Motif: A Wearable Sonic Cueing Device for Memory Support and Cognitive Intervention

Fig.1 Motif Neckpiece
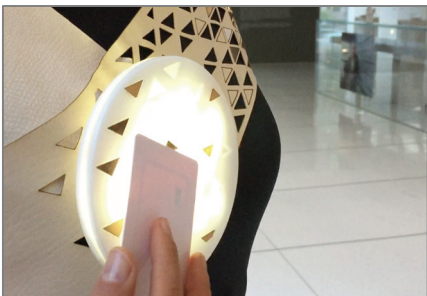

Fig.2 RFID Connection Triggering Light to Activate Signaling Start of Music

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Abstract

Alzheimer's is the 6th most leading cause of death in the United States, more lethal than breast and prostate cancer combined [1]. Currently, there are over 5.5 million Americans suffering from this disease. Inspired by this concept, we created Motif, a wearable device to support members of our society who need it most. Motif is an aesthetically pleasing, auditory cueing system for individuals at risk or suffering from Alzheimer's. By playing songs in response to particular people, places and situations, Motif is able to trigger memories and provide context. Patients at risk for Alzheimer's or individuals struggling with memory concerns can greatly benefit from this wearable musical intervention, to improve their wellbeing and quality of life.

Author Keywords

Wearable sonic device, memory support.

ACM Classification Keywords

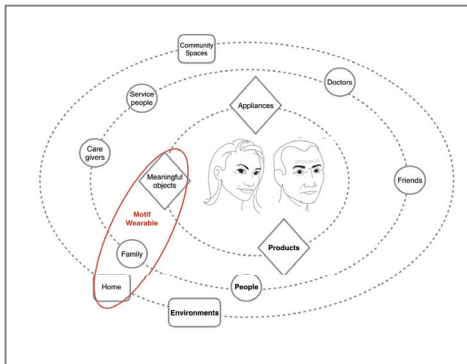H.5.2. User Interfaces: Auditory (non-speech) feedback.

Fig 3. Role of Motif in the Ecology of Aging

Fig 4. Earlier Prototype (5/4.5") vs final prototype (3.5/0.4")

Introduction

The Motif neckpiece is designed to allow elderly individuals at risk for or diagnosed with Alzheimer's to designate particular songs already associated with other people and locations. When loved ones or friends greet the wearer, approaching any of their RFID artifacts (via key-chain, ring or bracelet), their associated song will play, audibly cuing contextual memories for the individual wearing the neckpiece [Fig.1, 2].

Motivation

Three studies in particular support the creation and benefits of Motif. Firstly, a study conducted by H. B. Svansdottir Et Al. reveals music therapy to have the capability to reduce anxiety in patients with moderate to severe Alzheimer's disease and dementia, in a case–control study [2]. Another study, performed by Nicholas R. Simmons-Stern Et Al at Boston University in 2010, revealed patients with Alzheimer's performed better on a task of memory recognition when music was accompanying the exercise [3]. A third relevant study by Ayelet Dassa, PhD and Dorit Amir's 2014, showed "the role of singing familiar songs encouraged, connectedness, conversation and elicited memories" [4]. These studies reveal that the most difficult aspects of Alzheimer's disease: anxiety, lack of memory recall and decline in social interaction, can be directly alleviated by music. Individuals experiencing memory loss symptoms associated with Alzheimer's are able to recall personal narrative and contextual clues through hearing particular songs. This is because regions of their brain experience a greater level of connectivity when listening to music, allowing memories to become unlocked.

Project Concept

The Motif is a wearable neckpiece designed to give elderly individuals at risk or diagnosed with Alzheimer's a greater sense of extended cognition and wellbeing. As Svansdottir et al.'s study [2] revealed that the impact of music intervention in patients lasts only around 4 weeks post listening session. Therefore, the Motif is designed in the form of a neckpiece so that the intervention continually supports the wearer. Although there are numerous services, medications, and care plans designated for patients with forms of Dementia such as Alzheimer's, there are few interventions to improve the quality of life for individuals experiencing the symptoms accompanying these conditions. The highly-researched factors known to improve cognitive wellbeing in patients with Alzheimer's remain for the most part in research papers and do not become integrated into applicable models for clinical practice. The design of our product aims to maximize social connectedness by enabling wearers to record and associate some of their favorite songs with people in their social circle. Every time they encounter a caregiver or loved one, the designated song will play bringing them back to the original memory of how and when they met the person they're engaging with. With this design, we aim to work on prevention to help people in earlier stages of Alzheimer's to develop a series of habits and triggers supportive of memory maintenance.

Motif: Maintaining A Balanced Ecology of Aging

Extensive literature review and conversations with elderly individuals guide our design process. The term *ecology* is defined as a set of interdependent parts that feature particular relations within a system. For example, cultural ecology relates to the study of the symbiotic relationship between people and their social environment in anthropology [5]. This inspired us to consider how our design would fit in a senior's daily environment, allowing them to preserve their independence and identity [6]. Our project takes into account the role of products within the ecology of

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Brooch	Needs addressed Esteem Identity Recollection	Aesthetic core value Elegant Material Leather
Earrings	Needs addressed Esteem Self-Actualization Expression	Aesthetic core value Elegant Material Gold
Jewelry Boxes	Needs addressed Safety Belonging	Aesthetic core value Warm Material Wood
Scarf	Needs addressed Physiological Esteem Safety	Aesthetic core value Rich Material Textile
Watch	Needs addressed Physiological Safety Belonging Esteem	Aesthetic core value Functional Material Metal

Table 1 – Inspiration: Design Vocabulary of Everyday Objects for The Elderly

Fig. 5 Prototype Hardware

aging, as they play a vital part in maintaining a balanced way of coming of age. As seniors get older, it is common for physical and social spaces shift when they become unable to use certain technologies or reach out to other people in and they are no longer at the center of their ecology of aging. Our vision is that Motif can assuage or prevent these social imbalances by augmenting people's memory with musical references to various products, people and environments, which are defining elements of their ecosystem.

Using Music to Reduce Anxiety and Facilitate Memory
The most difficult aspects of Alzheimer's disease are the following factors: anxiety, lack of memory recall and the decline in social interaction [1,2,3]. The studies cited in this paper reveal that the implementation of hearing music directly reduces the three named symptoms to a highly notable degree. This research informed the creation of the MOTIF, a device which is able to provide musical integration for patients with Alzheimer's and Dementia in association with people, places and situations. The name is inspired by Wagner`s concept of "Leitmotif" meaning: a musical theme associated with a person, place, situation or idea [7]. The word "motif" itself indicates: "a dominant recurring idea or pattern." Knowing that individuals experiencing memory loss personal narrative and contextual clues through hearing particular songs, the MOTIF capitalizes upon this.

Intended User Base
A wide range of individuals can benefit from the Motif. Although initially targeted towards those concerned about memory loss due to Alzheimer's or other conditions, numerous studies and documented user-experiences reveal the multi-factor benefits of music for further conditions. While Motif is applicable as a memory cuing device for patients with Alzheimer's, individuals on the autism spectrum could rely upon it as a grounding mechanism during times of sensory overloads [8] if the Motif is programed to play a

soothing tone when individuals encounter typically triggering places or individuals - establishing routine and overriding symptoms of overstimulation. In individuals suffering from conditions such as PTSD, Motif could be implemented to increase grounding behaviors. Beyond this, the Motif form factor sheds light on creative learning interventions for several other conditions ranging from Williams Syndrome to Sensory Processing Disorders wherein music is shown to be effective.

Design
During our other studies in the fields of neuroscience and social robotics for aging in place, we interviewed more than a dozen seniors including those with and at-risk for Alzheimer's prior to building the prototype. Through user tests we quickly realized the importance of fading in and out the music so its entry and exit to and from the conversation is subtle and comfortable instead of jarring. Initial conversations such as this informed the pilot design which is currently undergoing user studies. We observed and analyzed a series of meaningful and evocative objects [Table 1] for seniors in order to draw both aesthetic and functional inspiration. We considered these elements of usability as well as the core aesthetic characteristics of wearable objects that are addressing elders need for dignity and control. This informed our decision to create a neckpiece that would be comfortable to wear on top of other clothes, with tones and colors that easily match most clothing. Like a scarf, it can be worn over, atop or just beneath jackets or backpacks. As presented the current design may appeal to a more feminine styling, however, the medallion format can be worn with a variety of straps to accommodate an array of preferences. We decided to prioritize an anthropometric fitting mechanism and have the medallion element of the neckpiece serve
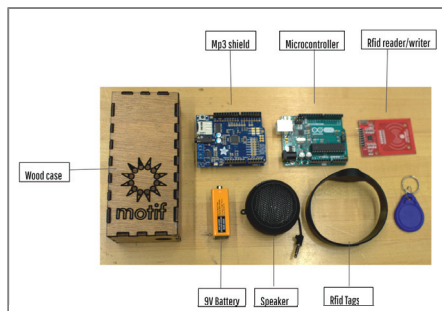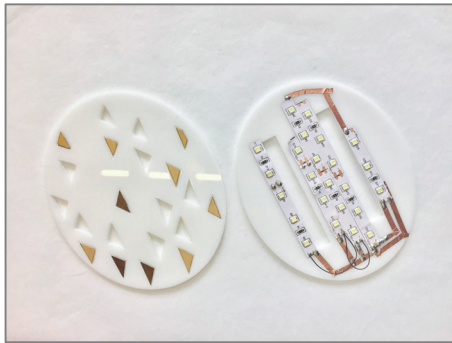
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Fig. 6 Outer Layers of Motif
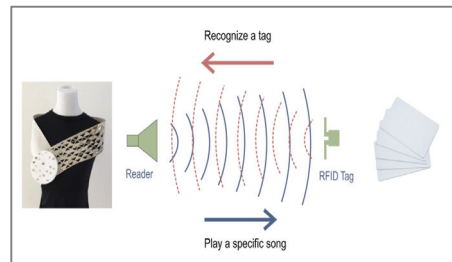

Fig. 7 Integration of Material

Fig. 8 Function Diagram

multiple purposes: enclosure with a belt-like adjustable mechanism; input: for card reading; output: for audio and visual signaling. The materials used were leather and white acrylic with the goal of creating both a noble and warm design. The fractal geometrical pattern symbolizes the idea of leitmotif, which represents one of our inspirations for the name of the project. The geometrical design continues from the leather band to the medallion as a symbol for how our piece enables the elderly to continue with their life by putting the pieces of their memory puzzle back together. The lights behind the medallion are diffused and discrete as the goal is to suggest shimmering when a card is detected. Music fades in and out slowly, as per our targeted users request. The lights can also be set to signal different states of the medallion such as: recording, low battery or unknown card for example.

Hardware

We started by building a first prototype [Fig. 5] with a common microcontroller board, an RFID reader/writer, an mp3 shield, a portable speaker a 9V battery and a series of RFID tags. The main reasons we opted for the RFID technology is because it would allow us to uniquely identify individuals consistently. As we are designing a wearable product, low power consumption is crucial so the wearer can enjoy the device for a sufficient amount of time. This is yet another advantage of the RFID readers as they have a reduced consumption of power. While power consumption and operating time are important factors in battery powered RFID readers, some of these parameters can be customized further in the firmware [10]. For the final prototype [Fig. 1] we used leather and acrylic as main materials and reduced the size of the medallion which is composed of four stacked layers. The bottom layer made of white acrylic serves the purpose of attaching the medallion to the shoulder band. The second layer supports a series of lights. The lights are connected

with copper tape and embossed into the transparent middle layer of the medallion [Fig. 6 ,7]. This allows for a homogeneous light diffusion on the side, which gave our medallion a very nice contour. The third layer is made of white light diffusion paper. The top layer continues the design of the shoulder band with triangles of different degrees of thickness, which create an effect of shimmering when the music is being played. The overall system is explained in the diagram [Fig 8]. The reader embedded behind the medallion is able to recognize different tags and trigger the speaker, which is positioned on the back of the wearer to play a specific song. When the user of Motif decides to record new songs, or sounds, they use a special card (attached either keys, worn as a bracelet or in a wallet). When this key card is read, the senior citizen can record audio for the next 10 seconds. RFID tags are passive and already well-integrated within society from our credit cards to badges and other appliances. They differ in ranges of activation but for the purpose of our project, we chose to use the most common type of cards, MIFARE tags. The maximal read/write distance between card and reader is 10 centimeters (3.9 in), but the actual distance depends on the field power generated by the reader and its antenna size [15].

Software

Our firmware was written in C and currently all the data and processing happens on the device. The song files are stored and recorded on a 14GB SD card hosted by the Mp3 shield. The RFID tags are addressed via an SPI bus interface. The SPI bus has three lines. These three lines are connected to 3 different digital pins on our microcontroller and the numbers of those pins are defined in our firmware. The devices are selected via the SS (Slave Select line) and each device needs a new line. In our design, we only have one reader so only one additional digital pin is necessary to select it. The current firmware (80 lines of code, 5KB) has three main functions: read, play and record.

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Tool	Interaction	Features	Focus
Wearable Memory	On Screen and On Body (flexible)	Autobiographical Memory	External Screen-Dependent
Senior Smart watch	On Wrist	Task Memory	Activity Support - Non-Private Reminding
ThermOn	Earphone/Headphone	Emotion Recall	Music and Emotion Interaction
Motif	On Body (flexible)	Autobiographical Memory, Contextual Memory, Task Memory, Emotion Recall	Symbiotic Cognition Enhancing Artifact

Table 2: Design Factors Framework

Fig. 9 Scanning of RFID card with Motif

Design Discussion

In the past decade, more researchers and designers are creating wearable tools for elderly individuals such as the Wearable Memory broach [11] made by the Cross-Cultural Design Lab at the University of Canberra. The Wearable Memory broach is a concept created to help elderly individuals recall autobiographical events. Loved ones and caregivers upload photographs and images of possessions, artifacts and places to the cloud. When the elderly wearer nears a compatible screen, a slideshow of pictures will appear. Similar to the Motif, the form factor takes into account anthropometric design, allowing the wearable to be comfortable for a diverse array of body types. Although the Wearable Memory device helps to trigger autobiographical memories, it does little to aid in contextual memory recall. For example, an elderly person may remember their own life story at a given moment, but would still wonder who has just entered the room. In consideration of this, the Motif plays specific sounds in relation to whom an elderly person interacts with and where they are at a given moment. When exploring wearables designed for elderly populations, it is important to examine one of the largest markets: namely wristwatch reminders. These smartwatches (such as Lively, UnaliWear and WatchMinder) designed for elderly individuals often feature the ability for individuals to record to-do's, tasks and medication reminders. As prior user studies and our interviews revealed that elderly people prefer to wear something around the shoulders we decided to design something that can be worn around the neck instead of the wrist [12]. Furthermore, many of the watches need to be connected to a computer to set specific alerts whereas the Motif is able to record audio on the go. Wearables connecting individuals to music and sound also have a standing presence in the world of design, in 2013 a ISWC paper about a design entitled ThermOn [13] presented a wearable thermal media system that enabled users to feel dynamic sensations triggered by changes in the music. As studies reveal that music strongly influences emotions, ThermOn seeks to increase this link via temperature changes to enhance a user's experience, similar to an animated visual that accompanies music. ThermOn combines these sensory components in a wearable format so users do not have to rely on screens to benefit from the experience. Similarly, Motif relies upon the wearable sound player and does not require external screens and visual aids. To examine the various wearables, we adapted a preexisting framework [14] that explores design factors in table format [Table 2]. This framework allowed us to imagine all the possible ways in which the Motif wearer may choose to customize the way they wear the medallion. This provides the wearer with flexibility as to which part of the neck the medallion would be placed, how it is worn (necklace style or "scarf fashion") and how long the strap should be such that he or she feels comfortable with other people approaching it with an RFID card to be read.

Conclusion

In our work, we highlight how the domain of wearable computing extends opportunities for individuals with mixed abilities and various neuro-diverse conditions such as Alzheimer's; stretching preconceived ideas on larger concepts such as aging. As our world is reaching an era (within the next 4 years) unlike any time in history, where people over 65 will outnumber young children under 5 [16], we turn our innovation towards designing for challenges pertaining to this population and groups facing similar concerns. Furthermore, we propose the use of wearables to actively channel facets of successful clinical research into user-friendly formats that increase patient compliance levels and effectively once in wearable form. We hope our design will bring a sense of playfulness and support into the lives of elderly individuals, while promoting a new wearable aesthetic for assistive technologies.

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