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Tackling the Challenge of the Aging Society: Detecting and Preventing Cognitive and Physical Decline through Games and Consumer Technologies

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Objectives: This study seeks to review some of the approaches employed to address health and well-being issues in the elderly population. **Methods:** This article reviews and analyses a range of projects and approaches designed for the elderly population and aimed at preserving and/or enhancing physical and cognitive capabilities in later life. **Results:** Various intervention measures have been developed across the globe to preserve and/or enhance physical and cognitive capabilities of the elderly population. A selection of these measures is described in this article. **Conclusions:** Approaches which combine games psychology and mechanics with enabling technologies designed to engage, influence and motivate elderly people can encourage healthy active aging lifestyles. Healthy active aging helps to realise a double dividend of reduced healthcare costs and an improved quality of life for the elder citizen.

Keywords: Aging, Cognitive Therapy, Exercise Therapy, Technology, Aged

I. Introduction

The aging society is a phenomenon which relates to the rising median age of the population as a result of declining fertility rates and/or increased life expectancy [1]. This phenomenon was first experienced in developed countries where life expectancy has increased because of a combination of higher standard of living, better quality of life and improvements in medical technology, diagnostics and treatment. It is an effect which is now becoming more ubiquitous in less economically developed countries.

Almost every country in the world, regardless of level of development, is facing a future in which the median age of the population will continue to increase [2]. Today, the median age of the world's population is the highest in mankind's history [3]. It is projected that the number of people in the world defined as elders (age of 60 and over) will reach 2.1 billion by 2050 [4,5]. This will drastically increase the dependency ratio.

As the median age of the population increases, with a growing percentage of the total population over the age of

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60, it also means that the percentage of the total population who are in employment and economically productive will decline. In simple terms, it will mean that there will be fewer and fewer working people supporting more and more retired and unemployed people. Therefore, it is not difficult to anticipate that the ratio of employed people under the age of 65 to retired people over the age of 65 will fall substantially, whilst the dependency ratio increases. Research [6] predicts that, in China, the number of working age adults for each person aged over 65 will fall from 7.9 in 2010 to 1.6 in 2100 and in India the ratio will fall from 11.0 to 2.1 in the same period. Conversely, in the United States and the UK, the fall is predicted to be less dramatic, at 4.6 to 1.8 in the United States and 3.6 to 1.6 in the UK. Despite a lower dependency ratio changes in the latter, the health care cost implications are much higher than in the former.

Clearly, these demographic changes, accentuated by various predictions about the impact of technologies like robotics and artificial intelligence, mean that the falling numbers of employed 'economically productive' people will face substantially increased burdens in supporting the population of unemployed 'non-economically productive' people, causing potential societal disruption and forcing fundamental policy changes in areas such as formal retirement ages and pension provisions. To reduce the aging burden in most European countries the retirement age is already increasing from 65 to 67–69 years.

The impact of the aging population on society is further augmented by the fact that, as people get older, they are more likely to require medical interventions for both physical and mental health problems such as frailty, COPD (chronic obstructive pulmonary disease), cardiovascular problems, mobility, cancer and dementia. The resources required to support and care for these problems under the conditions of established welfare systems with a public finance safety net will therefore come under increasing pressure.

In the United States in 2010, the amount of healthcare spending on senior citizens aged over 65 averaged $18,424 per person. The spending per elder is about five times the amount per person as the amount spent on children and three times the amount spent on working-age adults. The elderly over the age of 65 accounted for 13% of the population but 34% of healthcare-related spending [7].

It is against this background that this article seeks to review some of the approaches to addressing health and well-being issues in the elderly population aimed at preserving and/or enhancing physical and cognitive capabilities in their later life. Healthy aging reduces care resources utilization resulting in a double dividend of lower healthcare costs and higher quality of life for elderly people.

II. Serious Games and Health Applications

The expression 'Serious Games' refers to the Wikipedia definition [8]: "A serious game or applied game is a game designed for a primary purpose other than pure entertainment. The 'serious' adjective is generally prepended to refer to video games used by industries like defence, education, scientific exploration, health care, emergency management, city planning, engineering, and politics." The phrase is often attributed to originate from the development of a video game called 'America's Army' [9]. This video game was originally funded by the American Military with the intention of targeting young people for a recruitment strategy. The rationale was that simulating what it was like to be a soldier in an entertaining video game would help to make a career in the army more attractive and hence boost new recruit applications.

America's Army helped to stimulate an awareness that video games and simulations could play a major role in training scenarios which could cost effectively prepare soldiers for combat and emergency situations without some of the costs and risks involved in recreating realistic real-world models. It has been this combination of reduced costs and risks that has tended to shape the sectors in which serious games have had the biggest focus of attention. Games provide an environment in which experiential learning can take place without placing the participants or subjects in danger from the consequences of mistakes [10].

For these reasons and also the fact that, especially in emergency situations, it can be impractical or impossible to recreate a real-world scenario, early serious games and simulations came to be developed for many military and medical scenarios. One of the earliest examples of a research project aimed at evaluating the effectiveness of video game simulations compared to existing methods was a serious game called 'Triage Trainer.' This serious game simulated the effects of a terrorist bomb in a city centre with casualties with different degrees of injury. Control groups of paramedics responding to this virtual scenario were evaluated against colleagues going through traditional training with mannequins and those trained using 'Triage Trainer' achieved better learning outcomes, primarily because they felt more engaged in the scenario [11].

As the technologies and mechanics used in video games have become more sophisticated and mobile devices such as

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smartphones and tablets have become more ubiquitous, so the range and diversity of video games and simulations has expanded across all demographic groups. In addition, wearable and embedded devices have enabled the integration of real-world data within games environments to provide mechanisms which influence behaviours that are health-related. Many serious games have been developed to address a variety of medical challenges including obesity, sexually transmitted diseases, phobias, autism and attention deficit disorders.

This paper focuses on those serious games and applications designed to influence physical and cognitive well-being amongst the elderly population.

III. Serious Games and Cognitive and Physical Well-Being

Measuring physical and cognitive well-being and being able to clearly identify and manage the factors which most influence physical and cognitive well-being have attracted researchers' attention. As an exemplar, the National Centre for Sports Exercise and Medicine East Midlands (NCSEM-EM) has been working on sets of protocols designed to not only assess physical and mental well-being but also to assess the impact of different interventions on well-being [12]. This research indicates a positive link between physical activity amongst the elderly and both physical and cognitive well-being in this age group. In addition, 'fun' and 'social contact' were identified as important contributors to engagement and motivation.

The role of games and game mechanics to engage and motivate the elderly has been explored in various countries [13-15]. This review discusses some of the approaches taken and findings. 'Serious Games' is a discipline which researches and explores the potential of the technologies and methodologies employed in the consumer video games industry to address 'non-entertainment' issues such as education, health and the environment effects [16-18]. In particular, the use of games mechanics can not only engage, motivate and influence behavioural change [19-22] but can also be used as an indicator of and determinant of physical well-being [14-16,20,23] and mental health [14,17]. This review looks at some of the projects where games mechanics [13], psychologies and technologies have been applied to the some of the most common health and well-being issues within the elderly population.

1. Dementia and Cognitive Well-Being

There are over 46.8 million people worldwide with dementia. This is predicted to increase to over 75 million by 2030 and over 130 million by 2050. Research about Alzheimer's disease in UK indicates that around 1.3% of the population (850,000 people) suffers from dementia, and this figure is projected to rise to over 1 million by 2025 and to over 2 million by 2050 [24]. The vast majority of dementia sufferers (over 800,000) in UK are over the age of 65, and they are supported by around 700,000 informal carers. Also, it was reported that dementia is the leading cause of death in women in UK.

Dementia costs UK economy over £24 billion a year, this is a combination of health and care costs and the vast contribution made by informal carers. Caring for each person with dementia has an economic impact of almost £28,500 each year. By 2025 it is expected dementia will cost UK economy £32.5 billion and by 2050 it could be costing UK economy £59.4 billion at today's prices. Globally it is estimated that dementia costs the global economy over $818 billion each year [24].

A taxonomy of 'Serious Games' for dementia analysed a number of serious games used to influence the impact of dementia on potential sufferers, carers and health professionals [25]. This taxonomy categorised the serious properties of commercial games according to their usage for prevention, rehabilitation, education and assessment. In the study, none of the games identified sought to address the aspect of dementia assessment.

Whilst research into the impact of mental exercises on dementia, memory loss and Alzheimer's disease is still ongoing, there are indications that mental exercises and challenges can not only help to delay or lessen the impact of dementia, they can also help affected individuals to better manage daily tasks. Projects such as the European DOREMI (Decrease of cOgnitive decline, malnutRition and sedentariness by elderly empowerment in lifestyle Management and social Inclusion) initiative [26] have been developed to explore the potential of serious games to not only encourage physical and mental activities and thereby facilitate healthy aging but also to monitor and assess physical and mental capabilities for the benefit of patients, carers and medical professionals.

The European (and Global) challenges [27] that the DOREMI seeks to address are directly related to the future demographics that this review has identified. The serious games deployed within the DOREMI use a tablet computer loaded with a series of intuitive games challenges which mimic those embedded within traditional activities enjoyed by older people such as simple memory tests, arithmetic tests, jigsaw puzzles and pattern recognition tests. The speed and accuracy with which users play these games is used to

score performance and encourage progress to higher levels. Players are motivated to complete games via a visual reward system based on taking a pet round different cities. Other mechanics included in these tablet computer games are designed to detect any decline in cognitive ability and provide feedback to both carers and clinical professionals providing remote care. The DOREMI project also seeks to encourage physical activity, healthy eating and socialising through the combination of games and wearable technologies.

2. Physical Exercise and Well-Being

As citizens get older, their level of physical activity tends to decline. There are many physiological, psychological, environmental and social factors which can influence the level of physical activity. Research has reported that physical exercise such as walking has a beneficial effect on both physical and mental well-being [28-30].

There have been a number of studies to explore the potential of games to encourage walking and to combine walking exercises with cognitive exercises [31-33]. Well-designed computer and Internet games can also provide positive benefits through perceived improvements in personal strength and control which can lead to a reduction in incidences of depression [17,32]. Integrating physical exercise with cognitive exercise challenges in a context which is both familiar and engaging to older people can reduce cognitive impairment and depression amongst the elderly [17,32,33]. For example, 'Rejuvenesce Village' is a virtual environment used to recreate the experience of shopping [33]. By 'walking' on a pressure sensitive mat and using hand-held sensors, players can control a virtual character and complete a series of everyday tasks based on shopping.

Similar games have been developed in Europe to encourage and monitor physical and cognitive ability, not just amongst the elderly but also for rehabilitation from strokes, accidents and medical conditions such as Parkinson's disease. "Rehab@Home" is an exemplar, which resulted in a commercial product called 'Rehability' [34], and this is now being trialled successfully in different European Clinics and care homes in South East Asia [35].

Healthy aging can be considered a challenge for many countries with significant shares of elderly people [36,37]. The economic implications of population aging in Europe, China India and US are studied intensively [36-40]. Healthy aging diet, aging adjusted nutrition and physical fitness and other preventive measures are recommended to cope with aging [41-43].

Around the globe, there are many other examples of serious games designed to influence physical and cognitive well-being and examples include the Walking Game (Paldokangsan3) [44]. This game used a Microsoft Kinect Games Controller, special 'walking board' and an immersive visual display screen. The objective of this serious game was to encourage walking by creating a virtual world environment which elderly people could explore using the walking platform and controller to navigate.

Another example of the use of serious games to tackling cognitive decline amongst the elderly is the European funded Eldergames Project [45]. A consortium of partners created a portfolio of video games designed to function on a specially adapted touchscreen in a care home for the elderly, providing a selection of games which both entertained and stimulated the participants. These games, like those in the DOREMI project, were well received and enjoyed by the participants. The challenge lies in verifying the clinical effectiveness of these interventions and gaining adoption amongst mainstream users to not only maintain and/or improve physical and cognitive well-being amongst the elderly, but also to provide valuable insights into the factors which influence Dementia.

IV. Discussion

The review of some of the approaches employed to address health and well-being issues in the elderly population shows evidence of a number of linkages. Various measures such as fall prevention, diet, adjusted nutrition, physical fitness, game technologies and walking exercise are aimed at preserving and/or enhancing physical and cognitive capabilities in later life. They are effective in reducing economics and social costs of aging. Hence, healthy aging which results in a double dividend of reduced cost of healthcare and improved quality of life for the elderly people is an optimal approach to face the challenges of aging.

Further research is necessary to identify what type of technologies promote healthy lifestyle behaviours, what parts of serious games increase health promotion and which one, either entertainment-based or educational-based approach is more popular, engages long-term behavioral change, and elevates player motivation [15,18,20,46]. It is also suggested to develop research designs incorporating standardized protocols to increase the scientific rigor of clinical evidence and the effectiveness of interventions for health behavioural change [14,31,46]. This effort will translate evidence-based interventions to gaming-based approaches successfully [20,46].

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It does seem clear however that the rapidly maturing technologies associated with artificial intelligence, cloud computing, data analytics, Internet of Things, data visualization and mobile devices hold significant promise for creating an ecosystem of partnerships within and outside the medical profession to tackle the aging society issues identified into this paper.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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