Applying game thinking to slips, trips and falls prevention

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1. Introduction

Gamification is about the way in which 'game thinking' can engage participants and change behaviours in real, non-game contexts. Over the last decade it has been increasingly applied in a variety of contexts supporting environmental and social goals and there is some evidence that gamification can contribute positively to learning new behaviours. However, the evidence is mixed, context dependent and short-term [1,2,3].

There are calls for gamification to be applied in interventions designed specifically for and with older adults to facilitate healthy living and improve quality (and quantity) of life [4]. Slips, trips and falls (STF) are the largest cause of accidental death in older people across Europe with 30% of people aged 65 and older, and 50% of people aged 80 and over, falling at least once per year [5]. There is good evidence that exercises aimed at improving balance, muscle strength and power – if intensive, progressive and continued – can reduce falls [6,7], but there is low adoption and adherence to exercises in the home [8]. Improved awareness of home hazards and modifications has also been found to reduce falls, particularly in those with a history of falls [6,7]. Applying game thinking can potentially help to prevent STF, both directly and indirectly, and in doing so attenuate the high economic, social and psychological costs associated with treating and rehabilitating older people who have fallen.

Drawing from our own experience, the aim of this paper is to outline an innovation process for a gamified intervention to prevent STF. The user-centred, engaging, collaborative and rapid innovation process presented echoes Fleming et al's [9] call for a paradigm shift in digital interventions for health. The paper contributes to the assistive technology, digital health and computer science/human behaviour communities by responding to a gap in the literature for papers detailing the innovation process of developing interventions to improve health and quality of life [10,11,12]. The aim of the paper is of interest to the many stakeholders involved in enabling older people to live independent, confident, healthy and safe lives in the community.

2. Background: the challenges of applying game thinking to digital health

Gamification potentially offers a way to influence user behaviour and lead to improvements in quality and quantity of life. Ahola et al [13] argue that digital health interventions, especially in the form of games, may be more effective than other methods for improving health outcomes due to their ability to engage and interact. After education, 'health and wellness' has received the most attention in the gamification academic literature [3]. Previous gamified interventions have targeted a variety of conditions such as diabetes [e.g.14,15,16], obesity [e.g.17], pain [e.g.19], rheumatoid arthritis [e.g.20] and heart health [e.g.21], and promoted better general health and more exercise [e.g.22,23]. Most gamified interventions attempt to motivate behavioural change and improve awareness, or trigger engagement through social interaction or cues [24,3, 12, 18, 19].

Although many gamification studies are not based on strong theoretical foundations [14], Ryan and Deci's [25] 'self-determination theory' (SDT) has been frequently used as it builds on elements (autonomy, competence and relatedness) related both to motivation and social interaction. Cugelman [1] argues that behaviour change in users will follow strategies that "exert persuasive force on people, encouraging them to shift their beliefs, attitudes, and actions" (p.2). Gamification tactics – such as

levels, points and feedback – support these 'persuasive strategies'. The academic literature on gamification and health showcases lots of case studies [e.g.1,2,3], most of which demonstrate positive or mixed outcomes, but many studies have been criticised for their limited scope, context-dependent results, and lack of theoretical rigour [26,27].

Several challenges hinder the potential adoption and diffusion of digital health gamification interventions. One challenge is that there is no one-size-fits-all. As Buckley and Doyle [28] note, gamification interventions must be deployed in a nuanced manner. There is some evidence from wider gamification studies (in education as well as health), that effectiveness can be mediated by 'player types' [29], learning styles [30,31], age and gender differences [24] and game tactics [1,2]. This means that in the innovation process, careful consideration must be taken of the user and their social context, the most suitable platform (e.g. internet, 'app'), and the appropriate gamification strategies.

A second challenge is to ensure the effectiveness of the intervention. This has two aspects, first, building the intervention on strong theoretical foundations, incorporating best evidence and measuring appropriately the effectiveness of the intervention. Although there is mixed evidence on how far the use of theory contributes to effective behaviour change, Michie et al. [32] argue that this may be as a result of inadequate application and/or the choice of an inappropriate theory and advocate the systematic design of an intervention on strong and appropriate theoretical foundations. As for measuring the effectiveness, this can be achieved in a rigorous way through a randomised clinical trial (for digital health interventions see [13,19] for example). Depending on the context and the intended psychological and behavioural outcomes, there are tools and techniques one can use to measure effectiveness (e.g. see [9,13,19, 33, 34]).

A third challenge is how to unlock long-term user engagement and continued behavioural change. As Morford et al [34] put it, how can the intervention serve as a behavioural cusp? Of the few studies that do take a long-view, there are high attrition rates reported for digital physical activity programmes [10,9] or evidence of diminishing effects over time [30]. In addition to adherence, reach is another aspect of diffusion, and there are few studies discussing the challenges associated with diffusion beyond the early adopters [9].

Fourth, there are practical challenges associated with the development of the digital intervention. Development requires not only input from multi-disciplinary researchers but also close collaboration with developers, health professionals, or public entities [26]. User involvement at all stages of the innovation process is crucial.

To contribute to improvements in the quantity and quality of life, gamified digital health interventions must overcome these challenges of complexity, effectiveness, reach and adherence, and user-led collaborative development. The next section outlines a research method by which these challenges can be addressed in the context of preventing STF.

3. Method

3.1. The context: Slips, trips and falls among the over 65s

The first challenge is to tailor the intervention to the context. The direct and indirect annual costs of STF are substantial, reported to be over £2.3bn in the UK in 2013 [35]. It is a growing problem. The older population is increasing – in the UK for example, the number of over 65s has grown by 49% since 1974 and now accounts for 18% of the total population [36] – and the risk of STF increases with age. Despite less than 6% of the older population live in long-term care across Europe, between 20-25% of severe STF related injuries occur in long-term care.

There is strong evidence that specific strength/balance exercises can reduce falls by up to 42% and up to 55% combined with home assessment (7). Meta-analyses evidence that there are many complex social, physical and psychological factors which interact to motivate older adults to take part and then adhere to exercise [37]. Often the combination of these factors can be unique to each individual person. Older adults who acknowledge the benefits of exercise and have fewer barriers are more likely to engage in activity but poor health and pain are some of the major personal barriers to being active [37-43]. Studies of gamified health interventions indicate that age and gender can make a difference; for example, social interaction and usability are particularly important for females and older people [31]. In terms of an appropriate platform, there is good evidence that an application for tablet/mobile is both an effective medium and one that may facilitate wider reach for older people [45].

The ProFouND Falls Prevention Intervention Factsheets [4] collate the best current evidence and provide a multifactorial interventions list for falls prevention. Many ProFouND prevention interventions listed require the services of professionals, but game thinking could be applied to motivate specific exercises and increase awareness of other preventive initiatives. There are clear benefits for interventions that will: (1) enable a capacity for continued independence and resilience amongst older people in their homes and in the community; whilst providing high levels of reassurance to their families and caregivers; and, (2) attenuate the rapidly escalating levels of demand (and therefore costs) which STF amongst older people bring for organisations in health and social care services.

3.2. Design

The first step of the innovation process began with an in-depth literature review of existing interventions for preventing STF. This concluded that whilst there were a number of video games and applications to improve balance, strength and power (the cornerstone of any intervention to prevent STF), their potential diffusion was hindered by the cost and usability constraints of the technology. There was much evidence of Cugelman's [1] 'persuasive strategies' to motivate and engage users, though few existing interventions offered social interaction. Moreover, there was little education and awareness raising about the risk factors for STF. Therefore, the aim was to co-develop a prototype gamified application that (1) motivates behavioural change to routinely engage correctly in appropriate exercises to build strength and balance, and; (2) improves awareness of preventative/therapeutic interventions to reduce the fear and risk of falling.

The Medical Research Council recommends beginning the development of any effective complex intervention by identifying relevant theories to advance understanding of how to change behaviours [45]. Combining an understanding of the motivators and barriers to engage in physical activity with Cugelman's [1] persuasive gamification strategies and Ryan and Deci's [25] self-determination theory ensured that this process was followed closely. Table 1 summarises the connected motivators/barriers, gamification and behavioural change theories.

Table 1: Motivating users to behavioural change through gamification

Motivators	References	Objective of the app	Gamification strategy	Gamification tactics	Behavioral change	SDT
Maintaining health and independence	[46,47]	To improve muscle strength and balance through	P/S1. Goal setting P/S2. Capacity to overcome challenges	GT1: Providing clear goals GT2: Offering a challenge	Agree behavioural contract Action planning	Autonomy, Competence
Self - efficacy	[48,49]	To improve confidence and competence	P/S3. Providing feedback on performance P/S4. Reinforcement	GT3: Using levels GT4: Allocating points GT5: Showing Progress GT6: Providing Feedback GT7: Giving rewards GT8: Providing badges for achievements	Prompt self-monitoring of behaviour and outcome Provide rewards contingent on successful behaviour	Competence
Prompts	[50]	To trigger engagement, 2 to 3 times per week	P/S2. Capacity to overcome challenges	GT2: Offering a challenge	Time management Action planning	Competence
Music	[51,52]	To engage users	P/S7. Fun and playfulness	GT10: Contributing to a story or theme	Fun and engagement	
Demographics	[53,54]	To targeted over-65s, mainly female, at all points on fall risk lifecycle	P/S4. Reinforcement P/S5. Compare progress P/S6. Social connectivity P/S7. Fun and playfulness	GT3. Using levels GT4. Allocating points GT5. Showing Progress GT6. Providing Feedback GT7. Giving rewards GT8. Providing badges for achievements GT9: Showing some game leaders	Provide normative information about others' behaviour Plan social support/social change	Competence, Relatedness

A number of gamification tactics were used to support the persuasive strategies for behavioural change. For 'goal setting', an abstract challenge was provided, minimising complexity in a simplified scenario whilst connecting cause (exercise, increased awareness) and effect (reduced incidences and fear of STF, healthy aging). 'Rewards' came in the form of badges, for self-reporting exercise completion or spotting hazards. A visual indication of 'progression' against goals was illustrated with aesthetics (e.g. changing colour of character's clothes) and leaderboards provided normative information about the performance of others.

To anticipate the third challenge and assess the effectiveness of the intervention various tools were applied. To demonstrate the effectiveness, and meet the first objective (to motivate behavioural change to routinely engage correctly in appropriate exercises), usability was measured by the System Usability Scale [55], motivation by the Intrinsic Motivation Inventory [56], and physical activity by prompting self-reporting on the time and frequency of exercise. To meet the second objective (improve awareness of preventative or therapeutic interventions) data on declarative knowledge was used, from user attempts at the awareness raising game, and responses to questionnaires probing user's 'fear of falling'. Acknowledging that efficacy alone is not sufficient for significant impact, to meet the third challenge and evaluate reach and adherence, the technology acceptance model [57] was also used.

Finally, to overcome the collaborative requirements of a complex intervention, with funding from the Economic and Social Research Council, a team of multi-disciplinary researchers, older users from a sheltered housing provider, and digital designers was convened. Most digital intervention studies employ a user centred design for gamification interventions [14] and mixed methods approach for evaluating progress and effectiveness (combining interviews, observations, focus groups, workshops). In this project, an agile development process was followed where the product was tested with users from the outset using rapid development and testing feedback loops. A 'skinny product' was provided to end-users to gauge their reactions and inform the next steps of development. This iterative process continues until a near finished version is ready (sometimes referred to as a minimal viable product) when more formal and extensive testing can be conducted via a randomised controlled trial. The next section reports the preliminary results of user-testing.

4. Early results

After gaining University Research Ethics Committee approval, the prototype application was initially tested with a group of five residents from a sheltered housing scheme. It is generally considered that usability testing with five participants will reveal 85% of usability problems [10]. In the individual user testing, residents were encouraged to 'think aloud', a method whereby users simultaneously vocalise their actions and thoughts whilst engaging with the app. The tests affirmed existing research that touch is a natural method of input for older people. Overall, users reported that they enjoyed the experience of using the app. Usability issues that emerged from the first round of testing included shortcomings with interface design, navigation and terminology. Interface design refers to what users see in front of them, including content, font, colour, images, etc. For example, the participants struggled with some of the iconography. Navigation is about how users progress through the application to complete tasks. For example, participants did not recognise the bottom tab bar as a navigation tool, in some instances even after they accidentally clicked on it. Others did not realise that more content was available sat beneath "the fold" in the app. The terminology on the navigation bar also seemed confusing to some participants and this caused them to go into the wrong tab when asked to do a specific task. Other terminology issues surrounded the size of font: nearly all participants struggled to read the smallest text on the screen. These usability issues are not uncommon [10]: Apple's© guidelines on human-iphone interfaces stress the need for an easy interface, logical navigation and simple terminology.

Following the user testing, further qualitative evidence gathering is planned for February 2017 with two focus groups with 20 different residents from the same sheltered housing scheme.

5. Discussion and conclusions

Developing an effective gamified application to improve quantity and quality of life is not easy; innovation rarely is. The literature shows us that there are some pressing challenges that need to be overcome, namely, complexity, effectiveness, reach and adherence, and user-led collaborative development. The user-centred, engaging, collaborative and rapid innovation process outlined above tackles head-on these challenges in the context of STF prevention. With two grants the research team have demonstrated a 'proof of concept' of the 'skinny product'. To continue the development and evaluative work, the research team have applied for a further grant to continue the agile innovation process. By the end of 2017, the intention is to apply for funding to undertake a randomised clinical trial to rigorously test the product. Gamified health interventions are likely to grow in coming years and present an innovative, inexpensive and accessible approach that can be readily tailored to ensure they are context specific and personalised according to need and preferences. Given the potential benefits, ongoing research is required to support the adoption of assistive technologies like gamified health interventions.

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