. The results of this study will inform the next design phase of this prototype.

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