

Motivational Affordances for Older Adults' Physical Activity Technology: An Expert Evaluation

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Abstract. Gamification has become popular as a behavior change strategy to increase the motivation and engagement of users in a health and wellness applications. Motivational affordances or gamification elements can help to foster intrinsic or extrinsic motivation for an activity as mundane as achieving fitness and wellness goals. Research indicates that there are many motivations among older adults for playing digital games and exergames to encourage physical activity (PA). However, very few specific gamification elements (motivational affordances) have been defined for technology artifacts pertinent to older adults' physical activity (PA). We designed Spirit50, a gamified PA technology app and conducted an expert evaluation using long form questionnaires and the Heuristics Evaluation for Gameful Design instrument. Content analysis and comparisons of expert ratings of the heuristics provided specific insights into motivational affordances for older adults' PA technology.

Keywords: Gamification · Older adults · Motivational affordances · Expert evaluation · Physical activity · Intrinsic motivation · Extrinsic motivation · Behavior change

1 Introduction

Older adults struggle to develop adequate exercise habits to maintain their health [1] and face the challenges of decreasing strength [2], potential diminished mental capacity [3], and social isolation [4]. Encouraging older adults to participate in physical activity (PA) through persuasive technology interventions provides the additional benefit of being able to track user activity. One study showed that overcoming sedentary lifestyles can be achieved through systems like UbiFit Garden where rewards and tracking functions were used to encourage older adults to participate in physical activity [5]. Embodied

gaming or full-body interaction games improved the feeling of capability and encouraged older adults to play together for fun [6]. Interactive computer games [7] or exergames (technology combining exercises with digital gaming) have helped to overcome loneliness and encourage PA [8, 9] and improved physical functioning and cognition health outcomes [10–12]. Exergames have also served as a therapeutic instrument for improving physical function, cognition and social wellbeing [13, 14], provided a user-friendly medium for social interaction, diversion, wellness and rehabilitation [15–17].

While digital games and exergames exist to facilitate PA, gamification is a form of persuasive strategy which incorporates game design elements such as rewards and tracking functions to make mundane actions more playful and serves as a behavior change agent [18–20]. Such applications of a reward mechanism or gamification elements [21–23] or motivational affordances [24, 25] for PA facilitation are elements which help facilitate intrinsic or extrinsic motives. Persuasive technologies using gamification as a strategy indicated emergent themes such as feedback and monitoring, reward and threat, and goals and planning [26].

Prior research on the motivations and preferences to participate in PA indicated that health pressures and ill-health avoidance were significant motives for older adults to maintain an active lifestyle [27]. Understanding older adults' and their intrinsic and extrinsic motivation for PA is an essential primary strategy for the design and development of technology solutions facilitating PA [22, 28–31]. Therefore, we designed a PA motivation gamified technology that was goal-based (vague goals and specific goals) [32] with specific gamification elements and carried out an expert evaluation of this app.

The key findings of this expert evaluation showed that goal-based PA motivation technology designed for older adults' ability to do exercises based on their physical health conditions can be leveraged to foster intrinsic motivation to improve their health and wellness objectives. The contributions of this work can be used by PA technology designers and user-interaction researchers to customize and tailor gamified PA technology for older adults.

2 Theoretical Development

A comparison of existing gamification apps for PA technology revealed that the challenges of aging related to physical ability were not taken into consideration in the design of these apps [32]. These apps and gamified technology were not designed with older adults' needs and wants, and physical challenges due to aging. Based on preliminary studies [22, 27], these needs and wants were further categorized into vague-goals, specific-goals, barriers and current health conditions [32]. This taxonomy of goal-based differentiation of older adults' PA was developed into the Exercise Motivation Technology Framework (EMTF) (**Fig. 1**) [32]. Therefore, our research group designed Spirit50, a gamified PA technology specifically tailored for older adults' PA needs and challenges.

Spirit50 was a gamification application that was designed to provide customized and personalized exercise routines for older adults to help them participate in PA through daily and weekly exercise routines. This technology used SDT [33, 34] and the KEG

[20] model for its design and development. While considering the physical challenges faced by older adults, this artifact was tailored to adapt to the short-term and long-term motivations for PA (**Fig. 1**) that was based on the Self Determination Theory (SDT) [35, 36]. This theory posits that individuals participate in activities due to the inherent satisfaction from the activity (intrinsic motivation) or doing something for an external reward (extrinsic motivation) [20, 29, 35–37] or a combination of both.

In the specific context of this paper, an expert evaluation was sought for reviewing the motivational affordances emerging from a prior study [38] and the technology facilitation of PA using Spirit50. Motivational affordances emergent from the participant interviews helped with creating the mapping of motivational affordances for PA technology [38]. However, based on user experience research, it was important to review the technology mapping with experts to evaluate these motivational affordances in the context of older adults PA motivation. This paper illustrates the expert evaluation of a gamification application (Spirit50) using heuristics and questionnaire to review the technology facilitation of PA, its applicability, usefulness and ease of use of the Spirit50 application in the context of the guidelines of motivational affordances for PA by older adults [38].

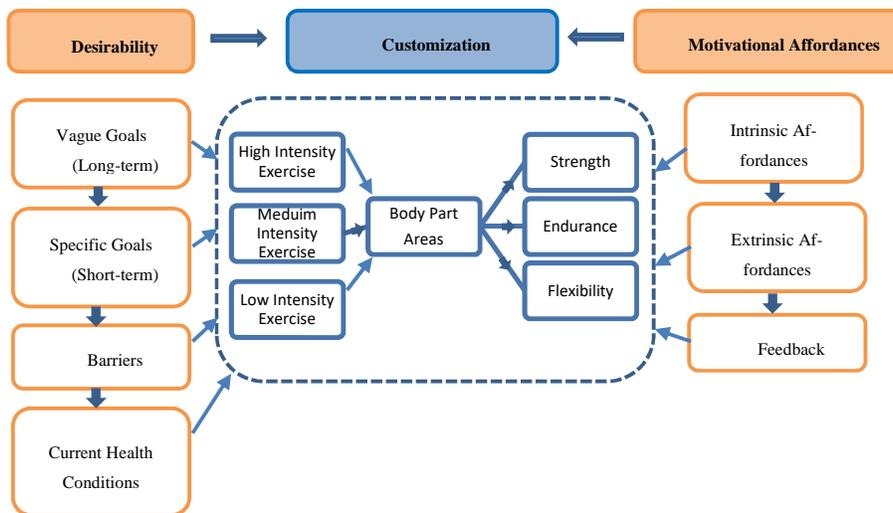


Fig. 1. Exercise Motivation Technology Framework (EMTF) [32]

3 Method

In this section, we review the expert review method and review the instruments used to evaluate the motivational affordances in Spirit50 from the older adults' motivation for PA.

3.1 Expert Evaluation

Expert evaluations are normally conducted to inspect an application or a tool from the vantage point of applicability and usability [39, 40]. An expert heuristic evaluation, or expert review, is a method of assessing a product or service for its usefulness, applicability and ease of use [41–43]. A panel of experts from multidisciplinary domains spanning HCI, computer science, game design and gamification were identified and sent requests for participation in the expert evaluation process.

3.2 Objectives of the Expert Evaluation

Motivational affordances [24, 25] for PA facilitation are elements which help facilitate intrinsic or extrinsic motives to participate in PA. Gamification is essentially applying strategies from game design (e.g., mechanics, dynamics, and aesthetics) to daily activities to make people's actions more engaging. In this expert evaluation "Motivational Affordances" and "Gamification Elements" terms were used interchangeably. Experts were recruited to evaluate the technology artifact (Spirit50.com) for the following objectives:

1. Evaluating motivational affordances for technology facilitated PA
2. Evaluating the usefulness of the Spirit50 application
3. Evaluating the ease of use of the Spirit50 application

3.3 Materials

While user testing of the Spirit50 design helped to resolve usability and interaction issues, the prior eight-week experimental study provided motivational affordances guidelines for technology facilitated PA [38]. Spirit50, to the best of our knowledge, was the only gamified technology designed specifically for older adults and tailored to their age-related abilities. A backup Spirit50 site was set up on a separate server so that it would not conflict with the commercial version of the site. Spirit50 is a web application designed with gamification elements for older adults over 50 years of age. Spirit50 incorporated the following gamification elements (motivational affordances): goal definition (quests), daily challenges, goal progression meter, points and badges (stars), roadmaps, daily challenges, weekly challenges and accolades for completing activities as motivational affordances (gamification).

The survey questionnaire posed questions for motivational affordances from the Heuristics Evaluation for Gameful (HEGD) design, a heuristic toolkit, designed for gamification applications [44] and also consisted of long-form (LF) questions pertinent to applicability of the Spirit50 for the older adult demographic and its usefulness. The LF questionnaire section comprised of the following questions:

1. Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others?
2. In your expert opinion, what other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50?
3. Do you think that the application provided adequate feedback to the participants?

4. If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users?
5. From an expert evaluation perspective, please list a few limitations of the Spirit50 application, if any?
6. From the perspective of older adults, can you suggest ways to improve this application?
7. Do you see any major hindrances in implementing Spirit50 application for older adults (over 50 years of age) in the context of Physical Activity and challenges caused due to aging?
8. Do you see any usability challenges with this application in context of older adults (over 50 years of age) physical activity and challenges caused due to aging?
9. From an older adult's perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities?

The combined survey questionnaire was set up using *LimeSurvey*¹, an open source survey platform on a secure password protected site.

3.4 Participants

As part of the recruitment process, seventeen experts in the domain of gamification and HCI were invited to participate in the expert evaluation. Twelve agreed to participate in the expert evaluation study. Three experts were unable to complete the expert evaluation process due to which reason only data collected from nine experts (F=1, M=8) was used in the final analysis. Experts represented gamification (n = 5), games user research (n = 2), and human computer interaction (n = 2) specializations. Seven of them had Masters Degrees and two held Doctorates. Five experts averaged four years and six months of expertise in gamification or gameful design [45]. While the most experienced expert had more than seven years' experience, the least experienced had two years of research expertise. The experts were invited to evaluate the motivational affordances, usefulness and ease of use of Spirit50.

3.5 Procedure

The expert evaluation was conducted in two stages.

Stage1: The Spirit50 site was cloned and given a login and password for remote access. Step-by-step instructions to access the site and to select the eight-week testing option was provided in a PowerPoint. While the commercial site had a payment plan, a discount code had to be set up so that experts would not have to pay for the site during evaluation. They were encouraged to use the web application as a user and evaluate the process of setting up their goals to exercise, input current health challenges, and select known barriers to exercising. All experts were asked to evaluate the setting up of their eight-week fitness roadmap for the specific goal of "Getting up and down off the floor

¹ <https://www.limesurvey.org/>

with ease”. This specific goal was chosen because it was the same specific goal used by participants in the experimental study described in a prior study [38]. Experts were required to perform all the fitness activities as indicated on the site and step through the task provided on a daily basis. They were allotted a time of one hour to evaluate the site and continue with the activities indicated in the app if they felt the need to do so.

Stage 2: Once the evaluation phase as completed, experts conducted an online assessment of the application using the survey questionnaire.

4 Results

The data from the expert evaluation stored through *LimeSurvey* and exported to SPSS for analysis. Comparisons of the ratings for the HEGD questionnaire and content analysis was carried out for answers to long form questions.

4.1 Comparison of HEGD and Content Analysis of LF

While the number of participants were low, the selections of experts from all 17 dimensions of the HEGD [44] were compared for correlations which are shown in Table 1. Results from detailed qualitative content analysis (QCA) [46, 47] of long-form questions are posted in Table 2.

Table 1. Scale correlations for the HEGD [44]

Intrinsic motivation	Extrinsic Motivation	Context-dependent
Autonomy - Creativity and Challenge - Competence	Ownership and Completeness - Mastery	Feedback and Completeness - Mastery
Autonomy - Creativity and Completeness - Mastery	Rewards and Completeness - Mastery	Feedback and Autonomy-Creativity
Relatedness and Completeness - Mastery	Rewards and Autonomy - Creativity	Feedback and Rewards
Immersion and Completeness - Mastery	Rewards and Relatedness	Actionable Feedback and Immersion
	Rewards and Immersion	Graspable Progress and Autonomy - Creativity
	Rewards and Ownership	Graspable Progress and Feedback
	Virtual Economy and Relatedness	Graspable Progress and Actionable Feedback
		Unpredictability and Relatedness
		Unpredictability and Scarcity
		Unpredictability and Graspable Progress
		Disruption Control and Ownership
		Innovation and Loss Avoidance

Within the **intrinsic motivation** dimensions from the HEGD [44] correlation between *Autonomy - Creativity and Challenge – Competence* imply that the app facilitated the freedom of choice of vague goals (long-term goals) and specific goals (short-term goals) with respect to their health conditions. The increase in difficulty level of the exercise routines afforded the correlation between *Autonomy - Creativity and Completeness – Mastery*. The potential of comparing their performance and their progression on a daily and weekly basis and sharing with others facilitated the *Relatedness and Completeness -Mastery* dimension. Engagement while doing the exercise routines with increasing difficulty levels afforded the correlation between the *Immersion and Completeness -Mastery* dimensions.

With the **extrinsic motivation** heuristics [44], achievement of virtual goods (points and stars) based on the completion of specific tasks of increasing difficulty facilitated positive correlations between the dimensions *Ownership and Completeness – Mastery*. Additionally, freedom of selection of tasks based on the individual's ability and health conditions afforded the *Rewards and Autonomy – Creativity dimension*. Fair acquisition of rewards [44] within the Spirit50 app and meaningful interaction with the narrative of the app afforded the dimensions *Rewards and Relatedness*, and *Rewards and Immersion*. Furthermore, the app facilitated the collection of rewards (points and stars) for task completion and daily and weekly progression helped with correlations between the dimensions *Virtual Economy and Relatedness*.

Within the **context dependent** heuristics [44], positive correlation *between Feedback and Completeness -Mastery, Feedback and Autonomy-Creativity, Feedback and Rewards* indicated that the system communicated the completion of tasks and achievements. Expert evaluation also affirmed the dimensions *Actionable Feedback and Immersion, Graspable Progress and Autonomy – Creativity, Graspable Progress and Actionable Feedback*, and *Graspable Progress and Feedback* due to the presence of progression feedback, daily and weekly roadmap, and comparison of their current standing in the roadmap. Furthermore, intermittent tasks, randomness of tasks contributed to ratings between *Unpredictability and Relatedness, Unpredictability and Scarcity*, and *Unpredictability and Graspable Progress*. Protection against cheating, and allowing ideas to be added for exercise routines, specific goals and health challenges helped with ratings between the dimensions *Disruption Control and Ownership*, and *Innovation and Loss Avoidance*.

5 Discussion

We conducted the expert evaluation of Spirit50, to determine the efficacy of the motivational affordances used in the gamification technology, its usefulness and ease of use for the older adult demographic.

5.1 Motivational Affordances and Older Adults' PA

Experts indicated that *autonomy* can be fostered by empowering older adults' the opportunity to do manageable and achievable PA within the app. Helping them take ownership of their PA activities can help to achieve specific goals [32] such as improving mobility in arms, legs and further leading to full-body mobility. Furthermore, selection of the type of exercise (strength, endurance and flexibility) and

the intensity of exercises (high, medium and low) will help with self-regulation and taking ownership of their PA decisions.

The opportunity to level up, competing on levels of exercise which increase in difficulty level and exercise intensity fosters *competence*. Creating achievement levels based on exercise intensity will enable mastery of specific-goals leading to a feeling of accomplishment. While incremental success at exercise routines in the app is a positive reinforcement for the PA, simplicity of routines can also lead to boredom. Therefore, randomness in the occurrence of difficult challenges could add to the element of curiosity and spontaneity in the gamified app.

Sharing of individual successes and task completion status with others fosters relatedness. The aspect of coaching others based on their own experiences at the activity could help with the concept of sharing. Portability of the app on a smartphone or a mobile device helped with the ease of access to the routines. Furthermore, being able to review the correctness of one's body-form in an exercise routine repeatedly adds value to the gamified PA technology.

Rewarding effort over task completion is an extrinsic motivator. This could be facilitated by interjecting praise for effort done throughout the app which would, in turn, reassure older adults about being on the right track. The app would serve as a virtual assistant or a virtual coach in the PA program. Such rewards would also provide validation of efforts and serve as achievement markers.

5.2 Spirit50 and Motivational Affordances

Intrinsic motivation: Content analysis showed that Spirit50 was one way to facilitate PA amongst older adults. Gamification elements like goals (quests), challenges, and routine activity can help to foster intrinsic motivation among older adults who are focused on improving their health and wellbeing. It could provide a platform for habit formation leading to the continued usage of the app over prolonged periods of time. The exercise routines were simple and could afford the possibility of easily remembering routines for quick repetition. The freedom of selection of vague-goals (long-term goals) and specific goals (short-term goals) [32] afforded *autonomy* among users. *Competence* at being able to do the exercise routines, completing the tasks on a daily basis, performing challenges which were laid out at higher exercise intensities in progressive weeks was also seen in the Spirit50 app. This was also seen in the comparisons of the answers to the HEGD [44] questionnaire, namely the *autonomy-creativity*, and the *challenge-competence*, and *completeness-mastery* dimensions. Furthermore, this showed that the challenges presented in the Spirit50 app were adapted to user's ability, health challenges and achievement of goals.

Extrinsic motivation: Experts valued the presence of virtual rewards' (points and stars) as a means to validate the effort of achieving the goal-based activity. The presence of progression on daily challenges and weekly increments indicated in the road map provided the assurance of task achievement and accomplishment of set activities within the app. This in turn, served as virtual praise for task completion. Therefore, the

presence of a simple reward mechanism for task completion would be meaningful to the user engaged in performing PA as specified by the app.

Feedback options: Experts noted that the presence of goal selection, number of steps and reps completed, the daily fitness roadmap and the visual representation of PA progression was essential feedback for older adults. Experts considered the simplicity of daily activities to be similar to achieving small achievable goals that could be scaled to more complex PA tasks. The presence of new exercise routines that were interjected spontaneously contributed to the surprise, curiosity and unpredictability dimensions of the HEGD [44].

5.3 Limitations of Spirit50 and Future Work

While the Spirit50 app used specific gamification elements', experts indicated that social interaction and community formation [1, 22, 28], two very important aspects for the continuance of PA were missing. Presence of this attribute would help older adults' with overcoming the feeling of loneliness in the aspect of doing PA [48–50]. Additionally, providing a performance rating (correctness vs effort) similar to the feedback provided by a fitness trainer could help with modulation of PA posture, stance, gait and feeling of improvement [27, 51, 52]. An eight-week study using Spirit50 also indicated the need for greater feedback on posture correction and stance improvement within the gamified system [38]. Such features within the system would help to improve older adults confidence in the system and foster competence [22, 53, 54]. While Spirit50 engendered a select collection of fitness routines, the closed system did not allow for the addition of new activities quickly because of depth of programming needed to make such additions. Providing options to change the exercise intensity and difficulty level on a real-time basis was not possible, which would have helped to foster greater *autonomy*.

Expert evaluation also indicated that the sizing of the points, stars and progression icons were small. Additionally, the interface design did not showcase the accomplishments of the users well on the page, leading to a lack of hierarchy of gamification elements on the interface. Furthermore, presenting a time to completion and current levels with reference to future levels in a graphical format would enhance the understanding of the PA quests within the gamified system.

Expert evaluation also showed that real-time feedback regarding correctness of posture could help older adults in improving their form while performing PA routines. This missing feature would need real-time scanning of body positions and overlaying with the computer-generated sequence of PA activities. Spirit50 also lacked showcasing the importance or value of doing a specific set of exercise routines. Additional pop-out screen with this information could help to reassure the value of doing specific PA routines in relation to the selected vague goals and specific goals [32]. Limited dexterity of their hand could also be a deterrent to older adults using a computer mouse when playing the gamified app. Concerns about the perception/misconception of older adults about games and gamification elements were also raised by experts indicating the need for onboarding opportunities within the gamified PA system.

Table 2. Content analysis of LF questionnaire

<i>LF1</i>										
<i>Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others?</i>										
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
goals	goals	goals	goals			goals		goals	6	19%
	points	points		points				points	4	13%
achievement						achievement		achievement	3	10%
					ability	ability	ability		3	10%
competence					competence				2	6%
mastery							mastery		2	6%
	progress bar							progress bar	2	6%
		improved performance					improved performance		2	6%
	feedback			feedback					2	6%
				stars				stars	2	6%
				commenting					1	3%
			competition						1	3%
			collaboration						1	3%
								Total	31	100%
<i>LF2</i>										
<i>What other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50 application?</i>										
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
	challenges	challenges	challenges	challenges		challenges	challenges		6	12%
	goals		goals		goals	goals		goals	5	10%
choice			choice		choice		choice	choice	5	10%
				ability	ability	ability	ability		4	8%
	stars			stars		stars		stars	4	8%
socialization				socialization	socialization	socialization			4	8%

			achievement	points		points		points	3	6%
			achievement			achievement		achievement	3	6%
mastery		mastery					mastery		3	6%
	progress bar						progress bar	progress bar	3	6%
comparison				comparison				comparison	3	6%
competence					competence				2	4%
					leaderboard		leaderboard		2	4%
	feedback			feedback					2	4%
				commenting	commenting				2	4%
			collaboration				collaboration		2	4%
freedom								freedom	2	4%
			competition						1	2%
		onboarding							1	2%
				content creation					1	2%
								avatars	1	2%
randomness									1	2%
								Total	51	100%

LF3 Do you think that the application provided adequate feedback to the participants?

EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
progress bar	progress bar	progress bar	progress bar	progress bar		progress bar	progress bar	progress bar	8	21%
points	points		points	points		points		points	6	15%
	stars		stars	stars		stars		stars	5	13%
completion status			completion status	completion status		completion status		completion status	5	13%
timer		timer		timer	timer			timer	5	13%
more feedback	more feedback		more feedback		more feedback	more feedback			5	13%

required	required		required		required	required				
more progress details		more progress details					more progress details		3	8%
		onboarding required					onboarding required		2	5%
								Total	39	100%

LF4 *If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users?*

EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
correctness			correctness	correctness	correctness	correctness	correctness		6	16%
	challenges		challenges			challenges	challenges	challenges	5	14%
value of exercises			value of exercises			value of exercises		value of exercises	4	11%
performance			performance		performance	performance			4	11%
		onboarding		onboarding			onboarding	onboarding	4	11%
exercise to goal contribution				exercise to goal contribution				exercise to goal contribution	3	8%
about rewards	about rewards			about rewards					3	8%
importance of exercises				importance of exercises			importance of exercises		3	8%
	intensity of exercises					intensity of exercises			2	5%
	points usage						points usage		2	5%
		reason for timer							1	3%
								Total	37	100%

<i>LF5</i>	<i>Limitations of the Spirit50 application, if any?</i>									
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
	show graphs		show graphs			show graphs		show graphs	4	12%
limited onboarding				limited onboarding			limited onboarding	limited onboarding	4	12%
single health issue		single health issue				single health issue			3	9%
	show use of points				show use of points			show use of points	3	9%
feedback on value of exercises			feedback on value of exercises				feedback on value of exercises		3	9%
limited to single goal				limited to single goal					2	6%
weekly achievements							weekly achievements		2	6%
lacking socialization						lacking socialization			2	6%
add randomness				add randomness					2	6%
	not responsive						not responsive		2	6%
	add more quests					add more quests			2	6%
			more health details				more health details		2	6%
			add collaboration				add collaboration		2	6%
add unpredictability									1	3%
								Total	34	100%

<i>LF6</i>										
<i>From the perspective of older adults, can you suggest ways to improve the Spirit50 application?</i>										
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
	more onboarding	more onboarding		more onboarding			more onboarding	more onboarding	5	17%
simplify app			simplify app			simplify app		simplify app	4	13%
	improve interface design		improve interface design				improve interface design	improve interface design	4	13%
			add usefulness of exercises	add usefulness of exercises		add usefulness of exercises			3	10%
add more choices					add more choices		add more choices		3	10%
		add responsiveness			add responsiveness	add responsiveness			3	10%
add benefits of routines			add benefits of routines						2	7%
				add feedback on form/gait				add feedback on form/gait	2	7%
	add value of rewards			add value of rewards					2	7%
		add overall workout plan				add overall workout plan			2	7%
									3	100%
								Total	0	%
<i>LF7</i>										
<i>Any major hindrances in implementing Spirit50 application for older adults in the context of PA and challenges caused due to aging?</i>										
older people and technology	older people and technology					older people		older people and technology	4	19%

						and technol- ogy				
	interface design		interface design				interface de- sign	interface design	4	19%
safety issues	safety issues						safety issues	safety issues	4	19%
		usability is- sues		usability issues			usability is- sues		3	14%
awareness of benefits			awareness of benefits				awareness of benefits		3	14%
					limitations of unsupervised activity			limitations of unsupervised activity	2	10%
						less patience			1	5%
								Total	21	100%

LF8 Do you see any usability challenges with this application in context of older adults' physical activity and challenges caused due to aging?

EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
interface design	interface design		interface design			interface de- sign	interface de- sign	interface design	6	23%
		simplicity of interac- tion steps		simplicity of interaction steps	simplicity of interaction steps	simplicity of interaction steps	simplicity of interaction steps		5	19%
	onboarding			onboarding	onboarding				3	12%
	explanation of the value of the app					explanation of the value of the app		explanation of the value of the app	3	12%
		simplicity of app	simplicity of app		simplicity of app				3	12%
	feedback loop					feedback loop			2	8%
explanations							explanations		2	8%

of icons										
	explanation of rewards		explanation of rewards						2	8%
									Total	26 100%
<i>LF9</i>	<i>From an older adult's perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities?</i>									
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
	meaningfulness to users		meaningfulness to users		meaningfulness to users	meaningfulness to users			4	14%
	mindful of health issues		mindful of health issues			mindful of health issues		mindful of health issues	4	14%
increased choice					increased choice			increased choice	3	11%
	onboarding			onboarding	onboarding				3	11%
opportunity for competence						opportunity for competence		opportunity for competence	3	11%
enable mastery			enable mastery				enable mastery		3	11%
increased options			increased options						2	7%
	increased difficulty levels			increased difficulty levels					2	7%
		increased challenges					increased challenges		2	7%
		incorporate safety					incorporate safety		2	7%
								Total	28	100%

6 Conclusion

Spirit50 was a gamified PA technology designed to improve motivation of older adults to participating in PA while considering their physical limitations and ability to do PA. We conducted an expert evaluation of this app which showed that the purposeful usage of motivational affordances (gamification elements) in PA technology can help with older adults' PA motivation. The expert evaluation used long-form questionnaires and the HEGD [44], a gamification toolkit to evaluate Spirit50. Experts indicated that Spirit50, with select gamification elements can foster intrinsic and extrinsic motivation for PA. Intrinsic motivation among older adults for PA can be achieved through the use of gamification elements like goals (quests), challenges, achievements, and task completion of specific exercise routines on a daily basis leading to an eight-week fitness program [38]. Reward mechanisms in the form of points, stars and progression metrics for task completion serves as a validation of effort and could foster extrinsic motivation for PA. Experts also indicated that Spirit50 could be improved by the addition of sub-goals, graphical progression meters, collaborative community building and deployment of the design on mobile devices such as smartphones and tablets. This expert evaluation helps to show that motivational affordances can help with PA motivation of older adults and identified how this app could be improved. Results of this expert evaluation can be used by PA technology designers and user-interaction researchers to customize and tailor gamified PA technology for older adults.

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References

1. Bethancourt, H.J., Rosenberg, D.E., Beatty, T., Arterburn, D.E.: Barriers to and facilitators of physical activity program use among older adults. *Clin. Med. Res.* 12, 10–20 (2014).
2. Gerling, K.M., Schulte, F.P., Smeddinck, J., Masuch, M.: Game Design for Older Adults : Effects of Age-Related Changes on Structural Elements of Digital Games. In: *ICEC 2012, LNCS 7522*. pp. 235–242 (2012).
3. Evenson, K.R., Buchner, D.M., Morland, K.B.: Objective Measurement of Physical Activity and Sedentary Behavior Among US Adults Aged 60 Years or Older. *CDC- Prev. Chronic Dis.* 9, 2–11 (2012).
4. Porter, K.N., Fischer, J.G., Johnson, M.A.: Improved physical function and physical activity in older adults following a community-based intervention: Relationships with a history of depression. *Maturitas.* 70, 290–4 (2011).

5. Consolvo, S., McDonald, D.W., Toscos, T., Chen, M.Y., Froehlich, J., Harrison, B., Klasnja, P., Lamarca, A., Legrand, L., Libby, R., Smith, I., Landay, J.A.: Activity Sensing in the Wild: A Field Trial of UbiFit Garden. In: Proc. of CHI'08. pp. 1797–1806 (2008).
6. Aarhus, R., Grönvall, E., Larsen, S.B., Wollsen, S.: Turning training into play: Embodied gaming, seniors, physical training and motivation. *Gerontechnology*. 10, 110–120 (2011).
7. Bleakley, C.M., Charles, D., Porter-Armstrong, A., McNeill, M.D.J., McDonough, S.M., McCormack, B.: Gaming for health: a systematic review of the physical and cognitive effects of interactive computer games in older adults. *J. Appl. Gerontol.* 34, NP166-89 (2015).
8. Brox, E., Fernandez-Luque, L., Evertsen, G., González-Hernández, J.: Exergames For Elderly: Social exergames to persuade seniors to increase physical activity. In: Proc. of the 5th International ICST Conference on Pervasive Computing Technologies for Healthcare. pp. 546–549. Ieee (2011).
9. Cota, T.T., Ishitani, L.: Motivation and benefits of digital games for the elderly: a systematic literature review. *Rev. Bras. Comput. Apl.* 7, (2015).
10. Hall, A., Chavarria, E., Maneeratana, V., Chaney, B., Bernhardt, J.: Health benefits of digital videogames for older adults: a systematic review of the literature. *Games Health J.* 1, 402–410 (2012).
11. Villani, D., Triberti, S., Serino, S., Riva, G.: Ageing Positively with Digital Games. *eHealth 2016*. 181, 148–155 (2016).
12. Zhang, F., Kaufman, D.: Physical and Cognitive Impacts of Digital Games on Older Adults: A Meta-Analytic Review. *J. Appl. Gerontol.* (2015).
13. Loos, E., Zonneveld, A.: Silver Gaming: Serious Fun for Seniors? In: Zhou, J. and Salvendy, G. (eds.) *Human Aspects of IT for the Aged Population. Healthy and Active Aging*, Second International Conference, ITAP 2016, Held as Part of HCI International 2016 Toronto, ON, Canada, July 17–22, 2016, Proceedings, Part II. pp. 330–341. Springer International Publishing, Cham (2016).
14. Chao, Y.-Y., Scherer, Y.K., Montgomery, C.A.: Effects of Using Nintendo Wii™ Exergames in Older Adults: A Review of the Literature. *J. Aging Health*. (2014).
15. Larsen, L.H., Schou, L., Lund, H.H., Langberg, H.: The Physical Effect of Exergames in Healthy Elderly—A Systematic Review. *Games Health J.* 2, 205–212 (2013).
16. Kappen, D.L., Mirza-Babaei, P., Nacke, L.E.: Older Adults' Physical Activity and Exergames: A Systematic Review. *Int. J. Human-Computer Interact.* 00, 1–28 (2018).
17. Loos, E.: Exergaming: Meaningful Play for Older Adults? In: Zhou, J. and Salvendy, G. (eds.) *Human Aspects of IT for the Aged Population. Healthy and Active Aging*. Third International Conference, ITAP 2017, Held as Part of HCI International 2017, Vancouver, Canada, July 9-14, 2017, Proceedings, Part II Applications, Services and Contexts. pp. 254–265. Springer International Publishing, Cham (2017).
18. Deterding, S., Dixon, D., Khaled, R., Nacke, L.E.: From Game Design Elements to Gamefulness: Defining “ Gamification .” In: *MindTrek'11*, September 28-30, 2011, Tampere, Finland. pp. 9–15 (2011).
19. Kappen, B.D.L., Orji, R.: Gamified and Persuasive Systems as Behaviour Change Agents for Health and Wellness, (2017).
20. Kappen, D.L., Nacke, L.E.: The Kaleidoscope of Effective Gamification: Deconstructing Gamification in Business Applications. In: *Proceedings of the First International Conference on Gameful Design, Research, and Applications - Gamification '13*. pp. 119–122 (2013).
21. Brauner, P., Valdez, A.C., Schroeder, U., Ziefle, M.: Increase Physical Fitness and Create Health Awareness through Exergames and Gamification . The Role of Individual Factors , Motivation and Acceptance Increase Physical Fitness and Create Health Awareness through Exergames and Gamification. In: *SouthCHI 2013*. pp. 349–362 (2013).
22. Kappen, D.L., Nacke, L.E., Gerling, K.M., Tsotsos, L.E.: Design Strategies for Gamified Physical Activity Applications for Older Adults. In: *Proceedings of the Annual Hawaii International Conference on System Sciences-49, IEEE*. pp. 1309–18. IEEE Computer

- Society (2016).
23. Hamari, J., Koivisto, J.: "Working out for likes": An empirical study on social influence in exercise gamification. *Comput. Human Behav.* 50, 333–347 (2015).
 24. Hamari, J., Koivisto, J., Sarsa, H.: Does Gamification Work? - A Literature Review of Empirical Studies on Gamification. *Proc. Annu. Hawaii Int. Conf. Syst. Sci.* 3025–3034 (2014).
 25. Lister, C., West, J.H., Cannon, B., Sax, T., Brodegard, D.: Just a Fad? Gamification in Health and Fitness Apps. *JMIR Serious Games.* 2, 1–12 (2014).
 26. Edwards, E.A., Lumsden, J., Rivas, C., Steed, L., Edwards, L.A., Thiyagarajan, A., Sohanpal, R., Caton, H., Griffiths, C.J., Munafò, M.R., Taylor, S., Walton, R.T.: Gamification for health promotion: systematic review of behaviour change techniques in smartphone apps. *BMJ Open.* 6, e012447 (2016).
 27. Kappen, D.L., Mirza-Babaei, P., Nacke, L.E.: Gamification through the Application of Motivational Affordances for Physical Activity Technology. In: *Proc. of CHIPLAY '17.* pp. 5–18 (2017).
 28. Schutzer, K.A., Graves, B.S.: Barriers and motivations to exercise in older adults. *Prev. Med. (Baltim).* 39, 1056–1061 (2004).
 29. Dacey, M., Baltzell, A., Zaichkowsky, L.: Older adults' intrinsic and extrinsic motivation toward physical activity. *Am. J. Health Behav.* 32, 570–582 (2008).
 30. Kuroda, Y., Sato, Y., Ishizaka, Y., Yamakado, M., Yamaguchi, N.: Exercise motivation, self-efficacy, and enjoyment as indicators of adult exercise behavior among the transtheoretical model stages. *Glob. Health Promot.* 19, 14–22 (2012).
 31. Motalebi, S.A., Iranagh, J.A., Abdollahi, A., Lim, K.: Applying of theory of planned behavior to promote physical activity and exercise behavior among older adults. *J. Phys. Educ. Sport.* 14, 562–568 (2014).
 32. Kappen, D.L.: Adaptive Engagement of Older Adults' Fitness through Gamification, <http://hdl.handle.net/10155/881>, (2017).
 33. Boulos, M.N.K., Yang, S.P.: Exergames for health and fitness: the roles of GPS and geosocial apps. *Int. J. Health Geogr.* 12, 18 (2013).
 34. Zuckerman, O., Gal-Oz, A.: Deconstructing gamification: evaluating the effectiveness of continuous measurement, virtual rewards, and social comparison for promoting physical activity. *Pers. Ubiquitous Comput.* 1705–1719 (2014).
 35. Ryan, R.M., Deci, E.L.: Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemp. Educ. Psychol.* 25, 54–67 (2000).
 36. Deci, E.L.: Self-determination theory: A Macro-theory of Human Motivation, Development and Health. *Can. Psychol.* 182–185 (2008).
 37. Ryan, R.M., Frederick, C.M., Lepes, D., Rubio, N., Sheldon, K.M.: Intrinsic Motivation and Exercise Adherence. *Int. J. Sport Psychol.* 28, 335–354 (1997).
 38. Kappen, D.L., Mirza-Babaei, P., Nacke, L.E.: Gamification of Older Adults' Physical Activity: An Eight-Week Study. In: *Proceedings of the Annual Hawaii International Conference on System Sciences-51.* pp. 1–12 (2018).
 39. Nielsen, J.: Finding Usability Problems through Heuristic Evaluation. In: *Proceedings of the SIGCHI conference on Human.* pp. 373–380 (1992).
 40. Nielsen, J.: Heuristic Evaluation. In: *Usability Inspection Methods.* pp. 25–62. John Wiley & Sons Ltd, New York, NY (1994).
 41. Desurvire, H., Desurvire, H., Blvd, W., Rey, M., Caplan, M.: Using Heuristics to Evaluate the Playability of Games. In: *Proc of CHI '04* (2016).
 42. Nacke, L.E., Drachen, A., Kuikkaniemi, K., Kort, Y.A.W. De: Playability and Player Experience Research. In: *Proceedings of DIGRA* (2009).
 43. Paaivilainen, J.: Critical Review on Video Game Evaluation Heuristics: Social Games Perspective. In: *ACM FuturePlay 2010.* pp. 56–65 (2010).
 44. Tondello, G.F., Kappen, D.L., Mekler, E.D., Ganaba, M., Nacke, L.E.: Heuristic Evaluation

- for Gameful Design. Proc. 2016 Annu. Symp. Comput. Interact. Play Companion Ext. Abstr. - CHI Play Companion '16. 315–323 (2016).
45. Landers, R.N., Tondello, G.F., Kappen, D.L., Collmus, A.B., Mekler, E.D., Nacke, L.E.: Defining gameful experience as a psychological state caused by gameplay: Replacing the term 'Gamefulness' with three distinct constructs. *Int. J. Hum. Comput. Stud.* (2018).
 46. Krippendorff, K.: *Content Analysis An Introduction to Its Methodology*. SAGE Publications, Inc, Thousand Oaks, CA (2013).
 47. Schreier, M.: *Qualitative Content Analysis in Practice*. SAGE Publications Ltd., London, UK (2012).
 48. Fife, D.L.: Reasons For Physical Activity and Exercise Participation in Senior Athletes, (2008).
 49. Marston, H.R.: Digital Gaming Perspectives of Older Adults: Content vs. Interaction. *Educ. Gerontol.* 39, 194–208 (2013).
 50. Vargheese, J.P., Sripada, S., Masthoff, J., Oren, N.: Persuasive strategies for encouraging social interaction for older adults. *Int. J. Hum. Comput. Interact.* 7318, null-null (2016).
 51. Pruitt, L.A., Glynn, N.W., King, A.C., Guralnik, J.M., Aiken, E.K., Miller, G., Haskell, W.L.: Use of Accelerometry to Measure Physical Activity in Older Adults at Risk for Mobility Disability. *J. Aging Phys. Act.* 16, 416–434 (2008).
 52. Bamidis, P.D., Vivas, a B., Styliadis, C., Frantzidis, C., Klados, M., Schlee, W., Siountas, A., Papageorgiou, S.G.: A review of physical and cognitive interventions in aging. *Neurosci. Biobehav. Rev.* 44, 206–220 (2014).
 53. Irvine, A.B., Gelatt, V.A., Seeley, J.R., Macfarlane, P., Gau, J.M.: Web-based intervention to promote physical activity by sedentary older adults: randomized controlled trial. *J. Med. Internet Res.* 15, e19 (2013).
 54. Franco, M.R., Tong, A., Howard, K., Sherrington, C., Ferreira, P.H., Pinto, R.Z., Ferreira, M.L.: Older people's perspectives on participation in physical activity: a systematic review and thematic synthesis of qualitative literature. *Br. J. Sports Med.* 49, 1268–1276 (2015).