

# Dementia, Music and Biometric Gaming

## *Rising to the Dementia Challenge*

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ABSTRACT

In 2012, the U.K. government launched its Dementia Challenge, authorizing additional funding for dementia research and health care. The search for curative medicines is ongoing, but scientific research reveals evidence that music can play a positive role in general health, and in dementia and Alzheimer's disease in particular. This article considers whether some of the challenges that dementia presents could be addressed through music therapy and proposes that biometric gaming might offer one means of channeling such associated health benefits to sufferers of dementia, even in the final stages of the disease.

In 2012, the U.K. prime minister announced the launch of his government's Dementia Challenge, pledging a significant increase in funding for dementia research [1]. This announcement came one year after a rough-cut excerpt of the film *Alive Inside* [2] was posted on YouTube, which appears to present tangible video documentation of music's transformative power on a man suffering from advanced dementia [3]. Henry, the subject of the film, undergoes a remarkable change: At the start of the clip, he appears largely unresponsive, but by its end, he is highly animated and communicative, capable of answering questions, recalling favorite songs and even singing remembered lyrics. Remarkably, the only evident stimulus for Henry's dramatic reanimation is that he is listening to his favorite music.

The clip has become the focus of numerous online discussions, some advocating the therapeutic power of music [4] and others questioning the true catalyst for Henry's transformation. Developments in brain-imaging techniques and associated research exploring the complex interplay among music, memory, language, cognition, emotion, behavior and related topics are enabling strides toward a better understanding of the brain and its responses to music [5]. The findings of such research could be of direct relevance when

applied practically in the fields of dementia care and music therapy, but might there be other, less-traveled avenues to explore?

The 2014 NeuroGaming Conference and Expo in San Francisco offered a glimpse of the potential of gaming within the context of health and wellness [6]. Discussions there broached the possibility of using games as a means to detect a person's cognitive ability or memory. More particularly, participants mentioned dementia and Alzheimer's disease in relation to gaming, suggesting that biometric games [7] might potentially slow the progression of these diseases or some alleviation of their symptoms. The varied array of gaming hardware and sensors on display added gravitas to these conceptual plans. More generally, recent patent applications for commercial biometric gaming sensors show that the games industry is serious in its intention to explore the possibilities and wider applications of biometric gaming [8].

Perhaps there has never been a better time to explore the true potential of music's transformative power through an interdisciplinary synthesis of scientific and medical research, music therapy and game development. If such a synthesis could be achieved and made accessible to the general public in the shape of biometric games, some of which exploit the positive benefits of music and are designed specifically for sufferers of dementia, it might go some way toward addressing the aims of the government's Dementia Challenge. Admittedly, biometric gaming is unlikely to result in a cure for dementia or Alzheimer's disease, but if it could improve cognitive functioning and well-being or provide some relief of symptoms (even if only temporary), then research into this application surely deserves to be attempted.

### ADDRESSING THE DEMENTIA CHALLENGE

In the United Kingdom, approximately 800,000 people suffer from dementia [9]; in the United States, more than 5 million people live with the disease, which accounts for one in three deaths in the elderly population [10]. These sobering statistics demonstrate the scale and prevalence of the problem. Sufferers and caregivers face significant challenges: managing

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changing needs as the disease progresses; coping with the costs of care and associated resources; managing difficult or challenging behavior; avoiding social isolation; and maintaining a decent quality of life.

Music can play a role in addressing some of these challenges. Music therapy reports, case studies and scientific research provide tangible evidence of music's positive benefits in the context of dementia care. For example, such studies have shown reduced levels of agitation, anxiety and depression [11]; amelioration of problematic behavior [12]; and improved social conditioning and mood [13]. Some studies point to improvements in cognitive functioning [14] and specific types of memory recall [15]. Surprising additional health benefits have also been found suggesting that music therapy can result in enhanced parasympathetic activities [16]; reduced congestive heart failure [17]; and improvements in systolic blood pressure, as it has a homeostatic effect and helps to prevent heart and brain diseases [18]. A number of studies have suggested that music therapy can result in increased melatonin levels in the blood [19] and increased "natural killer" lymphocyte cells [20]. One particularly interesting study even proposes that listening to music facilitates neurogenesis—the regeneration and repair of cerebral nerves—by "adjusting the secretion of steroid hormones, ultimately leading to cerebral plasticity" [21].

Clearly a full discussion of such research is beyond the scope of this article, but there is undoubtedly enough evidence to assert that music triggers profound physiological and psychological changes and holds the potential to offer tangible benefits for people suffering from dementia and Alzheimer's disease. Our challenge is not only to research such evidence further but also to apply the research in practical and accessible ways for those living with the debilitating diseases and to intensify music's positive benefits in daily life.

Music therapists have considerable expertise and experience in the therapeutic application of music in dementia care; however, many people do not have access to music therapists, and those who do might have only infrequent or short-term access. For this reason, it is necessary to find additional ways to deliver music therapy's benefits to the general population.

## TECHNOLOGICAL DEVELOPMENTS

The popularity and proliferation of digital technologies and computer/video games indicates one route through which these benefits could be channeled. Although the development of enabling technologies to support those with disabilities and progressive medical conditions is not new, interest in health-related gaming is growing.

Recent developments include the Forest Project [22] (a virtual reality video game) and NeuroRacer (a driving simulation game). The Forest Project gives late-stage dementia sufferers interactive control of a naturalistic environment through simple movements and actions. By contrast, NeuroRacer is designed for healthy people between the ages of 60 and 79 and aims to improve memory, focus and attention [23]. Game developments such as these are not isolated; Simon McCallum and Costas Boletis's recent literature review of dementia-related games speaks of "a proliferation of

cognitive training, exercise and social games" targeted toward dementia, but they suggest that the dementia-related gaming field is still "uncharted" [24]. Their latter statement is even more applicable to music-based dementia gaming, a field in which few explorations have been made.

Currently, one of the few video games designed to exploit the health benefits of music or music therapy is MINWii, a simple music therapy tool developed for Alzheimer's and dementia sufferers. It allows users to play predefined songs and to improvise on a virtual keyboard, and its objective is to reduce behavioral symptoms that can lead to institutionalization. The developers claim that the game improves self-image, encouraging "renarcissization" [25]. Although interesting, the range of benefits offered by the game is limited in scope when compared to those detailed in the scientific literature on music therapy in general. Furthermore, the game also requires a certain amount of control and so might not be suitable for late-stage sufferers—yet the potential for other therapeutic biometric game applications increases exponentially for such patients, whose movements are uncontrolled, concentration is limited and normal interactions are difficult.

## BIOMETRIC GAMING

In the context of dementia-related games, a synthesis of music therapy and biometric gaming has yet to be attempted. If appropriately developed, however, such a synthesis might offer the possibility of interaction, emotional expression or communication without the necessity of physical movement, speech, physical game controllers, technological know-how, prior gaming experience or the ability to learn and remember new skills. In cases of advanced dementia, simple wearable devices might be used to provide some indication of stress, engagement, mood or emotional state, and caregivers could use such biometric data to offer customized music therapy treatments, improving well-being, quality of life and ultimately health. Wearable haptic [26] technologies might further enhance such treatments by providing tactile feedback based on the biometric data that the gaming system receives.

To realize such goals, developers and other researchers might explore a number of possible directions, ranging from passive approaches that require minimal active, conscious or creative user input to highly interactive systems requiring significant levels of physical interaction, active control and creativity.

### Passive Systems

For people with advanced dementia, biometric gaming apps could be linked to streaming music services or large pre-loaded sound or music banks, possibly organized by genre or sound classification. Devices such as smart watches or headphones with integrated sensors could capture biometric data and send it wirelessly to gaming apps, which could then use the data to control evolving and adaptive playlists that are designed to prolong positive reactions while minimizing negative responses. Over time, the app would create an increasingly personalized profile to govern the playback probabilities of audio assets. Ideally, music therapists, and/or family members would first input audio preferences or other

relevant data to inform the first playlist selections—but this would not be an absolute requirement for an adaptive system, since it could customize initial randomized playlists on the basis of biometric data alone.

Developers might extend such an approach to incorporate the use of visual stimuli, ranging from familiar and personally significant images to more general ones or to generated media, both ideally linked to corresponding audio assets. They could incorporate eye-tracking technology as a supplementary indicator of preference, perhaps through the addition of smart glasses [27].

### Active Systems

Developers could create active systems for less-impaired users. For example, music therapy sessions often place great emphasis on improvisation and the creation of music or sound through interaction with the patient or client. Active gaming systems could allow similar opportunities for audio creation within responsive and interactive gaming environments. Developers could create gaming systems for supplementary use by music therapists in therapy sessions; alternatively, stand-alone applications might capture some of the benefits of music therapy without the presence of a therapist.

In either scenario, the application might use biometric data to inform the therapist or the game engine of the player's physiological response to stimuli. Negative physiological responses might then be countered through appropriate therapeutic changes in the musical stimuli or game environment. Similarly, positive physiological responses could be reinforced. The application or therapist could also interpret biometric data as an indicator of audio preference or even map data to specific audio parameters such as pitch, volume, tempo, timbre, texture, harmony and so on, allowing physiological changes to shape musical outcomes within a game environment based on music therapy principles.

Additional inputs, such as motion sensors, built-in microphones or standard game controllers, could provide more opportunities for active and conscious interaction or improvisation, particularly if they are reinforced by the game's visual environment through audiovisual mapping. For example, an application could link pitch tracking to position coordinates, or speed of motion to tempo. Such approaches would allow the reciprocal manipulation of sound and image and generate a continuous feedback loop in which changing audiovisual stimuli could generate new biometric data, triggering further audiovisual changes in the game environment and generating new stimuli in turn.

In active systems that combine various types of sensors, the influence of particular sensors' inputs might be weighted

hierarchically according to the patient's level of impairment. For example, the therapist or application could give greater precedence to biometric data to accommodate significant levels of mental or physical impairment.

### THE BIOMETRIC DATA CHALLENGE

Despite the potential of such systems, the numerous challenges of interpreting and implementing biometric data within game play cannot be overstated [28]. How, for example, would an industry geared toward entertainment gain sufficient understanding of the complexities of physiological and psychophysiological responses to create systems that accurately interpret biometric data and implement meaningful changes via appropriate real-time feedback and interaction? Challenges such as these are further compounded by the fact that scientific studies examining physiological and psychophysiological responses to various stimuli can yield contradictory results. Nor are test subject responses universal—one shoe does not fit all. When developers seek to create biometric games for those with specific health conditions or diseases, such challenges are amplified still further: Ethical considerations take on new significance, and research, design and development must be adapted to the needs of those with physical or psychological impairments.

Nevertheless, if such developments were successful, biometric sensors and data might offer tangible and measurable ways to detect an individual's response to aural and visual stimuli in the absence of other indicators, and these systems could provide caregivers and therapists with custom interactive treatments through the use of music and images—even in the final stages of disease. Such targeted treatments, or “gaming entertainments,” could also offer transferable health benefits to the general population, piggy-backing on the development of biometric technologies designed for commercial gaming applications.

### CONCLUSION

We conclude where we began: with the remarkable transformation of Henry, a man brought vividly to life through his love of music, momentarily freed in mind and enlivened in body. Imagine if we could extend such experiences by adding unobtrusive biometric devices that measure responses to inform playlist preferences or by delivering customized, “on-tap” music therapy treatments in response to changing needs. Achieving these goals depends upon our political will, research funding and interdisciplinary collaboration, and some of these necessary pieces are now falling into place. The challenges are significant for those at the coal face of such developments, but so, too, are the potential rewards.

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### References and Notes

- 1 See <[www.alzheimers.org.uk/site/scripts/documents\\_info.php?documentID=1886](http://www.alzheimers.org.uk/site/scripts/documents_info.php?documentID=1886)>.
- 2 Michael Rossato-Bennett, *Alive Inside* (Music and Memory, 2014).
- 3 For a YouTube clip of *Alive Inside*, see <[www.youtube.com/watch?v=fyZQfop73QM&list=UUWSWoVyPUvG8dfc9VtFQRg](http://www.youtube.com/watch?v=fyZQfop73QM&list=UUWSWoVyPUvG8dfc9VtFQRg)>.

- 4 For introductory overviews on music and health, see <[www.emedexpert.com/tips/music.shtml](http://www.emedexpert.com/tips/music.shtml)> and <[www.netdoctor.co.uk/healthy-living/wellbeing/health-benefits-of-music.htm](http://www.netdoctor.co.uk/healthy-living/wellbeing/health-benefits-of-music.htm)>. For specific examples of research related to music and dementia or Alzheimer's disease, see below in Refs. [11–15,17–21].
- 5 For a brief overview of recent developments, see <<https://voices.no/index.php/voices/article/view/742/637>>.

- 6 For further information, see <[www.neurogamingconf.com](http://www.neurogamingconf.com)>.
- 7 *Biometric gaming* refers to games that use sensors that are placed on the body of the player to measure physiological responses. The resulting data are then fed back into the interactive game environment, triggering adaptive changes in the game.
- 8 Typical biometric data that can be captured by current devices include galvanic skin response (a measurement of the electrical conductivity of the skin), heart rate and electrocardio data (via electrocardiogram, or ECG), the electrical activity of the brain (recorded in electroencephalography, or EEG), eye tracking, blood pressure and core temperature.
- 9 See <[www.alzheimers.org.uk/site/scripts/download\\_info.php?fileID=1677](http://www.alzheimers.org.uk/site/scripts/download_info.php?fileID=1677)>.
- 10 See <[www.alz.org/alzheimers\\_disease\\_facts\\_and\\_figures.asp#quickFacts](http://www.alz.org/alzheimers_disease_facts_and_figures.asp#quickFacts)>.
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- 16 *Parasympathetic system*: a part of the autonomic nervous system. Sometimes referred to as the "rest and digest" system.
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- 19 A.M. Kumar et al., "Music Therapy Increases Serum Melatonin Levels in Patients with Alzheimer's Disease," *Alternative Therapeutic Health Medicine* **5**, No. 6, 49–57 (1999).
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- 26 *Haptic*: relating to the sense of touch. Current developments in haptic technology include products such as touch screens, gaming vests and gloves, all designed to give facility to game play.
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