

Design Strategies for Gamified Physical Activity Applications for Older Adults

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Abstract

Staying physically active is essential to wellbeing in late life. However, many older adults experience barriers to physical activity. Past research has investigated the development of playful interactive systems to support exercise routines and reduce access barriers. Yet, little research has been done on older adults' needs and preferences regarding technologies that support physical activity. We address this issue through an exploration of older adults' exercise motivations grouped around themes relevant to technology design. We conducted semi-structured interviews with 19 older adults, and followed up with a focus group study of physical trainers and older adults with an active lifestyle. Based on our results, we discuss their conflicting perspectives and challenges on exercise and technology, which leads us to contribute design strategies to support designers as well as researchers wishing to create meaningful and playful fitness applications for older adults.

1. Introduction

Aging is associated with many cognitive and physical challenges that reduce older adults' opportunities to participate in recreational activities, such as playing games or exercising. This can have adverse health effects and negatively influence their quality of life [12]. Playful applications, such as motion-based video games, hold the promise of providing accessible physical activity (PA) for some older adults [22]. Prior research has demonstrated the benefits of such applications for them on their physical [44] and emotional [28] well-being. In addition, gamification—using game design in systems that primarily support non-game tasks to make them more fun, engaging, and motivating (see: Kaleidoscope of Effective Gamification [KEG]) [29]—has seen a surge in interest, and produced many playful applications to support exercise routines and encourage PA that could also benefit older adults [40, 28]).

However, little is known about the needs and preferences of older adults when it comes to technologies that support PA. This is problematic as developing a detailed understanding of player motives is at the heart of designing effective gamified systems [29] and meaningful fitness applications. Therefore, it is crucial that designers understand—when they develop technology-supported exercise regimens—barriers and motivational challenges

that older persons face along with preferences and needs that may differ from those of younger audiences.

We address this issue through a qualitative inquiry into older adults' exercise motivations grouped around themes relevant to technology design. We report results of two studies, a semi-structured interview study with 19 participants, and a follow-up focus group study with three pairs of personal trainers (PTs) and older adults. Our work surveys a range of older adults with different perspectives on PA and fitness motivations. We use Self-Determination Theory (SDT) [15,14] as a lens to analyze data with a focus on extrinsic and intrinsic motivation. Our results show that exercise motivation among older adults needs to be considered in the light of age-related changes, and that technology to support PA needs to accommodate conflicting views on feedback and encouragement, as well as social aspects of exercise. Based on these findings, we contribute design guidelines to help understand design challenges that need to be addressed to create meaningful technology that supports PA for an older demographic.

Arriving at a better understanding of how interactive technologies can be designed to meet the needs of older adults is an important move towards creating technologies that are meaningful in the context of their lives. This is a crucial step to enable older adults to leverage the benefits of playful technologies to support their efforts to stay healthy, and help them maintain and establish PA routines, which are vital to well-being in late life.

2. Related Work

We survey related literature with a focus on older adults' perspectives on PA, interactive technology to encourage PA among older adults, and the potential of playful applications for this demographic.

2.1. Older Adults and Physical Activity

Despite being interested in fitness activity, research suggests that many older adults are reluctant to pursue fitness programs because of the challenges of aging [16,5] such as social isolation, changes in cognition and mental distress, and decline of motor control [12]. Some of these challenges can be specifically addressed using technology [3], and, specifically, digital games [6,19]. However, challenges [27] of aging also present barriers to technology-supported fitness

activity, for example, an older adult who is unable to participate in PA because of age-related impairments [12] may experience difficulty when engaging with technology.

For older adults actively involved in PA, studies show that intrinsic motivation is greater than extrinsic motivation [10]. A study of younger participants doing exercises revealed that adherence was associated with motives focused on enjoyment, competence and social interaction in contrast to personal fitness or appearance [40]. Health benefits of older adults related to their fitness routines [35] are linked to motivating older adults adequately to initiate and maintain fitness activities [37]. Research on older adults' intrinsic and extrinsic motivation [13] explored their activity levels (inactives, actives, sustained maintainers) against dimensions of health and fitness, weight management, appearance, stress management, enjoyment and social/emotional benefits. An increase of intrinsic and self-determined extrinsic motivation was positively associated in this study with more PA of older adults.

2.2. Interactive Technologies to Encourage Older Adults' PA

Regarding the promotion of exercise, different approaches have been made. Systems like UbiFit Garden [11] and Flowie [2] target the older adult population, and try to encourage PA through pervasive technology interventions [18]. Addressing older adults in long-term care, Curious Companion [46], Robot Games for the elderly [26], and SilverPromenade [23] explored playful tools for encouraging PA among older adults. Studies on full-body motion control games [22] had a positive effect on the emotional wellbeing of older adults and led to guidelines for the design of full-body interaction in games. While the above helps to promote PA, mobile apps also promote such activities using smartphones and focus on individually tailored feedback and advice [32]. However, the study had low inter-rater reliability, probably caused by the lack of guidelines for this new mobile technology. While playful persuasive solutions [38], embodied gaming [1], and augmented gaming [31] discuss fun and socially engaging activities [9] and social influence [25], most technologies have only been evaluated in a lab setting, and key intrinsic and extrinsic reasons for older adults to sustain motivation have not been explored.

In this context, little research has been done to understand motivations of older adults to initiate, engage and sustain PA despite proven benefits on physical, cognitive and emotional health [7]. When looking at research that explores the potential of interactive technologies to promote PA among older adults, most approaches are accessibility-driven and focus on how to make technology-mediated PA available to this audience. This is an important first step towards allowing older adults to benefit from technology-supported PA, however, it is equally important to consider older adults' motives and barriers to exercise (or not to exercise) in the context of technology use. We address the issue of facilitating PA in older adults via intrinsic and extrinsic motivations. We are looking for insights into the challenges

of designing playful applications to help older adults engage in PA. We see our contribution in an understanding of barriers and motivations that are instrumental in developing PA applications through gamification.

2.3. Older Adults' Perspectives on Playful Technologies

Particularly regarding the design of playful applications for older adults, research has explored older adults' preferences and needs in the context of video game play. Among the first to investigate this area are De Schutter and Vanden Abeele [42], who suggest that connecting with others, self-cultivation, and being able to contribute to society are factors that older adults consider important in the context of games. Furthermore, work by Nap et al.[33] outlines that gaming may serve as a form of escapism, and that older adults enjoy games as a means of reminiscence. Brown [8] examined older adults' motives to play. In line with previous work, she found that enjoyment, social aspects, and perceived health benefits were major motivators for older adults to engage with games. Additionally, perceived exertion and visual complexity affect player experience [45]. However, use of gamification is shown to decline with increasing age [30] and similarly results regarding the social context of play are contradictory, and some research suggests that older adults might prefer solitary play over multiplayer settings [39,38], an aspect to be considered for gamification.

While the above research is generally focused on games and not on PA that motivates games, our work aims to make a contribution by combining these two important fields. Existing research in this field explores age-related needs of older adults related to gaming [22], barriers and motivations towards physical activities and activity levels [44] and a client-centered counseling approach [14] to motivate older adults towards fitness activities. However, there is a lack of research into motivational characteristics of older adults and how to use those to create design strategies that can support the design of meaningful technology-supported PA for older adults.

3. Qualitative Explorations of PA Motivations among Older Adults

We are interested in what motivates older adults to exercise on a regular basis and persuasive stimuli [24] with a focus on how these factors might be incorporated into technologies to support PA.

3.1. Analytical Framework

We build on SDT [16] and integrate it with the *Kaleidoscope of Effective Gamification (KEG)*[29] to create a method to categorize motivations of older adults engaged in an active lifestyle with the intent of developing a better understanding of this demographic in relation to technology to support PA.

SDT is an evolving theory of human motivation, which posits that intrinsic motivation is dependent on autonomy, competence and relatedness [16]. Amotivation, extrinsic motivation and intrinsic motivation forms an overarching taxonomy of human motivations [39]. SDT has been applied to video games [41], who have shown that the attractiveness of games is influenced by player need satisfaction related to motivational constructs of autonomy, competence and relatedness. In the context of SDT, intrinsic motivation refers to engaging in an activity because it is inherently interesting or enjoyable, and extrinsic motivation refers to doing something because it leads to a separable outcome [39]. There is some overlap between SDT and common approaches to gamification as the core construct of gamification focuses on the intrinsic and extrinsic motivations that an application provides [34].

The *Kaleidoscope of Effective Gamification* (KEG) [29] is a design and analysis tool, which presents guidelines for designing effective gamification applications. The analysis model is an iterative method for game designers to identify motivations facilitating internalization [15], designing game experiences, game elements and integrating fun, which is focused on identifying and evaluating user motivations.

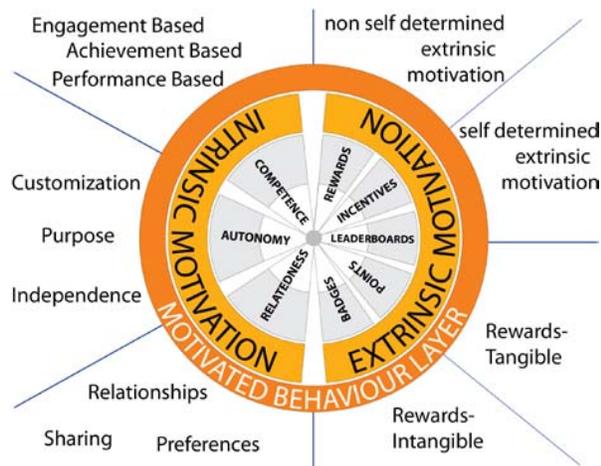


Figure 1. Categorization of Intrinsic and Extrinsic Motivations based on the Kaleidoscope of Effective Gamification.

The lens of skill atoms [12] relates gameful design and user activities towards designing motivating and enjoyable experiences. Additionally, social motivations predict attitude towards the use of gamification, and intentions to continue using a gamified service [22]. Based on the KEG model, the Motivated Behaviour Layer (MBL) needed to be defined, which identifies and categorizes the intrinsic and extrinsic motivations for a gamification context. We further created themes as shown in Figure 1 within each dimension indicated on the MBL. These themes served as triggers to categorize the attributes identified in the qualitative interview process. Within the intrinsic motivation sector from the MBL, the competence dimension was categorized into engagement based, performance based and achievement based themes. Autonomy was categorized into purpose, customization and independence themes. Relatedness was categorized into

relationships, sharing and preferences themes. The extrinsic motivation sector from the MBL was categorized into non self-determined extrinsic motivation, self-determined extrinsic motivation [13], tangible rewards and intangible rewards. While KEG was initially developed for business applications [29], we believe many of its elements can be a valuable tool to identify intrinsic and extrinsic motivation of users in different application contexts. We leverage its features here to integrate gamification perspectives with SDT to study technology-supported PA for older adults.

4. Research Questions and Study

We aim to address the following research questions focused on PA, motivation, and technology in our two studies:

RQ1: Using SDT and KEG as a design lens, do changes in motivations of older adults facilitate fitness activity?

RQ2: What are the underlying factors and challenges that facilitate or prevent fitness activities for older adults in the context of technology-supported PA?

RQ3: What are the challenges and design strategies for designing motivated gamified physical fitness activities and applications?

4.1. Study 1 Method: Interviews

Interviews were done together with Centre for Elder Research and Vintage Fitness, a company that specializes in physical fitness for persons aged 50 and older. Because our study was geared towards understanding *active* older adults, we took lower bound of age to be 50 years to include *late bloomers* (50-60 age segments). Participants were recruited from a research database housed within the Centre for Elder Research, (based out of Sheridan College, Ontario), that targeted adults aged 50 years and older, who use the Internet for information about health and wellness. The upper age bound was ultimately adjusted, because some individuals older than 70 years were avid exercisers and Internet users. We did not want to discount their opinions because of their age and because they expressed interest in the project. Our study was approved by the College's Research Ethics Boards (REB). As a token of appreciation, participants were entered into a draw to win a DVD.

Participants and Procedure: A total of 19 individuals agreed to be interviewed as part of this study. They ranged in age from 55-78 years (mean age 66.2 years, 16 female). 13 participants reported age-related injuries or physical discomfort (e.g., arthritis, osteoporosis, fatigue, stenosis of fasciae to mention a few). Regarding technology literacy, six participants had extensive computer experience and were internet users, three did not use computers expertly, and three participants played video games on a regular basis. Participants provided informed consent to participate in the study and agreed to have their interviews recorded for analysis purposes.

Each interview was conducted privately with a trained Research Assistant from the Centre. The investigator led the

discussion through themes and questions outlined in an interview protocol, allowing for discussion wherever necessary. Typically, interviews lasted between 45 minutes and an hour.

Interview Protocol: A semi-structured interview protocol was designed for this study by the Centre for Elder Research in consultation with Vintage Fitness. The main themes covered in the interview protocol were: the individual's current exercise habits, factors that motivate them to begin/maintain/return to an exercise program, their goal-setting behavior, strategies they use to remain accountable, life factors that impact their exercise behavior, their needs and preferences as far as exercise is concerned, and their computer/internet behavior and preferences.

Role of Playful Technologies: While the paper focuses on identifying the motivations of older adults to engage in PA, our interview questions were intended to elicit responses related to playful technologies. This prompted our decision to use the KEG, a gamification model and SDT in the context of fitness applications. Our interview protocol facilitated questions relating older adults' physical activities and their computer/Internet behavior. This research was conducted to understand motivations of older adults with respect to PA, as well as technological barriers and interaction limitations.

Data Analysis: We applied deductive thematic analysis, and applied a process in which qualitative data was reduced to themes through the process of coding and condensing codes [19]. Resulting themes were represented in tables and used in relation to motivational themes corresponding to autonomy, competence and relatedness, which were defined using the KEG gamification model with SDT. Motivational themes shown in Figure 1; these themes were identified as broad categories which evolved when comparing the SDT and KEG theory with the qualitative data.

4.2. Study 2: Focus Group Sessions Results

Informal focus group session questions were developed based on the findings from Study 1. We recruited participants in the age group of 50–70 years and an active lifestyle, meaning persons who are able to engage in activity equivalent to walking more than three miles per day, and independently carry out daily routines.

Participants and Procedure: Six participants (three older adults, three PTs experienced in working with older adults) were recruited for the focus group sessions. Older adults and PTs were paired. Three researchers helped them with questions in each session. Participants (Two males, one female, mean age 65.6 years) were comfortable with computer and Internet usage.

Participants were welcomed and gave informed consent. PTs and the older adult participants were paired randomly and assigned to informal discussion areas. A researcher assigned to each pair of participants facilitated the focus group session using semi-structured trigger questions specific to autonomy, competence and relatedness for intrinsic and extrinsic motivations. These participants' were

coded as PF1, PF2 and PF3. PTs were coded as PPT1, PPT2 and PPT3.

Focus Group Questions: We created a new set of questionnaires for a focus group discussion session with older adults. This set of questionnaires focused on intrinsic and extrinsic motivational triggers to engage maintain and sustain motivation in a fitness activity. Based on the KEG model [29], these questions were grouped under categories: amotivation, motivation, goals and accomplishments, physical tracking, accountability, staying on track.

5. Results

Data was recorded and themes coded from the review of the qualitative data were categorized based on SDT dimensions of intrinsic and extrinsic motivations specific to older adults' engagement with fitness activities and online scenarios. These themes which provided key categorizations were: mental motivations, physical motivations, amotivations, barriers to entry (mental and physical), goal setting, accountability, rewards, support networks, social groups, sharing, social interactions, safety, preferences in physical activities, preferences with online websites and preferences with fitness information.

5.1. Study 1: Interview Results

To define these themes in context to SDT and in relation to gamification, we used the Motivated Behavior Layer (MBL) from KEG [29] to map attributes that were actively raised from the qualitative data.

Motivations-Mental, Physical, and Contextual: We explored the intrinsic and extrinsic motivation attributes (see Figure 1) for thematic associations and disassociations. Categorizing older adults' intrinsic motivations into existing SDT dimensions of competence, autonomy and relatedness provided distinct thematic mappings in these dimensions. Relating the competence dimension to themes as in engagement-based, performance-based and achievement-based (cf. Figure 1) provided clusters of attribute mappings within these themes. Simplicity of activities versus complex routines, challenges with number of repetitions, focus on remembering steps, and ease of understanding formed bulk of the engagement theme. Ability to do the exercise steps correctly, maintaining proper posture and keep up with the pace of others formed a few attributes of the performance theme. Challenging peers into competition, and being able to complete the given routine were some attributes from the achievement theme.

Intrinsic Motivation – Competence: Fear of incompetence can drive motivation. Participant feedback was mixed regarding intrinsic motivation focused around the theme of competence. Some participants were concerned with their ability of participating in PA, outlining that they are “intimidated by sports activities and had a lack of sports lifestyle during childhood, and it is easy not to work out” (P1), and indicating that they “find it difficult to remember complex steps and forgetful at times” (P3). Regarding fitness

levels, one participant stated (P2) that “*stress and exercise is a challenge,*” but also commented that stress drove exercise motivation. Another participant indicated that the “*self-satisfaction of feeling better at end of each class, and movement is easier*” (P15) drove exercise motivation. When further exploring this theme, one participant (P2) mentioned “*fear of being confined to a mobility device,*” suggesting that fear of future physical incompetence influenced activity routines.

Intrinsic Motivations – Autonomy: Based on the qualitative interviews our themes of purpose; customization and independence informed us about the older adults attributes towards fitness activities within the SDT autonomy construct. **Purpose.** Participant wanted to do better at fitness activities, comfortable routines, incremental progression, reinforcing successes, internalizing rewards’ and responsibility formed key attributes within the purpose theme. **Customization.** Some responses indicated the opportunity to learn “new exercise” and “*learn something new or different or new knowledge*” (P4), and presented a new personal challenge (P1) “*an exercise routine was a personal challenge.*” **Independence.** Regarding freedom of modulating fitness routines and structured routines it was mentioned that some “*I prefer to break the activity into small steps, or do it in chunks or blocks of time*” (P2), modularity, and choice of changing goals, reinforcing progression through visual and verbal feedback depicted some attributes in the customization theme. The opportunity of accomplishment at a self-directed pace to “*prefer to [...] follow*” their “*own programming*” (P6) with selection of routines and accountability was described as well.

Intrinsic Motivations – Relatedness: We looked at the themes of relationships, sharing and preferences within the SDT relatedness construct. **Relationships.** Fostering social connections under the overarching context of fitness activity was predominately an important theme for older adults. Inspiring friends and peers with the activity group and outside the activity group, engaging in competitiveness with other people, meeting new people, providing encouragement “*a friend encouraged her and pushed her to exercise if the activities were not done*” (P2); receiving positive feedback and motivation from others indicating “*friends and family offered encouragement*” (P6), validation from others in that “*the physical trainer offered verbal encouragement*” (P4) formed a few of the many attributes with the relationships theme. **Sharing.** Regarding sharing achievements and experiences one participant stated “*I like to inspire and encourage friends and near ones to be active and I like to get feedback and give feedback to people*” (P4). Being an example to peers within the fitness activity domain, exchanging feedback with peers and trainers and being validated for performance by the trainer and doctors as such formed a few of the attributes within the sharing theme. **Preferences.** Working and being active within a group, structured activity where exercising with people was a motivation, and the presence of trainers was a positive impact as stated “*I like a coach that does not ‘let up’ and*

pushes harder and is a ‘motivator’” (P5). Comfort of being within a familiar group was positive response outlining that “*competitiveness with other people, working with others pushes me forward and I can gauge my own performance by the way other people*” (P1). Social interaction indicating that “*meeting and chatting with the ladies in the dance class*” (P3), also formed a major attribute within the relatedness category.

Extrinsic Motivations: Based on the taxonomy of human motivations [39] where extrinsic motivation is posited as being factors of external regulation, introjections (non-self-determined extrinsic motivation), identification (self-determined extrinsic motivation) as in “*ability to exercise itself is reward for me*” (P6) and integration. We added tangible rewards and intangible rewards as themes within external regulation. From the thematic analysis of extrinsic motivations that were coded from the qualitative interviews, **tangible rewards** as better looking skin, appealing dessert and indulgence in food after a fitness activity “*I like to eat food or desserts that I can burn the next day*” (P6), or the prospect of fitting into a slimmer dress and giving away oversized clothes were observed to be attributes within the external regulation dimension. Fear of immobility like their parents (P4) “*I do not want to become immobile like my parents*” also anchored their focus towards being active. Furthermore, attributes such as validation from coaches, praise, pushing for better performance “*physical trainer’s acknowledgement of my achievement itself was reward*” (P3), and bragging rights were reported as specific attributes for the **intangible rewards** theme for older adults’ fitness activity.

Barriers to Entry (Fitness Activity): Our thematic classification of barriers to engaging in a fitness activity, into **physical barriers** and mental barriers provided interesting insights into older adults psyche towards fitness activities. Most participants were faced with the inertia of overcoming their lack of physical mobility because of age related infirmities saying they are “*afraid of failing and injuring myself*” (P12), some of which were health issues, such as osteoporosis, back pain, knee issues and bodily injuries. The feeling of lack of energy (“*I do not feel the energy to think of exercising*” [P9]) complemented their sedentary lifestyle further and was a barrier to fitness activities. Interestingly, the most commonly noted **mental barrier** was the lack of feeling well to engage in any fitness activity. The unavailability of time and reluctance to exercise because of fear of aggravating their existing health conditions, prohibited indulgence in any form of exercise or fitness activity. The challenges of being intimidated by the pace at fitness workshops and the fear of being ridiculed by younger people fueled their reluctance to engage in fitness in a social setting like in a gym environment.

Amotivation: Many interesting themes were coded from this category providing insights into the lack of motivation to even initiate a fitness routine. Lack of sleep (P1), fear of being confined to a sedentary lifestyle (P4, P13) posed an inclination to get involved in activities; participants

struggled with the **inertia** of initiating a fitness routine. Fear of immobility as stated (P2) *“I am afraid of being confined to a mobility device, hence I want to get involved in an exercise routine”* Even though health was a priority for many, challenges’ with lack of availability of time, because a busy schedule prevented older adults from engaging in a fitness routine. Loneliness posed a challenge where one participant (P3) mentioned to *“not want to do any activity alone and I get tired [...]”*

Goal Setting and Accountability: While these themes formed a major part of the autonomy category of the SDT framework and were discussed earlier; interesting attributes were reported which furthered the need to indicate these results separately. Many of the participants’ preferred to set **smaller and achievable goals** for themselves (P5) and the preference was to allow the PT to set these achievable goals for them and one participant (P1) indicated *“I prefer the PT to set up the program and I trust them to understand my condition”* With regards to accountability, a few of the participants (P4, P11) expected the PT to keep track of the correctness of the activity in terms of gesture and poise and for one participant (P5) just showing up was an accountable action. **Establishing a routine** was also critical as one participant (P6) indicated *“I prefer to set up a regular time and day of the week for fitness activities, and, showing up for classes shows my dedication, but I prefer to do my own programming”* there was a preference by another participant (P3) to maintain a diary.

5.2. Study 2: Focus Group Results

The study design based on interviews helped us explore behavioral attributes related to the key dimensions of intrinsic motivations (i.e., autonomy, competence and relatedness) and extrinsic motivations [39]. This inspired us to modulate the set of focus group questions to be focused on the barriers to taking part in a fitness activity and intrinsic and extrinsic motivational triggers to engage, maintain and sustain motivation in a fitness activity.

Barriers/Amotivation: Ease of adapting to a sedentary lifestyle due to **work-related environments** posed a crucial barrier for older adults to engage in fitness activity where one participant (PF1) stated *“work commitments and schedules made me postpone fitness activities”* and another participant (PF3) had **injuries** and stated *“I do not have not enough time available, but joined a gym due to back injury [...] however fear of failure and the need to be ‘fit to be fit’ was a stressor.”* The same participant (PF3) was **embarrassed** and added *“I am ashamed or embarrassed, and mentally not ready or not keen on being seen in gym attire and furthermore I am intimidated by the buff fitness younger guys [...]”* Another participant (PF1) sacrificed fitness health over comparing to younger people.

Motivations: Small achievable steps. During the sessions the participants were asked about their motivation triggers to engage in a fitness activity. Regarding PA one participant (PF1) indicated constraints at home to be a reason to joining a gym; need for routine activities (PF2); and escape from

boredom and *“be able to kick a ball with my granddaughter”* for another participant (PF3) initiated joining a fitness program. Regarding capability, correctness of performance (PF2); small achievable steps defined by trainer where participant said *“the small steps from the trainer would help to overcome the barriers of being overwhelmed with the idea of being able to do the activity.”*

Simple routines that reinforce small successes. Interestingly it was noted that too many negatives connotations or feelings suppressed the positives capabilities and often times reinforcing small successes helped with the motivation as stated by fitness trainer (PPT1) *“most of my clients are keen on trying to do a simple routine and be successful at it, and they like being praised.”* Regarding competency one participant (PF1) was comfortable with simple routines because it allowed easy recall from memory of the routines and helped to build confidence and stated *“when I can do the exercises that I remember, and to do these simple ones makes you feel better for that moment [...] and extend my feeling on my own to other activities.”*

Praise, wellbeing and health are rewarding. Many participants were critical about the value of rewards to overcoming mental and physical barriers indicating that (PF1) said *“the external reward would be losing that extra weight or being able to walk that extra mile”,* (PF3) *“the reward was the progress. I wanted to inspire other friends to be active as I am, to overcome obesity and depression”* Ability to feel good and be energetic was reward in itself (PF2); the thought of competition was also a different feeling *“as I was always of a competitive spirit”* (PF3). Reward was perceived in the form of health benefits as stated *“reward is your health”* (PF3). The PT also indicated their clients were not keen on medals or certificates, but on praise, which helped to validate their progress. Individual success and acknowledgement of achievements was critical for their clients (PPT2) *“acknowledgement made them feel as though she existed for the PT on her radar.”*

Accountability and Staying on Track: Self-monitoring and external feedback. The degree of accountability varied for different participants; in that it had to be a *“personal connection”* (PF1), where they *“prefer to be accountable to oneself, and to the PT.”* However, *“to be accountable online may be difficult as it needs to be a personal connection as opposed to being a non-relationship avatar.”* Participants held themselves accountable by measuring calories (PF2), maintaining a diary (PF3) or *“by making effective choices as in good choices or bad choices, playing mental games with myself”* (PF1). There was the fear *“of not being able to keep up”* (PF3). Regarding accountability to someone else stated *“pre-planning and the need to keep up with the goals set by the PT or a group or to another team person make the process encouraging”* (PF1) and additionally *“accountability to a teacher or PT helps with validation”* (PF2). With regards to staying on track, *“knowing how many kilometers one walked was fascinating”* (PF1). Regarding feedback, one participant stated *“feedback of progression via a computer would be stressful [...] not keen on a computerized feedback [...] not*

of digital age.” PF2 stated “*working with equipment helps with getting feedback instantaneously.*” A PT (PPT3) indicated “*clients are always keen on knowing from me if they hit their target that was planned of the activity.*”

Social Context: Togetherness and sociability at a common workout place. Social interaction and sharing during fitness activities was noted to be a means to respect and understand the presence of many in similar situations as themselves. Being motivated by a group (PF1) as opposed to working out with a DVD; recognizing that “*others are in the same boat as you [...] bouncing of ideas with others*” (PF1); and “*sharing information about my success or failures, as the opinions of others affect my persona only in a small manner*” (PF2); “*build friendships and a common element ties people together in a fitness activity especially in older age group*” (PF3) were some common responses.

5.3. Summary of Results

Our analysis of interviews and focus groups reveals a range of motivations for older adults that can inhibit or facilitate exercise. We discuss our findings and relate them back to SDT and KEG aspects that would help augment PA for older adults with technology. Motivating factors are:

Intrinsic motivations can be broken down into purpose of the exercise, customization of exercise routines, independence of how and when to work out, the ability to form relationships, and being able to share information about exercise. Togetherness and sociability at a common location was emphasized in the focus groups. Older adults use PA in a gym setting to connect with others of their own age (keeping in mind that the presence of younger, active persons may act as an inhibitor and reduce confidence). This stresses the importance of social interaction that could be incorporated in technology. In addition, the fear of incompetence and immobility is a strong intrinsic motivator for older adults: interview sessions and focus groups show that the importance of exercise to maintain an attractive body is shifting to the application of exercise to reverse or avoid age-related changes and impairments and to maintain a *functional* body (e.g., being able to play with grandchild, or not having to use assistive device in the future). Fear of aging can drive a desire to exercise in some cases, because responses were rather emotional and explicitly focused on physical impairments they had witnessed in other people.

Extrinsic motivations are not as valued by older adults and tangible rewards are mostly related to food, while intangible rewards often relate to acknowledgments and praise from their PTs. Good food choices can also be motivating when they fit into the exercise regimen.

Barriers to exercise can be physical and mental, which are often related to an age-related health condition or injury, and also appeared to have an impact of older adults’ self-image, e.g., causing insecurities when comparing themselves to younger persons. In this context, it is interesting that interview questions designed to investigate how older adults experienced competence in the context of PA largely evoked answers focused on their *incompetence*, fear of failure, and

perceived barriers, suggesting a self-conscious perspective on PA. Other factors were mental barriers such as the embarrassment of working out in public, and technology was often mentioned as a potential barrier.

Small goals, and simple routines are important design factors mentioned in the focus group session. Older adults expressed strong preferences for simplistic exercises that are easy to learn and allow them to take ownership by designing experiences that fit their lifestyles and abilities.

Praise, wellbeing and health benefits are seen as natural rewards in exercise regimens for older adults. A recurring theme was the importance of feedback. Older adults expressed strong needs for continuous feedback on their performance (e.g., whether movements were carried out correctly, and whether they were making progress) either from the fitness instructor, or from peers. This was supported by PTs who participated in the focus groups, who also outlined that continuous positive feedback might help increase older adults’ confidence when engaging in PA. Despite their strong need for external approval, older adults expressed concerns when asked whether they would like to receive performance feedback through a computer system, highlighting a challenge when creating PA applications for them.

The above thematic analysis using SDT and KEG as an analytical lens provided us with the opportunity of being able to identify key motivating factors, which were internalized by the older adults engaged in PA. This helped to answer our research question (RQ1). This exploratory process of using SDT and KEG in conjunction helped us identify key barriers and factors discussed above which were of prime importance in the design strategy of a fitness gamification application and supports our research question (RQ2).

6. Discussion

This paper provides a qualitative inquiry into older adults’ motivations to engage in PA grouped around themes that are relevant to the design of playful technologies to support exercise routines. We used SDT to create categorizations of fitness motivations for older adults and found key motivational drivers but also barriers for fitness activity. We reflect upon the application of SDT and KEG to guide qualitative inquiries into user motivations, and we discuss our findings with a focus on the introduction of gamification to create motivating fitness applications for older adults. We provide an overview of design strategies to make our findings actionable for researchers, designers, and the wider CHI community, and we explore design challenges beyond motivation that need to be addressed to create meaningful fitness applications for older adults.

Applying SDT and KEG to Study Fitness Motivations: The use of SDT in conjunction with the KEG to identify and analyse fitness activity motivations of older adults gave us insights into the specific intrinsic motivations of older adults. The understanding of these motivations of the MBL ring layer (KEG) is the first important step for designers to design

fitness applications with attributes of personal importance dedicated to this specific demographic. This methodology focuses on the identification of needs of the older population to maximize the value of design strategies geared to satisfy the need satisfaction dimension of autonomy, competence and relatedness. This first stage in the KEG design process model helps to establish the core value proposition of the fitness gamification application. Thus, an intersection of SDT—a psychological model used in KEG—facilitates the discovery of needs of the specific demographic. KEG presents a method for developing fitness gamification applications to satisfy internalization of these needs. These intrinsically motivating identifiers can be used to customize and personalize gamified fitness applications tailored to address the needs of specific samples in an older population.

Strategies for Designing Playful Technologies to Support PA among Older Adults: Our findings expose a number of design challenges that need to be addressed when creating interactive systems to support PA among older adults. This section discusses four key themes that were condensed from our analysis.

Challenge 1: Understanding the Life Stage of Older Adults to Motivate Users Without Playing on Their Fear. A theme that was coded in our analysis was older adults' fear of age-related change and impairment as driver for exercise. Some work suggests that emphasizing risks is an effective strategy in persuasive technology for health [36]. While this approach is easy to implement and may appeal to designers, it is also important to be mindful of the life stage that older adults are at. When addressing younger persons, health threats are avoidable if behavior is adapted. In the reality of older adults, health threats are more immediate, and every person will be exposed to some level of age-related changes regardless of their PA routines. If applications to promote activity exploit fear, they are more likely to reduce confidence, instead of empowering older adults to take charge of their own activity routines. Particularly when creating playful applications, focusing on challenge as a means of fostering engagement can be difficult as this may prompt users to reflect upon their abilities, potentially exposing vulnerability [21].

Design strategy: Highlight benefits of PA without referencing age-related changes. Build confidence through positive reinforcement. Design in milestones at small fitness routine intervals to provide encouragement tailored to individual need-satisfaction characteristics. When designing playful technologies, be aware that users need to be able to overcome challenge appropriately, and design experiences that adapt to individual needs.

Challenge 2: Offering Engaging Feedback on PA Routines. Our results show that older adults are keen to receive PA feedback from peers or professionals, but are apprehensive to accept feedback from technology (e.g., fitness applications). This creates a design challenge when building gamified systems: A core benefit of technologies is their ability to provide immediate performance feedback to

users. However, if this feedback is not meaningful to older adults, it is unlikely to contribute to continued engagement.

Design strategy: To provide appropriate feedback while offering older adults some of the benefits of technology-supported PA, designers should explore opportunities to use automated feedback to augment that from peers and exercise professionals. The number of steps walked in a day or a digital representation of heart beat at various activity levels could be incorporated into a gamified application.

Challenge 3: Enabling Social Sharing to Create Community While Avoiding Social Pressure. Participants expressed a strong desire to share activities with friends, give and receive feedback from peers, and generally viewed community as a motivator to participate in PA. This suggests that social sharing would be a means of encouraging user engagement. However, some persons admitted feelings of self-consciousness in the presence of persons perceived as more active, turning the social context into a barrier to PA. Therefore, some gamification solutions, such as leaderboards that allow for comparison with other participants or the sharing of achievements to notify others of one's own success, may not be appropriate for this older audience.

Design strategy: Mindful sharing. Be clear about what is shared. Pick the right things to share, which means sharing of motivational messages, peer support of individual activities and inspirational anecdotes about overcoming challenges could be shared. Do not give out badges, but let older adults take ownership and let them reward each other: Rewards for being positive to one another, giving a digital hug, reaching out to someone in need could all add value in building an online fitness community.

Challenge 4: Supporting PA, Encouraging Ownership, and Enabling Autonomy. A lot of research on the application of interactive technologies to facilitate PA among older adults focuses on the promotion of exercise in a context where technology drives and defines the exercise experience of the older adult (e.g., [2],[32]). However, our findings show that autonomy plays an important role in older adults' enjoyment of PA, particularly selecting exercise routines that fit their lifestyle and the ability to shape activity.

Design strategy: To engage older adults, designers need to shape experiences that enable older adults to take ownership of PA. For example, engaging in a digital dueling match over number of steps climbed in a day, encouraging brisk walking to track distance and time taken for exchange with an online community, and enabling peers to retrace others paths, share narratives and encouraging storytelling and life-logging are design options. This also facilitates gamification as autonomy is one of the core elements of a positive player experience [41].

The above discussion of factors and challenges leading to design strategies supports our research question (RQ3) on the value of analysis of rich qualitative data in the context of designing gamified fitness applications.

Technology Integration: While the above discussion identifies key design challenges in PA for older adults, the integration of technology in the form of digital interventions

[4] can serve as triggers to initiate motivation, sustain interest and maintain a progression within the space-ability-activity continuum.

Challenges for Fitness Applications beyond Older Adults' Preferences: Health tracking and gamification of physical exercise are on the brink of becoming part of our daily routines. Apple has just released a new mobile operating system with a health tracking app and other solutions such as smartwatches are becoming available for the mass market. However, there is a range of challenges if older adults use those systems that extend beyond motivational application design. In the context of gamification as well as quantified health applications, many are created for younger audiences, which may be problematic as threshold data is rarely adjusted to older users. For example, general fitness goals such as taking 10,000 steps a day [44] may not be suitable for older adults with age-related mobility impairments. Thus, applications will need opportunities to adapt such features, suggesting that to effectively engage older adults in fitness applications, we need to rethink all of their elements to ensure they are not only motivating, but also safe to use. In a similar vein, the technology older adults use to exercise should not replace the personal relationships that they have with their trainers and peers. A computer trainer would likely not have the same effect on older adults than a real-life person in terms of social benefits. Small functional feedback might be acceptable, but for the main part, the technology should enable communication with real people and allow older adults to keep as connected and social as they would be when exercising in a gym together.

7. Limitations and future work

As our work is of exploratory nature, there are some limitations related to the sample of older adults that was included. First, many of the older adults that we interviewed were already physically active and not completely sedentary. They were interested in working out more regularly, which might lead to some bias toward PA in this study, and it is important to view our findings in this light. Furthermore, participants were mostly female and the data is therefore skewed in regards of gender. Additionally, health and fitness are personal issues lending a personal bias to the focus group discussions. More work is necessary to survey attitudes towards technology-supported PA among older adults leading sedentary lifestyles, and results might imply the necessity of different technology solutions. Another opportunity for future work lies in the comparison of perspectives on technology-supported PA among older and younger adults. It would be beneficial to this research to explore how an older and younger demographic differ in their baseline exercise motivations, and more distinctly how both groups approach currently available technologies to support PA. This could also lead to insights into how they view gamification of any activity.

8. Conclusion

PA is important at all life stages. To some people, fitness and PA comes naturally, while others appreciate the support that technology and gamification provide. Few technologies are available to support the efforts of older adults wishing to maintain PA routines when health tracking and gamification of physical exercise are on the brink of becoming part of the daily routines of the younger population. Our work provides first insights into older adults' perceptions of technologies to support PA with the goal of helping researchers and designers better understand design challenges when creating playful applications for this demographic. Creating tangible and real digital applications affording the upkeep of motivations, monitoring progress, providing validation and support; and social connections will help to reinforce the necessity of technological interventions for the betterment of older adults' PA. In the context of older adults' lives, such technologies would enable them to support their efforts to stay healthy, and help them maintain and establish PA routines which are crucial to well-being in late life.

9. References

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