Gamification through the Application of Motivational Affordances for Physical Activity Technology

Dennis L. Kappen  
Humber College and University of Ontario Institute of Technology, Ontario, Canada  
dennis.kappen@humber.ca

Pejman Mirza-Babaei  
University of Ontario Institute of Technology, Oshawa, Ontario, Canada  
pejman.m@acm.org

Lennart E. Nacke  
University of Waterloo, Waterloo, Ontario, Canada  
Lennart.Nacke@acm.org

ABSTRACT
Motivational affordances are attributes of interactive technologies or game elements that promote participation in physical activity (PA) routines. Although these affordances have been previously integrated into technologies in nontailored approaches, the motivations of adults for PA are specific (e.g., to improve one’s health, wellness, or fitness). There are no previous comparisons of either the motivation to participate in PA or motivational affordances that facilitate PA in different age groups. Therefore, we conducted an online survey with 150 participants using the Exercise Motivations Inventory-2 scale (EMI-2) together with long-form questions to explore motivational affordances and PA technology preferences in four age groups. Our results suggest health-related pressures are significant motivations for PA in different age groups. Additionally, a content analysis of preferences allowed us to distinguish between gamified motivational affordances and feedback elements. These results provide age-group-specific gamification design guidelines for incorporating motivational elements in PA technology.

Author Keywords
Motivational affordances; gamification; physical activity; motivation; user experience design

ACM Classification Keywords

INTRODUCTION
Successful commercial fitness games, such as Nintendo’s Wii Fit games or Majesco’s Zumba Fitness games, are designed with the general population in mind and are not tailored to appeal to specific age groups. While fitness-tracking technologies like Fitbit [71], Nike+ FuelBand [70], and Google Fit [72] have enabled people to become motivated and track their physical activity (PA), it is not clear how people in different age groups use these technologies. There are major differences in the motivation to keep fit between younger adults [57] and older adults [48]. As the population ages, older adults are trying to lead healthier lifestyles while maintaining their physical and mental wellness [1,8]. Not all older adults pursue fitness in the same way, and they often face more substantial cognitive and physical challenges compared to younger populations [63]. Thus, it is important to compare the motivations and preferences of adults within different age groups.

Motivational affordances [23,38] for the facilitation of PA are elements that help facilitate intrinsic or extrinsic motives to participate in PA. This idea follows from gamification, which is the application of strategies from game design (e.g., actions, challenges, and achievements) to daily activities to help make people’s actions more engaging [14]. Research has shown that gamified fitness applications have the potential to engage people in regular PA [38]. Habits of playing and reasons for not playing exergames (combining PA and gaming technology) studied in age groups (<24, 25-34, 35-44 and >45) revealed preferences in exergame technology, resource and temporal issues [30]. However, the motivations of adults in different age groups including seniors (65+) to become more physically active (PA motivations) have not been studied in detail. Adult preferences for motivational elements that facilitate participation in PA (PA facilitation) have also not been explored before. Thus, we conducted a survey study that combined open-ended answers and self-report scales, including the Exercise Motivations Inventory (EMI-2) [40], to compare the PA motivations of adults in different age groups (18-29, 30-49, 50-64, and >65 years old) and to elucidate their preferences for motivational elements that facilitate PA.

There were significant differences in the motives to participate in PA in the health pressures and ill health avoidance EMI-2 dimensions among the four age groups. Additionally, we identified differences in the motivational affordances preferred by the different age groups, and used these to develop age-group-specific design guidelines.

We make four strong contributions to the CHI PLAY community: (1) We provide empirical evidence of significant
differences in motives for becoming physically active among different age groups. (2) We specify age-group-specific motivational affordances, because our results suggest people in different age groups have different preferences regarding motivational affordances. (3) We classify motivational elements into gamified motivational affordances and feedback elements facilitated by a content analysis. (4) Finally, we deliver age-specific design guidelines for incorporating motivational elements into technologies used to facilitate PA. A better understanding of how interactive technologies can meet the needs of adults in different age groups should enable us to create meaningful fitness and PA technologies.

RELATED WORK
Many commercial systems have combined gamification with PA [38] as a behaviour-change strategy to help individuals achieve health and fitness goals. For example, fitness trackers have been shown to motivate workout activities by providing feedback [52]. Initially, we will review the literature on the motivation to participate in PA, the relevance of gamification, and fitness and motivational affordances in a PA context.

Comparison of Motivation to Participate in PA
A systematic review of PA and exercise motivation grounded in Self-Determination Theory (SDT) emphasized the importance of autonomous (identified and intrinsic) over extrinsic regulation in promoting PA [65]. Participation in exercises depended on habit formation that needed a minimum of four bouts of exercise over a six-week period [32]. Technology apps like Lift (now: coach.me) have been shown to support habit formation for tracking diet, exercise, spirituality, personal hygiene, education and personal growth, but they require continual usage [56]. However, this previous study did not address PA or motivational affordances. Additionally, while intrinsic rewards have been shown to promote exercise in the initial phase, habit formation helped to maintain participation in exercises over time [18,54]. Furthermore, while motives for participating in PA differ across type of activity, age, and gender in adults [47], this previous study did not identify any motivational affordances of technology-assisted PA. To explain why it is important to compare the motivation to participate in PA in different age groups, we will first discuss younger adults and older adults in the context of PA and the use of motivational affordances in gamified technology.

Younger adults and PA
Self-determined situational motivation (the reason why someone does something in a particular situation) drives self-determined contextual motivation (the understanding of why someone is doing something), and social factors have been shown to positively predict the motivation of younger adults to participate in exercise and PA [35]. Studies involving younger populations participating in Tae Kwan Do and aerobics have revealed exercise adherence improved when motives were enjoyment, competence, and social interaction, as opposed to motives focused on fitness or appearance [61]. Motivational affordances provided by a wrist-worn activity monitor were shown to have only a short-term positive effect on PA and sedentary activity (SED) in young men [24]. Monitoring of physical activity metrics and tracking was shown to be motivating because of the increased awareness of one’s own behaviour [46]. While college students reported that enjoyment and challenge were intrinsic motives for participation in PA, extrinsic motives included appearance, weight, and stress management [39]. Motivational affordances are made possible through persuasive technologies and gamification, and foster social collaboration and PA [66]. Goal-setting in the form of a daily step count has been shown to facilitate increased PA [6]. In the game Fish’ n’ Steps, participants were encouraged to overcome a sedentary lifestyle by having their daily step count determine the growth and actions of an animated fish [36]. However, the preferences for motivational affordances by younger adults in technology-facilitated PA have not been investigated.

Older Adults and PA
Previous studies [5] have examined the benefits of gaming activities and how older adults use game technology [3]. This research has focused predominantly on the relevance of gaming and its applicability in rehabilitation, physical and cognitive training, leisure and entertainment, and adult learning. While older adults often participate in aerobic activity classes, dancing, yard work or gardening, swimming and water aerobics [17], or even Tai Chi [55], cognitive changes and increasing physical challenges associated with aging reduce the opportunities of older adults to play digital games or exercise using video games [37]. Playful applications, such as motion-based video games, hold the promise of encouraging accessible PA in older adults [19]. Prior research has demonstrated that these game applications may have beneficial effects on the physical and emotional wellbeing of an aging population [27,63]. Motivational characteristics, such as purposeful interactions, customization of activities, fostering of independence, building relationships, sharing and accommodating preferences [28], are commonly seen with older adults, and these relate to their lifestyle attitudes. PA motivation for older adults with persuasive technologies depended on social, physical and intrinsic triggers [58]. Additionally, as a result of improved wellness and decreased sedentary time [1], prescriptive interventions with casual video games have been suggested to prevent and treat stress [59], and thus to improve the mood of participants.

Behaviour-Change and Motivational Affordances
While gamification relies on intrinsic and extrinsic motivations provided by a gamified application, Larsen found a user’s external motivation could increase their internal motivation over time [34]. The fact that human behavior can

---

1 https://www.coach.me
be influenced using game design principles in decision-making applications and services [29] suggests that it may be possible to identify behaviour-change elements to foster intrinsic motivation. Customization of these gamification elements based on demographics or age groups may contribute to the personalization of playful technologies. This customization of playful technologies necessitates the understanding of specific preferences of triggers that motivate gameful PA [31]. The association of different skill atoms with different age groups—based on preferences, needs, and wants—is critical for the design of technology artifacts. The exploration of physical activities through gamification [20] could help provide access to activities that would otherwise be precluded by age-related challenges. Therefore, the investigation of motivational affordances based on demographic characteristics such as age groups should promote our understanding of how to implement game design elements in technological artifacts. Although a few research projects have studied behaviour change in fitness and health apps (see below), there has not been a detailed comparison of motivational affordances facilitating PA technology based on age groups.

While Lister et al. reported how gamification can change health behaviours by using game elements in fitness and health apps [38], their study did not compare age-group-specific preferences. King et al. reported strategies to influence health behaviours, which led to the collective aim to develop digital ‘games with a purpose’ [33]. However, they did not address any demographic-specific strategies. Other researchers have applied motivational affordances to help maintain adherence to mundane and boring activities such as exercise and daily physical activities [22], but that study focused on a demographic comprised of younger adults. Commercial devices and websites (such as Fitbit [71], Nike+ FuelBand [70], Fitocracy [73] and FitOrbit [74]) have leveraged the quantification of achievements to motivate users. However, little research has been done on the motives for using these technologies among adults in different age groups.

A study of exercise habits in younger participants (mean age = 21) revealed that adherence (continued participation in PA or exercise routines) was associated with motives focused on enjoyment, competence, and social interaction rather than personal fitness or appearance [61]. Health benefits resulting from the observation of fitness routines [50] are linked to the motivation of older adults (mean age = 78) to initiate and maintain fitness activities [53]. Research on intrinsic and extrinsic motivations in older adults (mean age = 63.8 years) [11] explored their activity levels (inactives, actives, sustained maintainers) against dimensions of health and fitness, weight management, appearance, stress management, enjoyment, emotion, and sociality. For younger adults (mean age = 18.6 years) who were actively involved in PA, studies have shown that intrinsic motivation has a greater effect than extrinsic motivation [7]. None of the studies mentioned above compared age groups and they all specifically focused on either a young population or an older population. In contrast, our study offers a comparison of different age groups, preferences for motivational affordances in PA technology and PA.

**Toward a Survey Study of Motivational Affordances**

Survey studies have been used in investigations of personality-targeted gamification [25], the social influence on gamification [22] and persona development [44]. We specifically examined recent CHI papers on survey studies to obtain methods and procedures for reporting survey results [4,25].

While research has shown gamification can be used to add motivational affordances to mundane activities such as exercise routines and physical activity [38], it is important that we investigate the relevance of these affordances in different age groups. Additionally, physical activity is important in all life stages, and while health technologies and gamified fitness strategies have been widely adopted by the younger population, little research has been done on the motivational affordances facilitated by technology among different groups. Previous studies [11,42] have examined the intrinsic and extrinsic motivations of older adults and younger adults to engage in physical activity [49,57]. PA could include daily activities like work, yard and garden activities, walking for leisure and/or routine exercises. However, to the best of our knowledge, no previous study has compared motivational affordances preferred by adults in different age groups using gamified fitness applications to influence PA participation. Here, we describe a survey study that sought to identify the similarities and differences in motives to participate in PA and the influence of motivational affordances as a technology facilitator for PA.

**THEORETICAL DEVELOPMENT**

Self-Determination Theory (SDT) posits the self-regulation of uninteresting activities is an inherently motivational construct that occurs through the process of internalization. The facilitation of internalization [12] serves as a catalyst to engage with a gamified application. However, the expectation of extrinsic rewards can marginalize intrinsic motivation [13,60]. Intrinsic motivation is facilitated when autonomy, competence, and relatedness—the three psychological needs of human motivation—are satisfied [62]. From the perspective of the intersection of SDT and PA, integrated regulation was an important predictor of exercise behaviour [16]. In middle-aged adults (mean age = 31.8 years) using PA technology social comparison provided greater motives to participate in PA [69]—while the effects of extrinsic motivational affordances (e.g., virtual rewards) were inconclusive.

To select a scale for our study, we reviewed different measures used by researchers to study motivation and PA: (1) The Intrinsic Motivations Inventory (IMI) [43] addressed the need for the accurate assessment of psychological constructs in a competitive sport setting. According to a study that used the IMI, apparent intrinsic motivation may be extrinsic—fueled by rewards such as weight loss, im-
provements in physical appearance, and social recognition [41]. (2) The Self-Motivation Inventory [15] aimed to identify variations in adherence to physical activity and dropouts [21] within female and male participants. (3) The Exercise Motivations Inventory (EMI) [40] and Exercise Motivations Inventory-2 (EMI-2) [41] proposed a collection of exercise participation motives in adults that could be applied to both exercisers and non-exercisers. (4) The Psychological Need Satisfaction in Exercise scale (PNSE)[67] validated high levels of need satisfaction in exercise contexts. We decided to use the EMI-2, because the focus of our study was to compare motives to participate in PA between age groups.

Based on the focus towards investigating PA motives and preferences towards motivational affordances, the theoretical development in this study consisted of the triangulation of three domains: (1) Motivation to participate in PA, (2) Motivational Affordances, and (3) PA.

**Research Questions**

Participation in daily PAs, exercises, or fitness routines is critical to overcome a sedentary lifestyle and helps to maintain and improve health and wellbeing in adults of all ages. Motivation to participate in PA can be achieved through gamified behaviour-change strategies [2, 28, 51]. However, there has been little research on the differences in the motives to participate in PA among age groups. Using devices and apps to monitor physical activities and exercise routines makes it possible to also monitor progression or regression over time [38]. Many of these apps situate motivational affordances to help foster intrinsic and/or extrinsic PA motivation [64]. Additionally, the understanding of age-group-specific preferences for these motivational affordances is critical if we hope to integrate them into the design of PA technologies. While a non-tailored, generalised approach is being used in current fitness-tracking and gamified PA technology, more research is needed to understand the preferences for these motivational affordances in adults in different age groups. Thus, we asked the following research questions:

**RQ1:** Are there differences in the motivation to participate in PA between adults from different age groups?

**RQ2:** Does the choice of motivational affordances differ between age groups?

**STUDY DESIGN AND METHODS**

We conducted a survey study using a questionnaire in both online and printed formats. A recruitment drive for participants was carried out through email and blog posts, by posting the survey link through social media channels such as Twitter, LinkedIn, and Facebook, and through recruitment at community centres and fitness centres.

**Survey Design**

We included a “by hand” option for participation because we were also targeting older adults (65+). This questionnaire was a compilation of EMI-2 [41]—a revised Exercise Motivations scale—demographic questionnaires, and questions on preferences for motivational affordances to participate in PA. The EMI-2 is a multidimensional, 51-item scale designed to assess an individual’s motives to participate in exercise. These 51 items are categorised into 14 dimensions (Stress Management, Revitalization, Enjoyment, Challenge, Social Recognition, Affiliation, Competition, Health Pressures, Ill Health Avoidance, Positive Health, Weight Management, Appearance, Strength & Endurance, and Nimbleness). We extended the applicability of this scale by replacing the term ‘exercise’ with ‘physical activity’, so that it included a wide range of activities defined as light, moderate, or strenuous PA, which is relevant for older adults [10].

**Participants**

Data were collected over a four-month period (April 2016-July 2016). Participants were offered the option of a chance to win one of three Amazon.ca gift cards, each valued at $30 CDN. In total, 192 participants took part in the survey: 22 respondents filled the survey by hand and responses were then transferred to the survey database, and 170 responses were completed in an online questionnaire format. Forty-two of the total survey responses had to be purged because of incomplete data, resulting in 150 complete responses.

**DATA ANALYSIS AND RESULTS**

**Participant Demographics**

Most PA guidelines are defined for age groups: adults (18-64) and older adults (65+) groups [9, 68]. However, to compare the needs and preferences of adults in different age groups, we used age cohorts from a study on adults and gaming [26]. Based on this research study, we binned the data into four age groups: 18-29 years old (G1), 30-49 years old (G2), 50-64 years old (G3), and 65+ years old (G4). These groups were coded 1-4 for data analysis. Gender was equally distributed (F=75, M=75) in the total sample population and gender distribution within each group is shown in Table 1.

We collected demographic information from participants (as a percentage of the overall sample population) regarding

<table>
<thead>
<tr>
<th>Total Participants</th>
<th>(N=150)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
</tr>
<tr>
<td>(1) 18-29 (17, 11.3%) (GF=11, GM=6)</td>
<td>M=25.7, SD=2.5</td>
</tr>
<tr>
<td>(2) 30-49 (58, 38.7%) (GF=28, GM=30)</td>
<td>M=39, SD=5.85</td>
</tr>
<tr>
<td>(3) 50-64 (43, 28.7%) (GF=25, GM=18)</td>
<td>M=56.9, SD=3.9</td>
</tr>
<tr>
<td>(4) 65+ (32, 21.3%) (GF=11, GM=21)</td>
<td>M=71.9, SD=4.9</td>
</tr>
</tbody>
</table>

| Devices used to play digital games |         |
| Smartphones | 35.0% |
| Cell-Phones | 11.7% |
| Tablets | 22.3% |
| Desktop PC | 9.7% |
| Laptop computers | 9.7% |
| Game Consoles | 7.8% |
| Online | 1.9% |
| All on the list | 1.9% |

Table 1: Demographics; GF= Gender Female, GM= Gender Male, N= Total, M=Mean, SD = Standard Deviation.
their age, gender, hours spent sitting per day, hours spent sleeping per day, inclination to play digital games, devices used to play games, time spent in physical activity per day, apps used to monitor physical activities and devices used to monitor physical activities. Detailed information not shown in Table 1 is shown in our supplementary materials.

From the total sample (N=150), more than half of the respondents (60.1%) spent more than five hours sitting per day, and slept for 7-8.5 hours per day (54.4%). While a high percentage of the respondents did not play any digital games (52%), among those who did, smart phones (35%), tablets (22.3%) and cell-phones (11.7%) were the most desirable media for playing digital games. Additionally, while a high percentage of the respondents spent less than an hour per day participating in PA (28%) and did not use any apps (71.3%) or devices to monitor their PA (60.7%), Fitbit (19.1%) and pedometers (17%) were most often used by the remaining respondents. Our data indicate that, of the respondents who played digital games, mobile devices were preferred for digital games and wearable tracking devices were preferred technology choices.

Data Analyses
We used a mixed-method approach to analyse the data. Survey responses from the EMI-2 questionnaire were analysed quantitatively. Content analysis was carried out on the long-form text responses buy identifying frequencies of motivational affordances and grouping them into the question categories.

Reliability and Normality
All 14 dimensions of the EMI-2 scale [41] had high reliabilities, Cronbach’s α =.90. The scale reliability with dimensions deleted is shown in the supplementary materials. Data from the 51-item, 14-dimension EMI-2 scale were non-normal (Kolmogorov-Smirnov test).

Motivational differences between age groups
Non-normal data from the four groups binned according to age groups were tested using the Kruskal-Wallis test for differences. Only two dimensions, ‘health pressures’, $H(3) = 7.96, p < .05$, and ‘ill health avoidance’, $H(3) = 8.90, p < .05$, differed significantly between the age groups. This indicated that among the age groups, ‘health pressures’ and ‘ill health avoidance’ facilitated participation in PA.

<table>
<thead>
<tr>
<th>DV (control)</th>
<th>Age Category</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>30-49 years old</td>
<td>$U=358, r = -.20$</td>
</tr>
<tr>
<td></td>
<td>50-64 years old</td>
<td>$U=224, r = -.30$</td>
</tr>
<tr>
<td></td>
<td>65+ years old</td>
<td>$U=165, r = -.32$</td>
</tr>
<tr>
<td>IHA</td>
<td>30-49 years old</td>
<td>$U=284, r = -.30$</td>
</tr>
<tr>
<td></td>
<td>50-64 years old</td>
<td>$U=206, r = -.34$</td>
</tr>
<tr>
<td></td>
<td>65+ years old</td>
<td>$U=146, r = -.38$</td>
</tr>
</tbody>
</table>

Table 2: Mann-Whitney U statistic. EMI-2 scale dimensions: HP = health pressures; IHA = ill health avoidance.

Pairwise comparisons using the Mann-Whitney test were performed to follow up the above finding and to investigate further differences between age groups within the two dimensions identified above. We used G1 (18-29 years old) as a control group and compared the results with those in the other three age groups. Health pressures (HP) and ill health avoidance (IHA) and dependent variables (DV) were significant with G2 (30-49 years old), G3 (50-64 years old) and G4 (65+), as shown in Table 2 (all $p < .05$). Additionally, to investigate the trends in dimensions between age groups we used the Jonckheere-Terpstra statistic to test for ordered patterns of the averages of the 14 EMI dimensions of the four age groups. Jonckheere’s test revealed a significant trend in health pressures ($J = 4795, z = 2.78, r = .22$), ill health avoidance ($J = 4579, z = 2.02, r = .16$), and nimbleness ($J = 4716, z = 2.495, r = .20$) (all $p < .05$).

Motivational Affordances for PA
The respondents answered the following questions:
1. What types of feedback do you look for in an app to help you with PA?
2. Can you suggest attributes in the app that could motivate you to participate in PA?
3. Can you suggest attributes in the app that do not motivate (negative attributes) you to participate in PA?
4. Can you suggest attributes in the app which could help facilitate goals for PA?
5. Can you suggest any attributes which could help you continue to participate in physical activity sessions over a longer period of time?

A content analysis of the answers to long-form text questions in the survey was performed using Excel (Microsoft, Inc.). Long-form text data were categorised based on the motivational affordances for PA [23,38]. The frequencies of the attributes were determined as a percentage of the total number of attributes ($n_{at}$) listed by the respondents per age group. While the content analysis revealed many attributes for each question, we report excerpts of the percentages of the attributes for each of the question categories. The remaining percentages for the attributes are shown in the supplementary materials.

Feedback types: The comparison of the feedback types looked for by each group showed respondents in each group sought different feedback types. Table 3 shows the excerpts of the percentages feedback attributes in each group.

Representative responses from G1: for calories: ‘I would look for calories’; ‘calories burnt’; ‘calorie counter’; for heart rate: ‘[...]it would be good to see heart rate’; for step-counters: ‘noting steps is like hitting a mark’.

G2: for calories: ‘[...]used for calorie count/calories burned’; for distance travelled and step counters: ‘step counter to see the distance between places and sometimes how much calories need to be burn(ed) if I eat a certain type of food’; ‘the number of calorie / weight / progression / number of steps’.
for time: ‘want to do this often’; ‘the more I do it, the faster I go’; ‘check time taken to do this’; ‘performance improvement over time’; for points: ‘like to see my points’; for feedback: ‘step counters and calorie counters’; ‘[...]with Fitbit: Step and miles counter’; ‘immediate feedback on number of steps taken’.

**Table 3: Feedback types**

<table>
<thead>
<tr>
<th>Age Cat</th>
<th>Types of Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29</td>
<td>Calories (15.7%), heart rate (13.7%), step counters (9.8%)</td>
</tr>
<tr>
<td>(n=110)</td>
<td></td>
</tr>
<tr>
<td>30-49</td>
<td>Calories (18.2%), distance travelled (15.5%), step counters (16.4%)</td>
</tr>
<tr>
<td>(n=117)</td>
<td></td>
</tr>
<tr>
<td>50-64</td>
<td>Time (19.3%), points (17%), feedback (11.4%)</td>
</tr>
<tr>
<td>(n=88)</td>
<td></td>
</tr>
<tr>
<td>65+</td>
<td>Step-counters (17.9%), distance travelled (14.5%), calories (14.5%)</td>
</tr>
<tr>
<td>(n=81)</td>
<td></td>
</tr>
</tbody>
</table>

**Motivation to participate in PA:** Excerpts of percentages of three preferences of attributes that could motivate to participate in PA in each of the four age groups are shown in Table 4.

**Table 4: Affordances**

<table>
<thead>
<tr>
<th>Age Cat</th>
<th>Affordances</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29</td>
<td>Badges (11.4%), progression (11.4%), goals (9.1%)</td>
</tr>
<tr>
<td>(n=44)</td>
<td></td>
</tr>
<tr>
<td>30-49*</td>
<td>Calories (10.4%), step-counters (8.3%), progress (6.3%).</td>
</tr>
<tr>
<td>(n=96)</td>
<td></td>
</tr>
<tr>
<td>50-64**</td>
<td>Calories (12.3%), distance travelled (12.3%), weight loss (8.8%)</td>
</tr>
<tr>
<td>(n=57)</td>
<td></td>
</tr>
<tr>
<td>65+</td>
<td>Step-counters (10.6%), distance travelled (10.6%), progression (6.4%)</td>
</tr>
<tr>
<td>(n=94)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* no monitoring (12.5%)</td>
</tr>
<tr>
<td></td>
<td>** no monitoring (21.1%)</td>
</tr>
</tbody>
</table>

**Table 5 shows excerpts of percentages of negative attributes that affect participation in PA.**

**Table 5: Negative attributes**

Representative responses from G1: ‘[...]step-counters- I've never used one and don't care to try[...]seems unnecessary’; ‘[...]too much pressure with counting and maintaining steps[...]’; for social affordances: ‘[...]social aspects don't interest me’; ‘[...]I do not like the pressure of sharing’.

**G2:** for challenges: ‘[...]the competition side of the physical activities’; for step counters: ‘[...]too much time it takes to learn something, too much fiddling’; for social affordances: ‘[...]too much social stuff, I don't need to share every time I take a deep breath[...]’; ‘[...]other people don't motivate me, I prefer to work out alone[...]’; ‘[...]Notifications from the app which tell you that your friend is doing better than you, really annoying I feel like that's childish[...]’.

**G3:** for calories: ‘[...]good to know how much I burned’; for distance travelled: ‘I love the stats on the Fitbit [...] weekly totals of (km) walked’.

**G4:** for distance travelled: ‘I like walking, so distance is important’; ‘distance monitoring device’; for progression: ‘comparisons to previous similar exercise / i.e. cycling routes same climbs and compare times’; ‘show progress or improvement’.

**Negative attributes:**

**Table 6 shows excerpts of percentages of attributes that help in facilitating PA.**

**Affordances that facilitate goals for PA:**

Representative responses from G1: ‘[...]I like receiving badges’; ‘[...]anonymous competition between friends resulting in like Fitbit badges’; for progression: ‘[...]seeing how far behind I am compared to friends’; ‘progress indicator towards goals’; ‘comparison of past few results towards a goal’.

**G2:** for calories: ‘[...]need to know calories and general trend’; calories burned’; for progression: ‘the Nike running app has motivated me to run more based on the tracking my progression and setting up challenges’; ‘along with daily stats it also provides tips which is specific to you’; ‘daily progress chart’; ‘logging of activities’.

**G4:** for time: ‘watching the clock is a stress’; for challenges: ‘[...]do not like challenges that are tough’; ‘fear of falling’; ‘complex steps’; ‘complex routines’; ‘easy to remember (difficulty)’; ‘fear of exertion’; ‘Intensity of physical activity’; for progression: ‘[...]as the day progresses I am less likely to be active or want to start anything’.

**Affordances that facilitate goals for PA:**

Representative responses from G1: ‘[...]I like receiving badges’; ‘[...]anonymous competition between friends resulting in like Fitbit badges’; for progression: ‘[...]seeing how far behind I am compared to friends’; ‘progress indicator towards goals’; ‘comparison of past few results towards a goal’.

**G2:** for calories: ‘[...]need to know calories and general trend’; calories burned’; for progression: ‘the Nike running app has motivated me to run more based on the tracking my progression and setting up challenges’; ‘along with daily stats it also provides tips which is specific to you’; ‘daily progress chart’; ‘logging of activities’.

**G4:** for time: ‘watching the clock is a stress’; for challenges: ‘[...]do not like challenges that are tough’; ‘fear of falling’; ‘complex steps’; ‘complex routines’; ‘easy to remember (difficulty)’; ‘fear of exertion’; ‘Intensity of physical activity’; for progression: ‘[...]as the day progresses I am less likely to be active or want to start anything’.
<table>
<thead>
<tr>
<th>Age Cat</th>
<th>Affordances</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29 (n=34)</td>
<td>Goals (14.7%), challenges (11.8%), step counters (11.8%)</td>
</tr>
<tr>
<td>30-49 (n=78)</td>
<td>Challenges (14.5%), goals (12.0%), progression (9.6%)</td>
</tr>
<tr>
<td>50-64 (n=65)</td>
<td>Choice (14.1%), goals (9.4%), step-counters (7.8%)</td>
</tr>
<tr>
<td>65+ (n=112)</td>
<td>Goals (8.9%), badges (8%), challenges (7.1%)</td>
</tr>
</tbody>
</table>

**Table 6: Affordances that facilitate goals for PA**

Representative responses from G1: for goals: 'I'd need to have goals for what I want to accomplish in mind'; 'I need calculating goals for me based on diet [...]'.

G2: for goals and challenges: ' [...] the goals that I have for my life help decide my activity goals'; ' [...] I've used a running app in the past which trains you to reach a specific running goal (5km runs); ' [...] cumulative milestones like run 500 km in a year or other milestones like fastest 10km run'.

G3: for goals: ' [...] prefer to achieve goals'; ' [...] burn off calories'; ' [...] benchmark in terms of physical activity expected for age - to compare myself against the benchmark'.

G4: for goals: ' [...] simple routines'; ' [...] easy to remember and recall steps'; ' [...] I do the same activities over and over again'; ' [...] age related goal suggestions'; ' [...] incremental goals'; ' [...] simple steps and routines'.

**Continuance of PA:** Table 7 shows excerpts of the attributes that could facilitate continuance of PA over a longer time frame.

<table>
<thead>
<tr>
<th>Age Cat</th>
<th>Affordances</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29 (n=37)</td>
<td>Badges (16.2%), goals (16.2%), progression (13.5%)</td>
</tr>
<tr>
<td>30-49 (n=56)</td>
<td>Progression (10.7%), step counters (10.7%), time (10.7%)</td>
</tr>
<tr>
<td>50-64 (n=55)</td>
<td>Goals (12.7%), step counters (10.9%), feedback (9.1%)</td>
</tr>
<tr>
<td>65+ (n=86)</td>
<td>Feedback (15.1%), progression (14%), goals (12.8%)</td>
</tr>
</tbody>
</table>

**Table 7: Continuance in PA over a longer time**

Representative responses from G1: for badges: ' [...] I think virtual badges are neat'; ' [...] some kind of game/badge element with goals for completing a given exercise'; ' incentives'; 'stars'; 'badges'.

G2: for progression: ' [...] a graphical completion chart'; 'progression history'; ' [...] tracking progress of how you are improving'; ' [...] tracking over time to show progress'.

G3: for goals: ' [...] like training targets'; ' [...] do nature stuff'; ' [...] good health'; ' [...] speed to complete 6 km of walking per night'; ' [...] willingness to have a healthy body'.

G4: for feedback: ‘Involuntary updates (perhaps weekly) delivered to me with graphic information indicating progress’; ‘I prefer improvements on daily and weekly basis’; ‘ [...] more interaction and feedback on an app like using my Fitbit’; ‘ [...] need feedback on improvements [...]’; ‘ [...] advice of family physician’; ‘ [...] praise’.

While social affordance generally had a lower percentage for facilitating the continuance of PA, a few comments regarding this affordance were: ‘ [...] someone to compete with directly and share [...]’; ‘ [...] social linking to track progress easily and participate remotely in shared exercise with friends’ (G2); ‘ [...] prefer a consistent social group’ (G3); ‘ I need a social environment for higher motivation to initiate and stick to physical activity’ (G4). The content analysis provided insights into the preferences of respondents from the four age groups for motivational affordances that facilitate PA or serve as triggers to help foster motivation in PA.

**DISCUSSION**

In this study, we surveyed motives to participate in PA and compared preferences for motivational affordances for technology-facilitated PA among four age groups. Health tracking and the gamification of physical exercise are becoming part of our daily routines. However, a range of affordances that are used in these wearable and online applications are generalized towards a generic population, and are not tailored towards the exercise motivations of specific demographic populations. The presumption that the design of these applications can involve the universal adaptation of these systems to different age groups may be flawed. Our survey study helps to shed more light on this issue by providing insights into age-specific motivations for PA. Our survey study analysed positive and negative attributes that could help facilitate or hinder technology-facilitated PA.

**Comparison of Motivational Differences of Age Groups**

In our study, we reduced the 51 scale items into 14 dimensions as suggested by the EMI-2 literature [41]. The 14 dimensions for motives to participate in PA had high reliability. Non-parametric tests revealed significant results only for the health pressures and ill health avoidance dimensions. Based on the EMI-2, this result indicated that advice from doctors, the desire to prevent illness prevalent in the family and the need to recover from an illness took precedence over scale items from other dimensions. Similarly, avoidance of heart disease, prevention of health problems, avoidance of ill health and the desire to stay healthy were significant motivations in the ill health dimension. Furthermore, a pairwise comparison between two groups (using G1 as a control group) revealed significant results for the three other age groups in the health pressures and ill health avoidance dimensions. These two dimensions are important motives for participating in PA for all age groups.

We observed a statistically significant trend of higher median scores (Jonckheere-Terpstra statistic) within the health pressures, ill health avoidance, and nimbleness dimensions. These findings help to answer our RQ1 regarding differ-
ences in motivation to participate in PA between adults from different age groups.

Motivational Affordances for Different Age Groups

Feedback Types
A content analysis of long-form survey responses showed the following. Firstly, the most popular feedback type that age groups 1 and 2 refer to was feedback on calories. Time taken to complete a task was a popular feedback preferred by group 3, whereas step counters was popular with the older demographic. We could argue that possibly keeping track of calories matters more during our active years in life, while later in life we want more specific feedback like scheduling our exercise around our (often family) life and even later we want to ensure we are staying active and remain mobile at all. Often a little walk can do wonders to an otherwise sedentary retirement lifestyle. It is possible the participants in group 4 walked more than those in the other groups, which made distance travelled the second-most favourite type of feedback preferred by this group. We would like to assume that this likely refers to feedback that incentivizes walks and promotes mobility for older adults. For the design of gamified health applications to facilitate PA in these age groups, this means that these types of feedback elements can be given greater focus.

The least-favoured types of feedback were achievement, choice, cost (G1); weight loss (G2); achievement, cost, distance travelled and sound (G3) and achievement, cost, sharing and weight loss (G4). This is interesting because in the following discussion we outline that badges are important to the younger age group (G1) and that they do not have negative feelings about challenge. It is arguable that the form of achievement feedback matters for this age group more than for other age groups. Another disparity is seen for G2, who clearly liked feedback on their calorie consumption but would not prefer to see actual weight loss indicated. This could be because weight loss at that age might be challenging (simply because we are generally entering our working life and it is hard to find time for losing weight when we are starting families and securing our advancement on the job market). To avoid frustration, it is easier to show progress and monitoring of calories than to indicate (possibly slower) weight loss for this age group.

Motivational Affordances Facilitating PA
In terms of motivational affordances to facilitate PA, the most popular affordances were badges and progression for G1, calories for G2 and G3, and step counters for G4. This suggests that extrinsic motivational affordances are more popular with the younger age group and tracking metrics (and setting goals to track intrinsic motivation) are more favoured by older age groups G2, G3 and G4. We should note that many of the respondents in G1 were part of the millennial generation. This generation grew up surrounded by video games and it is possible that they more generally understand extrinsic rewards like badges. This generation also likes challenge as part of their health-tracking routines and possibly finds it more attractive to mask caloric progress in badge systems (that can possibly be shared in their social circles as well).

The least popular motivational affordances were trailing feedback (G1), competition, comparison with friends and negative feedback (G2), competition and comparison with friends (G3), and levels (G4). This implies that participants in G2 and G3 were reluctant to share their performance and metrics with others, as were those in the older age group for complex or difficult PA. This might highlight a shift from the older generations towards the millennial generation (G1) in terms of how they share their personal information related to their wellbeing and fitness.

Regarding negative attributes, step counters (G1), challenges (G2 and G3), and time were the least favourite of the motivational attributes. This is consistent with the finding that the least favourable motivational affordance for both G2 and G3 was competition. Time was the least favourable negative attribute for G4, which also implies that the time taken for PA was a negative pressure in this group.

Regarding attributes that aid/facilitate goals for PA, the survey responses were coherent. Goals (G1), challenges (G2), choice (G3) and goals (G4) were the most popular of the attributes. Interestingly, challenges were also a negative attribute for respondents in G2. Further investigation of the responses indicated that respondents were averse to challenge pressure (negative attribute) as opposed to challenges as an attribute. We could interpret these findings as G1 wanting to be rewarded for their progression, G2 and G3 wanting to know that they are progressing toward targets, and G4 wanting to know if they are improving or progressing towards maintaining their health at all.

The least favoured attributes were achievement (G1), sound and device (G2), narrative (G3) and sound and calories (G4). One respondent (G3) was quite interested in narratives, but indicated that the relevance of the narrative was important to the context of the app design. Again, we can see how calorie tracking is of little importance for older adults (G4) and how, controversially, the millennial generation (G1) does not like achievement yet finds badges highly valuable.

Favourite Attributes of PA Technology
Regarding physical activity or exercise adherence (continuance of PA over time), badges (G1), progression (G2), goals (G3) and feedback (G4) were key favourites within each category of technology attributes. In G4, feedback as a generic term meant to get feedback on improvements, form-checking and gait. Again, older adults are more interested in remaining active than in achieving physical targets or fitness goals. In contrast to this, the results from the other age groups were more fitness-related.

Form-checking and speed (G1), cost (G2), speed and quests (G3), and health data (G4), as in the privacy of personal information, were the least favourable attributes that could
hinder participation in PA. G1’s preference for badges but no regard to form-checking could imply an interest in quick fixes and apps that provide rewarding feedback instead of critical feedback aimed at improvement of form (or speed). It is interesting that G3 seems to be averse to quests, because many people of that generation might be baby boomers and are less interested in game mechanics as part of their fitness-tracking applications.

Age-group-specific Design Guidelines
Our survey study focused on comparing the motivation to participate in PA between four age groups and investigating preferences for motivational affordances in PA facilitated by technology. While the motivation to participate in PA differed significantly in the health pressures and ill health dimensions of the EMI-2, a content analysis of long-form survey questions provided design guidelines for tailoring motivational affordances by age group.

<table>
<thead>
<tr>
<th>Age Cat</th>
<th>Design Guidelines for PA Technology</th>
</tr>
</thead>
</table>
| 18-29   | **Motivation for PA**: While fostering intrinsic motivation through affordances like goals and progression, it is also critical to integrate extrinsic motivational affordances like badges and rewards.  
**Facilitating goals for PA**: Incorporate accomplishment affordances while fostering challenge within the context of PA  
**Continuance of PA**: Provide the opportunity to earn badges and rewards while working towards goals |
| 30-49   | **Motivation for PA**: Incorporate feedback elements like calories and distance travelled while providing daily progression and comparisons with a social circle.  
**Facilitating goals for PA**: While integrating a combination of short-term goals/long-term goals, and challenges, provide progression affordance in the form of reaching milestones  
**Continuance of PA**: Integrate progression in the form of visual graphs to show progress over time and achievement of goals |
| 50-64   | **Motivation for PA**: While integrating feedback elements like calories and distance travelled to facilitate walking, incorporate weekly progression elements to foster intrinsic motivation.  
**Facilitating goals for PA**: Provide the opportunity to achieve goals with provisions for comparison with benchmarked PA markers  
**Continuance of PA**: Provide the opportunity to set up goals with feedback on progression |
| 65+     | **Motivation for PA**: Provide monitoring of activities to encourage walking using feedback elements like step-counters and distance metrics while indicating progress or improvement as affordances from a feel-good perspective.  
**Facilitating goals for PA**: Integrate simple routines and challenges while providing opportunities to earn badges  
**Continuance of PA**: Integrate feedback elements to provide involuntary feedback, praise and improvement |

We categorised these age-group-specific design guidelines based on our long-form survey responses into three types: (1) motivation to participate in PA, (2) facilitating goals for PA, and (3) continuance of PA. Our suggested design guidelines are shown in Table 8. These guidelines are important for designers because it helps to customize and personalize motivational affordances for the design of age-centric PA technology. As an example, based on these guidelines, fitness applications like Fitbit or Nike Fuelband could deliver goals and progressive challenges with a mix of rewards and badges while fostering challenges and promoting the feeling of accomplishment among potential customers in G1. In contrast, customers in G4 could be provided with simple routines intermingled with praise for the completion of simple tasks to enable a feeling of validation for their efforts.

Motivational Affordances and Feedback/Tracking Metrics

| Motivational Elements | Gamified motivational affordances  
(Intrinsic elements) | Gamified motivational affordances  
(Extrinsic elements) | Feedback elements |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Badges</td>
<td>Calorie tracker</td>
<td></td>
</tr>
<tr>
<td>Challenges</td>
<td>Rewards</td>
<td>Step-counters</td>
<td></td>
</tr>
<tr>
<td>Progression</td>
<td>Points</td>
<td>Distance travelled</td>
<td></td>
</tr>
<tr>
<td>Achievements</td>
<td>Incentives</td>
<td>Daily notifications</td>
<td></td>
</tr>
<tr>
<td>Choice/options</td>
<td>Leaderboards</td>
<td>Time spent</td>
<td></td>
</tr>
<tr>
<td>Quests</td>
<td></td>
<td>Heart rate</td>
<td></td>
</tr>
<tr>
<td>Social sharing</td>
<td></td>
<td>Breathing rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sleep cycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sound inputs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weight loss indicator</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physical form-checker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gait/posture-checker</td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Differentiating gamified motivational affordances and feedback elements

From a technology-facilitated PA solution perspective, it is important to distinguish between gamification elements and feedback/tracking metrics (Table 9). Our content analysis findings indicate gamification elements as important as motivational affordances. A few of these intrinsic elements that could play a role in fostering motivational participation in PA are goals, challenges, progression, achievements, choice quests, and social sharing leading to a feel-good context. Extrinsic elements such as badges, rewards, incentives, points, and leaderboards were also key findings in
this survey study. As indicated in related literature, many of these extrinsic elements may also support intrinsic motivation to different degrees of intensity [11,22,45]. Many levels of feedback elements or tracking metrics of PA activities can also serve as motivational affordances in technology-facilitated PA, including calorie tracking, step counters, distance travelled, daily notifications, time spent, heart rate, breathing rate, speed, sleep cycle, sound inputs and weight loss indicators. Additional attributes such as physical form-checking, posture correction and gait-checking were also desirable attributes. However, it is important to consider the target demographic when designing PA technology. As our study showed, strong differences in preferences for feedback types and key motivators exist between the millennial generation and older generations. To ensure that PA technology is adopted within the target demographic group, different design decisions must be made early on in the technology design process. We hope that our design guidelines provide a helpful starting point for the development of successful PA technology for different demographics.

Motivations for Physical Activity

Prior studies have shown motivation for PA has intrinsic and extrinsic components [11,15,41]. However, our survey study revealed that the driving force for fostering participation in PA is the desire to maintain good health. The definition of good health can shift over time as people age, where younger people have a stronger tendency to get quick feedback on the things they track, and middle-aged people prefer the ability to set their own goals and follow individual health and fitness targets. Older adults generally use PA technology to ensure their mobility and to maintain physical health.

Thus, our findings help identify and differentiate motivational affordances in adults in different age groups. Our findings also help to differentiate (1) feedback/tracking metrics from (2) gamification elements, thereby helping to minimize the confusion in their application. While both elements serve as motivational affordances for participation in PA, they are distinctly different in function and usage, as explained in the subsection above. As we clearly showed in Table 9, all of the elements are available for the design of motivational PA technology and the emphasis on which ones to use should come from designers, who are informed about their target demographic. In user experience design in general, contextual inquiry (i.e., field studies where designers observe user interactions with similar products as the planned product) is recommended as a first step towards designing a successful interactive product. For building successful PA technology, we would recommend augmenting any findings coming from contextual inquiries with information about demographic tendencies presented here.

Applications that serve as technology-facilitators for PA will need to apply this distinction between feedback metrics and gamification elements diligently. While feedback is a generic term and a gamification element is not, our content analysis indicates that it is important to distinguish feedback elements in the form of tracking PA from feedback within a gamification context. We hope that this differentiation will help designers establish gamification elements and feedback/tracking elements for PA facilitated by technology.

Limitations and Future Research Directions

While the survey study had many participants, G1 included only 17 participants. The small sample size of this age group could be a limitation to this study. While surveys may have their own limitations (e.g. the number of questions presented), this survey study allows us to understand the overall preferences of respondents within these binned age groups. An interview-based qualitative study over a longer period of time would be a possible next step to understand the detailed motivational affordances (intrinsic and extrinsic) that facilitate PA. This would also make it possible to understand the changes in motivational affordances over time. We plan to use these findings to investigate specific motivational affordances and tracking metrics for select age groups to enable the identification and evaluation of gamification elements, tracking elements or feedback metrics. Additionally, the influence of these motivational affordances (intrinsic and extrinsic) can lead to a better understanding of their applicability and influence on intrinsic and extrinsic motivations to participate in PA.

CONCLUSION

While health technologies and gamified fitness strategies have been widely adopted, there has been little research to support the differentiation of motivational affordances for PA in specific age groups to maintain PA routines. This paper contributes to our understanding of the design of gamified PA technology.

Firstly, we provide evidence that health pressures and ill health avoidance significantly influence participation in PA. Furthermore, to the best of our knowledge, this work provides new insights into the differentiation of motivational affordances to be tailored for different age groups, with the goal of helping researchers and designers better understand design challenges when creating PA applications for different age groups. This is an important step in the development of meaningful health technology applications for both young and old adults. This would allow individuals to apply technology for the initiation, maintenance and adherence of PA to promote physical and mental wellbeing. Finally, this research identified a difference between gamified motivational elements and feedback elements, and we provide age-group-specific design guidelines that could be critical for the development of customisable and tailored technology for PA. These are valuable contributions to the growing body of work in human-computer interaction and games.

ACKNOWLEDGMENTS

We thank Dr. Elisa Mekler for providing helpful comments on previous versions of this document. We would like to thank SSHRC (895-2011-1014), NSERC (RGPIN-418622-
REFERENCES


