Exergames for Assessment in Active and Healthy Aging
Emerging Trends and Potentialities

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Abstract: This paper articulated the position, based on literature research findings as well as experiences and considerations, of the authors regarding the role of exergames in stealth cognitive assessment. The conclusions presented therein are based on a long and lasting experience of design, implementation and piloting trials with seniors over the last six years. They are also supported by literature findings concerning exergames' engagement, acceptance, perceived usefulness and ease of use. The authors express a positive outlook regarding the role of daily exergaming programs regarding their capacities in stealth assessment. Furthermore, it is postulated that additional research efforts should focus on providing even more concrete, evidence based arguments for convincing researchers and clinicians of the potential clinical value of exergames in terms of cognitive assessment.

1 INTRODUCTION

Independent and healthy lifestyle of elderly population has become an increasingly important social issue, due to the increase of population age across developed countries. It is documented that regular physical activity is essential for healthy aging (Chodzko-Zajko et al., 2009) in terms of physical (Konstantinidis, Billis, et al., 2014) as well as cognitive health (Lautenschlager et al., 2008; Angevaren et al., 2008).

Exergames, which have been in focus of an increasing number of research efforts, are technology assisted solutions engaging the elderly in physical exercise or activity through gaming. They aim to motivate seniors to get involved in either physical activity or physical exercise and, hence, promote a more active lifestyle, through gaming (Konstantinidis, Billis, et al., 2014). Towards this end, the emergence of studies measuring exergaming platforms' usability for seniors led to proper design implications, recommendations and guidelines for exergames (Konstantinidis, Billis, et al., 2014).

Beyond the obvious physical benefits of exercise, exergames demonstrated positive changes in mood (Kirk et al., 2013; Gerling et al., 2012), socialization (Gerling et al., 2011; Velazquez et al., 2013), and confidence in everyday functional activities (Rendon et al., 2012) as well as overall quality of life improvement (Chodzko-Zajko et al., 2009; Rosenberg et al., 2010).

Serious games for elders, which are games designed for a primary purpose other than pure entertainment aimed at a senior target group, focusing either on cognitive or physical training, are deemed either preventive/therapeutic interventions or assessment oriented tools (McCallum, 2012). Specifically, recent neuroscientific studies provided increased evidence on the protective effects of cognitive and physical training with regards to cognitive decline and dementia (Bamidis et al., 2014). On the other hand, serious games, especially cognitive games, are considered as potential assessment tools by emulating pen and paper assessment tests (Hagler et al., 2014) or by encapsulating cognitive tasks in a game-like interface (Jimison et al., 2010; Jimison and Pavel, 2006; Tarnanas et al., 2014). The integration of these assessment techniques in the games, in a way that the player is unaware of, is defined as stealth assessment (Shute, 2011).

However, exergames only recently gained the attention of researchers as cognitive status assessment means. Virtual environments, simulations of daily activities and daily usage exergames have just emerged, exhibiting promising findings (Tarnanas et al., 2013; Zygouris et al., 2014).

From the previous exposition it appears that the

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potential assessment aspect of exergames is only starting to be investigated so far. There are not yet design guidelines or even suggestions about assessment through exergames, apart from the general rule for successful assessment through serious games: participation in the game.

On the other hand, the number of research efforts on the assessment aspects of exergames is not large enough to convince the research community for their value in the field. Corresponding findings can be deemed as indicators about the potential value of exergames but not as evidence. Additionally, the role of serious games has been debated over the last few years. A large number of commercial or custom exergaming platforms, which have been utilized by seniors, are not tailored to them. Therefore, as it is stated in previous work of the authors (Konstantinidis, Billis, et al., 2014), they present a significant learning overheads and entrance barrier for the elderly users, which, in turn, reduces their overall efficacy.

In line with this, Robert et al. reported poor academic and professional acceptance of serious games (Robert et al., 2014). This is based on the fact that serious games are viewed by many researchers and clinicians as expensive toys gaining no scientific and clinical credibility (Anon, 2014). However, the acceptance of serious games as tools for new treatment options, is slowly starting to take root (Robert et al., 2014).

In the following section (section 2) we present the arguments about the value of exergames as stealth assessment tools based both in the literature and in the authors' experience in the field. We close this work in section 3 with some concluding remarks.

2 EXERGAMES FOR ASSESSMENT

2.1 Exergames for Stealth Assessment

Aerobic exercises are presented as a promising tool for physical health assessment in exergames by measuring indirectly the caloric expenditure and heart rate (Staiano and Calvert, 2011). In the same notion, the perceived exertion scale (Borg, 1982) could estimate the senior's effort since it is directly correlated with the heart rate. In addition, a large research effort on assessment in exergames focuses on fall risk. In-game performance metrics, like movement and response time (Pisan et al.. 2013), step length (Garcia et al.. 2012) and grip strength are used towards fall risk assessment or even early signs detection of frailty (Zavala-Ibarra and Favela. 2012).

Beyond physical status assessment, only recently, exergames dealt with cognitive assessment. Virtual environments (Tarnanas et al., 2013; Zygouris et al., 2014) as well as daily usage exergames (Konstantinidis et al., 2015) have recently turned towards assessment. Some of these works correlated significantly in-game metrics with standard clinical screening and assessment tests. However, it should be kept in mind that the nature of these games requires extra effort towards cognitive assessment rather than physical status assessment.

2.2 Exergames Are More Engaging than Cognitive Games, Thus More Efficient for Stealth Assessment

Participation to serious games is the main rule for successful assessment. According to the technology acceptance model (Davis, 1989), which has been developed to explain ICT use, perceived usefulness (PU) and perceived ease of use (PEOU) are the primary determinants that affect use attitude. Therefore, the fact that physical exercise's effects are observable by the seniors after a very short period of training, in conjunction with the immediate positive mood changes after physical activity (Kirk et al., 2013; Pierce and Pate, 1994; King et al., 2000), emerge the potential of a strong perceived usefulness factor of exergames (c.f. Figure 1).

The authors' experience concurs with that. Wide pilot trials, in terms of time (2 months) and participants (116 seniors), of the FitForAll (Konstantinidis, Billis, et al., 2014) platform demonstrated this. This platform encapsulated the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) protocols, guidelines and recommendations regarding the exact type and intensity of elderly exercise regimens (Chodzko-Zajko et al., 2009). The pre- and post-intervention Fullerton physical status assessment provided clear evidence that integration of these recommendations led to an overall physical status improvement of the seniors. Besides that, the vast majority of the participants reported that they felt their body more light weighted, increased sleep quality and that they performed daily activities with greater flexibility even after a small period of exergaming sessions. Most of them reported that although they had felt bored to follow an exergaming regimen before participating in the first sessions, they were happy to follow the daily regimen. Seniors' adherence to the daily schedule, and thus to the

physical exercise protocol schedule, reached 82%. Moreover, 85.4% of the seniors reported that they perceived the FFA platform as allowing them to control their health better. Thus, the incorporation of existing, established physical exercises during design and implementation of exergames could serve as an additional guideline for their design.

On the cognitive games axis, the effects in cognitive function, could be observed only after long term training. As an indicative example, Minge et al. reported the results of a focus group among seniors where serious games were rated as possibly helpful (Minge et al., 2014). To this end, authors observed that seniors tend to undertake cognitive games because they have been told that they are helpful for their cognition contrary to exergames of which the effects are immediately observable in their daily life. Some of the seniors' response when they were asked about exergames, were: "*Better mobility. It helped me with the pain on my back and on my joints. I lost weight. I fall asleep more easily*". When they were asked regarding the cognitive games they responded: "*I like these games because they will help my memory. I believe that they will help me against dementia*". This delayed emergence of cognitive games' perceived effects (as denoted by the testimonials' future tense and qualifiers) may not be able to sustain the initial games' engaging factor introducing a larger dropout risk since the participants might not reach the time threshold of its perceived usefulness. On the contrary, exergames' more immediate effects could be complementary to the initial motivation which stems from the joyful experience of the "gaming" component (Konstantinidis, Billis, et al., 2014; Brox et al., 2011; Shubert 2010). Finally, there is a trade-off on the efficiency for stealth assessment (exergames) and the accuracy of stealth assessment (cognitive games).

2.3 Exergames Acceptance and Participation

Regarding perceived ease of use, recent technological advances and services that support controllers utilized by exergames (e.g. Kinect, Balanceboard, etc.) (Konstantinidis, Antoniou, et al., 2014), led to rich internet applications available to contemporary devices like SmartTV, tablets and smartphones. Studies have shown that these devices are far more useful to elderly users for access to internet based services (Werner et al., 2012). Moreover, the ease of access provided by these devices, far outweighs the lack of versatility in comparison with traditional computer systems. Therefore, barriers in participating to exergames due to technology constraints (PC usage, etc.) have been lifted in the last years. More specifically, the Kinect smart TV combination could be deemed as a natural interface for exergaming. To the authors' experience (Konstantinidis, Billis, et al., 2014), the seniors reported that 5 days familiarization with the exergaming platform were enough for feeling that have mastered the platform. On the other hand, when the exergames utilized by the seniors by means of Kinect gestures and postures through a smart TV, the seniors reported that they needed 4 days for the same feeling.

2.4 Carefully Designed Features Increase Stealth Assessment Quality and Accuracy

The authors' experience during the design and implementation of FitForAll as well as during the intervention trials, the data analysis and the literature research led to a number of design recommendations for exergames which have bearing on assessment.

- Designing and incorporating proper in-game stealth assessment is a challenging (Bellotti et al., 2013) process. However, the value of its outcome denotes it as a promising component of serious games and justifies the extra effort.
- Exergames should be tailored to the elders in order to secure increased adherence.
- When serious games are utilized for assessment of elders not familiar with the technology, a short learning period is required. Assessment during this period reflects also familiarization and initial perception of components.
- High resolution monitoring, incorporating as much as reasonably acquirable information as possible, provides opportunities for data mining towards new design recommendations.
- Exergames could incorporate games that motivate users to perform tasks identical to those in standard assessment tests both in the cognitive and in the physical domain
- Cognitive tasks should be required during exergames but without overloading the elders.
- Open policies for exergaming data accompanied by semantic markup have to be provisioned inherently in future research.
- Twin scope exergames, focusing both to prevention and assessment, is feasible. A game's daily session could be divided in long training periods and short assessment periods with less physical intensity (focus on cognitive assessment) so as to avoid cognitive overload

and to prevent overexertion and wrong pacing (Gerling et al., 2012).

- A very simple assessment task, which could be representative of the elders' daily mood and cognitive function (e.g. reaction time), should be included in the beginning of the serious game in order to provide a baseline for each daily session.

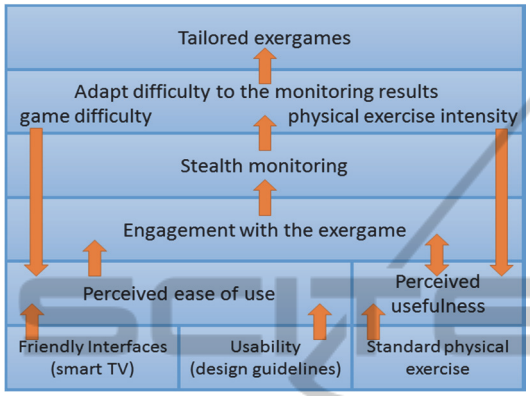

Figure 1: Perceived ease of use and perceived usefulness are greatly affected by the exergame's interface and its physical exercise intensity. Both of these factors have to be tailored to the seniors in order to ensure engagement with the game and consequently stealth monitoring.

2.5 Screening Games versus Exergames

Virtual environments have entered in the field of the cognitive assessment. Walking on a treadmill visualized as a stroll in a virtual environment (Tarnanas et al., 2013; Tarnanas et al., 2014), or trying to accomplish some daily tasks (Zygouris et al., 2014), were exploited as screening games with promising results as such. However, the very fact that these games are administered as screening games and not as daily usage games may open them to the same vulnerabilities as conventional clinical assessment. Clinical cognitive screening is not part of the elder's lifestyle (Jimison et al., 2010). Besides this, seniors have strong motivation to do well on cognitive screening tests, to prove that they are not suffering from cognitive decline, to avoid social stigma (McKanna et al., 2009). Moreover, day to day variations in performance can confuse the diagnosis for a significant time periods (McKanna et al., 2009).

Contrary to that, as discussed above, exergames are adoptable by seniors in daily life. Due to that temporal immediacy, the aforementioned vulnerable points are negated. There is, of course, a trade-off on the accuracy of the cognitive assessment of exergames which is undergoing research. Preliminary results of the authors' work reveals a classification accuracy among healthy, people with mild cognitive impairment and mild dementia over 70% (Konstantinidis et al., 2015). This accuracy level, with respect of the fact that the seniors did not consider exergames as monitoring tool (Antoniou et al., 2015), turn out to be a promising combination in accordance with the Plato's statement "...you can discover more about a person in an hour of play than in a year of conversation...".

2.6 Exergames in Light of Healthcare Cost Reduction

The absence of an effective treatment against cognitive decline denotes the early administration of the available treatments as the more efficient approach (Gauthier, 2005). An unobtrusive and low cost tool that could contribute to early detection of cognitive decline symptoms could provide opportunities for early administration of available treatments at a time that they may be more effective (Jimison and Pavel, 2006). Such a system could contribute to the delay of cognitive decline onset, since it is already well documented that physical exercise is a preventive intervention for it (Bamidis et al., 2014). Moreover, exergames that could be used by the seniors themselves in their home would contribute to the insurances' and public healthcare system's cost reduction (Robert et al., 2014). To this end, the financial benefits and costs of serious games with prevention and screening aspects must be measured in conjunction to the value of timely and correct diagnosis (Borson et al., 2013).

3 CONCLUSIONS

This position paper aims to provide some food for thought about exergames and their role in cognitive assessment in conjunction with their primary scope which is physical training. Both literature findings and the authors' experience substantiate the claim that exergames will continue to remain in the focus of research within the next decade. Additional research efforts should be put on providing evidence based arguments for researchers and clinicians about the potential clinical value of the exergames as means of assessment.

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