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The motivational power of mobile gamified exercise apps

El poder motivador de las aplicaciones móviles gamificadas de ejercicio físico

Paula Bitrián*, Isabel Buil[a], Sara Catalán[b]

[a] *University of Zaragoza. Faculty of Business and Economics, Department of Marketing Management. María de Luna, s/n - Edificio "Lorenzo Normante" – 50018, Zaragoza, Spain – ibuil@unizar.es - https://orcid.org/0000-0001-6631-8909*

[b] *University of Zaragoza. Faculty of Business and Economics, Department of Marketing Management. Gran Vía 2, 50005, Zaragoza, Spain – scatala@unizar.es - https://orcid.org/0000-0001-5268-1723*

* ***Corresponding author:*** *University of Zaragoza. Faculty of Business and Economics, Department of Marketing Management. Gran Vía 2, 50005, Zaragoza, Spain – pbitrian@unizar.es – https://orcid.org/0000-0001-6325-6773*

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ABSTRACT

This study analyses how gamification motivates users of gamified mobile exercise apps and enhances their health. Data from 276 Fitbit users were analysed using structural equation modelling. The findings showed that feelings of competence and autonomy arise when exercise apps include achievement and progression-oriented affordances, and that feelings of relatedness arise with social, immersion and achievement and progression-oriented affordances. They also revealed that exercise apps should satisfy the needs for competence and relatedness to develop individuals' intrinsic motivation, which in turn leads to greater physical, mental and social health. These findings offer insights for managers in this industry.

Keywords: Gamification, Mobile Apps, Health, Psychological Needs, Motivation.

RESUMEN

Este estudio analiza cómo la gamificación motiva a los usuarios de aplicaciones móviles gamificadas de deporte y mejora su salud. Se analizaron los datos de 276 usuarios de Fitbit mediante un modelo de ecuaciones estructurales. Los resultados mostraron que las necesidades de competencia y autonomía se ven satisfechas cuando las aplicaciones de ejercicio incluyen elementos de juego orientados al logro y la progresión, mientras que la necesidad de relación se ve cubierta cuando la aplicación móvil incluye elementos sociales, de inmersión y orientados al logro y la progresión. Los resultados también revelaron que las aplicaciones de ejercicio deberían satisfacer las necesidades de competencia y relación para desarrollar la motivación intrínseca en los individuos, lo que a su vez conduce a una mayor percepción de salud física, mental y social. Estas conclusiones ofrecen información a los diseñadores y desarrolladores de este tipo de aplicaciones móviles.

Palabras clave: Gamificación, Aplicaciones Móviles, Salud, Necesidades Psicológicas, Motivación.

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1. INTRODUCTION

Recently, the global fitness app market size has skyrocketed due to people's increased interest in health and wellness, the spread of the COVID-19 pandemic, and the increasing penetration of smartphones. This market, valued in $1.1 billion in 2021, is expected to have a compound annual growth rate of 17.6% from 2022 to 2030 (Grand View Research, 2022). While different types of technology have also emerged to help individuals to exercise, such as exergames (e.g., Ho *et al.*, 2017; Li & Lwin, 2016) and wearable activity trackers (e.g., Attig & Franke, 2019; Lunney *et al.*, 2016), mobile health and fitness apps are widespread, as shown by the number of downloads worldwide, which grew from 488 million in 2019 to 593 million in 2020 (Statista, 2021).

Health and fitness apps make it easier for individuals to track and monitor their physical activities (Lunney *et al.*, 2016). To keep their users motivated and engaged, many of them provide individuals with short-term challenges, rewards and social support (Hamari & Koivisto, 2015). This emerging technological approach towards motivating people is known as gamification, and involves the use of motivational affordances —that is, game elements and mechanics— that are common in games in non-game contexts (Deterding *et al.*, 2011). Gamification is particularly beneficial in fields where individuals need to display long-term commitment and persistent behaviours, and tend to procrastinate (Koivisto & Hamari, 2019a), such as health and physical exercise. However, despite the initial excitement they feel when using gamified health and fitness apps, many users discontinue using them shortly after they download them (Feng *et al.*, 2020), mainly due to loss of motivation (Attig & Franke, 2020). Therefore, a question arises: in the context of fitness apps, is gamification failing to motivate users and to improve their health?

In recent years, gamification has gained the attention of practitioners and researchers as a way to promote exercise and well-being. Some works have explored the use of gamification in the context of mobile exercise apps (e.g., Cechetti *et al.*, 2019; Eisingerich *et al.*, 2019; Hamari & Koivisto, 2013; Hamari & Koivisto, 2015; Hassan *et al.*, 2019; Hassan *et al.*, 2020; Jang *et al.*, 2018; Kari *et al.*, 2016; Koivisto & Hamari, 2014; Spil *et al.*, 2017; Tsai *et al.*, 2021; Tu *et al.*, 2019). However, reliable scientific evidence for the effectiveness of gamified mobile exercise apps is still scarce (Stiglbauer *et al.*, 2019). Previous research and marketing practice have also provided mixed results about the effects of gamification-based fitness apps (Feng *et al.*, 2020). In addition, as recently noted by Koivisto and Hamari (2019b, p. 107), particularly in the health and exercise context, gamification *"has still lacked an empirically rigorous body of literature examining its effects"*. Moreover, it has been noted that many studies fail to provide a linkage to prior theory to explain the motivational process driven by the elements of gamification (Johnson *et al.*, 2016; Sardi *et al.*, 2017) and how motivation influences health outcomes (Kaczmarek *et al.*, 2017). Besides, existing research has focused on a limited set of game elements, mostly points, goals, leaderboards and progress visualization (Koivisto & Hamari, 2019b), and a limited set of health outcomes, mostly physical health (Johnson *et al.*, 2016). Finally, methodological shortcomings have also been identified, such as small sample sizes, the absence of inferences and the use of non-validated measures (Hamari *et al.*, 2014; Koivisto & Hamari, 2019a; Matallaoui *et al.*, 2017; Seaborn & Fels, 2015).

Therefore, this research aims to provide new insights into how gamification motivates users of gamified mobile exercise apps and enhances their health. Specifically, the present study draws on self-determination theory (Ryan & Deci, 2000), which provides a useful framework for analysing motivation, and proposes and tests a comprehensive model to gain insights into how different motivational affordances embedded in gamified exercise apps foster the satisfaction of individuals' psychological needs for competence, autonomy and relatedness, promoting intrinsic motivation to use the apps. Finally, the effects of motivation on physical, mental and social health outcomes are analysed.

By doing so, this study makes several contributions to the academic literature and to managerial practice. First, researchers have emphasised the importance of measuring users' interactions with motivational affordances (Xi & Hamari, 2019). However, many studies in the context of health and exercise apps have explored the effects of gamification only at a general level or as a research context (e.g., Hamari & Koivisto, 2013; Hamari & Koivisto, 2015; Jang *et al.*, 2018; Kari *et al.*, 2016; Koivisto & Hamari, 2014; Spil *et al.*, 2017; Tsai *et al.*, 2021; Tu *et al.*, 2019). In addition, most studies in this context have investigated a limited number of motivational affordances (e.g., Cechetti *et al.*, 2019; Giannakis *et al.*, 2013; Hassan *et al.*, 2019; Zuckerman & Gal-Oz, 2014). Therefore, this study seeks to advance knowledge about the effects of different motivational affordances used in gamified mobile exercise apps on users' motivations and health.

Second, previous research into gamification in health and exercise has mainly analysed the continuous use of a platform and/or the increase of exercise and physical activity as the dependent variable (e.g., Hamari & Koivisto, 2013; Hamari & Koivisto, 2015; Harris, 2019; Hassan *et al.*, 2019; Ho *et al.*, 2017; Jang *et al.*, 2018; Kaczmarek *et al.*, 2017; Kari *et al.*, 2016; Koivisto & Hamari, 2014; Koivisto *et al.*, 2019; Li & Lwin, 2016; Lunney *et al.*, 2016; Pasco *et al.*, 2017; Peng *et al.*, 2012; Smeddinck *et al.*, 2019; Spil *et al.*, 2017; Stragier *et al.*, 2016; Tsai *et al.*, 2021; Tu *et al.*, 2019; Zuckerman & Gal-Oz, 2014). Although physical health is an important dimension of users' health, as recognised by the World Health Organization, one's health also includes mental and social well-being facets. Therefore, this study further explores the role of gamification in all the dimensions of health. In addition, many previous studies collected information directly from the app to measure dependent variables objectively, such as biometric variables (e.g., González *et al.*, 2016), and measures of physical activity such as steps, daily walking time and/or average speed (e.g., Giannakis *et al.*, 2013; Pasco *et al.*, 2017; Tu *et al.*, 2019; Zuckerman & Gal-Oz, 2014). Although useful, objective measures do not capture users' beliefs, motivations and attitudes. Thus, this research provides valuable, useful insights into users' subjective experiences.

Third, while Hamari *et al.* (2014) conceptualised gamification as a continuous process consisting of motivational affordances, psychological outcomes and behavioural outcomes, most research into gamification in the health and exercise context fails to provide such a holistic view. Drawing on self-determination theory, the present study responds to calls for more empirical research in the health and exercise sector (Koivisto & Hamari, 2019b), and extends earlier studies (e.g., Attig & Franke, 2019; Koivisto *et al.*, 2019; Quintas *et al.*, 2020; Tsai *et al.*, 2021) by exploring the underlying mechanisms that explain the effects of different motivational affordances on three health dimensions —physical, mental and social health— in the context of mobile exercise apps. In addition, by examining a real mobile exercise app, this research represents an advance on previous studies that invented apps for the purpose of their investigations (e.g., Tsai *et al.*, 2021; Zuckerman & Gal-Oz, 2014).

This paper is structured as follows. Section 2 opens with a review on existing literature on gamification in health and exercise, describes the theory on which this paper is based and presents the research model and the proposed hypotheses. Section 3 explains the methodology followed, while Section 4 presents the results obtained. Section 5 discusses the main contributions of this study, as well as its limitations, and proposes ideas for future research. Finally, Section 6 shows the main conclusions of the article.

2. LITERATURE REVIEW AND RESEARCH HYPOTHESES

2.1. Gamification in health and exercise

Gamification has been defined as *"a design approach of enhancing services and systems with affordances for experiences similar to those created by games"* (Koivisto & Hamari, 2019a, p. 193). Motivational affordances refer to *"the various elements and mechanics that structure games and aid in inducing gameful experiences within the systems"* (Koivisto & Hamari, 2019a, p. 193). Koivisto and Hamari (2019a) classify motivational affordances into three categories: achievement and progression-oriented affordances, which include elements such as badges/medals, points, leaderboards/rankings, progress bars and increasingly difficult levels; social-oriented affordances, which include elements such as cooperation, competition with others, social networking features and teammates; and immersion-oriented affordances, which include elements such as avatars or profiles, narrative and customisation.

The motivational affordances included in gamified systems are designed to lead to a series of psychological outcomes which direct individuals towards the attainment of specific behavioural outcomes (Hamari *et al.*, 2014; Koivisto & Hamari, 2019a). In the healthcare sector, one of the most promising contexts for the application of gamification, it is used to promote health, defined by the World Health Organization as a state of physical, mental and social well-being.

Previous health and exercise-based studies have analysed the effectiveness of gamification in producing different outcomes. For instance, some works have analysed whether interacting with gamification elements might promote gameful experiences (Hassan *et al.*, 2020), flow experiences (Huang *et al.*, 2018; Quintas *et al.*, 2020), playfulness (Koivisto & Hamari, 2014; Tsai *et al.*, 2021), enjoyment (Ho *et al.*, 2017; Koivisto & Hamari, 2014; Li & Lwin, 2016; Pasco *et al.*, 2017; Peng *et al.*, 2012; Stragier *et al.*, 2016), motivation (Attig & Franke, 2019; González *et al.*, 2016; Kari *et al.*, 2016; Liu & Lipowski, 2021; Peng *et al.*, 2012; Quintas *et al.*, 2020; Smeddinck *et al.*, 2019) and positive mood among users (Ho *et al.*, 2017). Other works have examined the impact of gamification on users' attitudes and/or behavioural intentions towards gamified technologies (e.g., Hamari & Koivisto, 2013, 2015; Hassan *et al.*, 2019; Ho *et al.*, 2017; Koivisto & Hamari, 2014; Li & Lwin, 2016; Lunney *et al.*, 2016; Spil *et al.*, 2017; Stragier *et al.*, 2016; Tsai *et al.*, 2021; Tu *et al.*, 2019). Similarly, prior studies have analysed the potential of gamification to lose weight (Song *et al.*, 2018) and promote health (Stiglbauer *et al.*, 2019), healthier lifestyles and eating behaviours (González *et al.*, 2016), physical activity (Harris, 2019; Kaczmarek *et al.*, 2017; Pasco *et al.*, 2017; Smeddinck *et al.*, 2019), daily walking time (Zuckerman & Gal-Oz, 2014), average walking/running speed (Giannakis *et al.*, 2013) and users' overall performance (Liu & Lipowski, 2021; Tu *et al.*, 2019). Previous research has also investigated the influence of players' orientations on their physical, mental and social health (Koivisto *et al.*, 2019). Finally, some studies have analysed the impact of health and exercise-based gamification on marketing outcomes such as customer engagement and/or purchases (Eisingerich *et al.*, 2019; Jang *et al.*, 2018).

2.2. Self-determination theory

To explain gamification effects, it is important to understand individuals' motivation. One of the most influential theories of human motivation is self-determination theory (SDT, Ryan & Deci, 2000; Ryan *et al.*, 2006), which has recently become a key framework for gamification studies, especially for those in the context of health and exercise (Matallaoui *et al.*, 2017).

SDT differentiates two types of motivation, intrinsic and extrinsic. Intrinsic motivation arises when individuals behave voluntarily and do not seek any results beyond fun and enjoyment (Ryan & Deci, 2000). By contrast, extrinsic motivation refers to behaviours that are performed with the intention of attaining some external outcome (Deci & Ryan, 2015).

Among the different types of motivation, to achieve the best outcomes from any activity or task, it is preferable that individuals are intrinsically motivated (Ryan & Deci, 2000). Due to its importance, the study of the environmental conditions and processes that promote intrinsic motivation has received great attention (Deci & Ryan, 2000). In particular, cognitive evaluation theory (Ryan & Deci, 2000), a sub-theory of SDT, proposes that factors that facilitate the satisfaction of the individual's basic psychological needs for competence, autonomy and relatedness foster greater intrinsic motivation (Deci & Ryan, 2000). Feelings of competence are evoked when one experiences one's behaviour as effective (White, 1959). In other words, competence is related to the individual's ability to complete an activity satisfactorily. Autonomy refers to the experience of feeling one's behaviour is choiceful (de Charms, 1968), which corresponds to the possibility of choosing among options. Finally, relatedness refers to the feeling of being connected with others (Baumeister & Leary, 1995).

2.3. Research hypotheses

Following the conceptualisation of gamification proposed by Koivisto and Hamari (2019a), the model (see Figure 1) proposes that motivational affordances (i.e., achievement and progression, social and immersion-oriented affordances) included in a gamified health and exercise app produce a series of psychological outcomes, in this case meeting the individual's needs for competence, autonomy and relatedness, which in turn influences his/her intrinsic motivation to use the app. This intrinsic motivation leads, in turn, to the behavioural outcomes that the gamification is designed to achieve (i.e., physical, mental and social health).

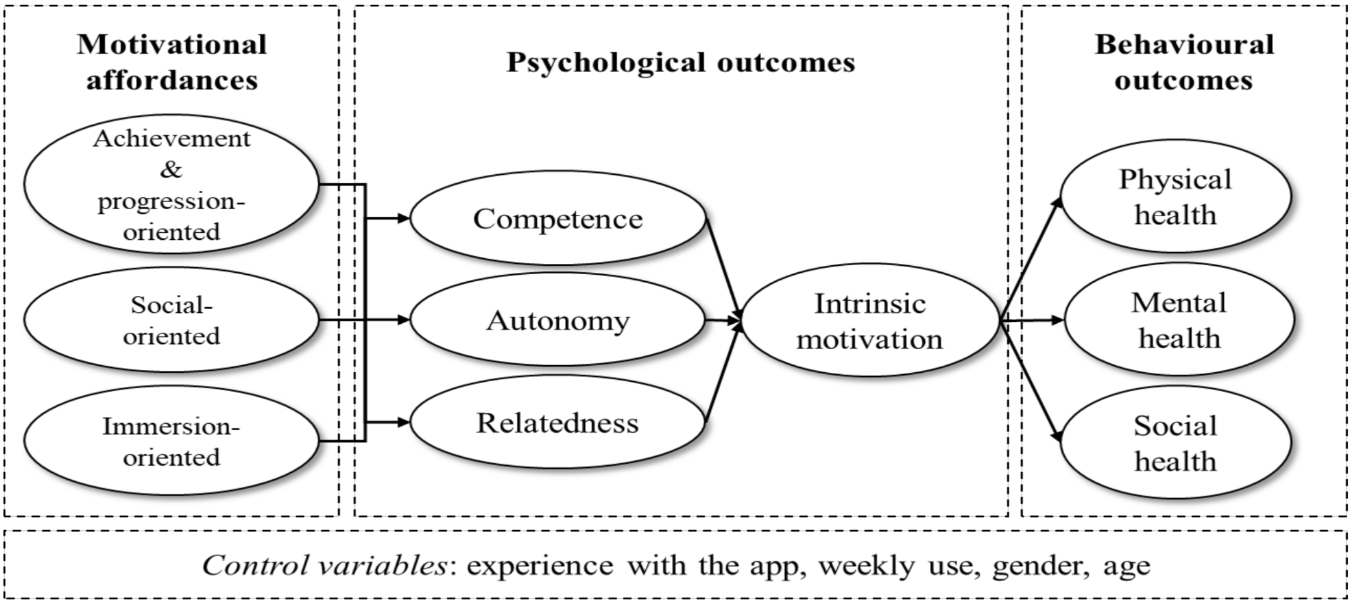

Figure 1
Proposed model
Source: Authors.

Achievement and progression-oriented affordances include elements such as badges or medals, points, leaderboards or rankings, progress bars, and increasingly difficult levels (Koivisto & Hamari, 2019a), among others. Previous research suggests that users' interactions with these affordances help satisfy their basic psychological needs (Deci & Ryan, 2000; Xi & Hamari, 2019). Feelings of competence arise in players when using: leaderboards/rankings (Sailer *et al.*, 2017; Xi & Hamari, 2019) because they provide information about their success (Sailer *et al.*, 2013); badges/medals (Peng *et al.*, 2012; Sailer *et al.*, 2017; van Roy & Zaman, 2019; Xi & Hamari, 2019) because they are visual representations of their achievements (Werbach & Hunter, 2012) that fulfil their need for success (Sailer *et al.*, 2013); challenges/quests (van Roy & Zaman, 2019; Wee & Choong, 2019) because they provide clear goals, offer a sense of purpose and highlight the importance of their actions (Sailer *et al.*, 2013); and performance graphs (Hassan *et al.*, 2020; Xi & Hamari, 2019) because they provide feedback on their progress (Sailer *et al.*, 2013). Feelings of competence also arise when the player faces increasingly difficult levels/tasks (Peng *et al.*, 2012; Xi & Hamari, 2019), because the tasks become more difficult as his/her performance improves, which gives him/her a sense of accomplishment (Peng *et al.*, 2012). Similarly, previous research has shown that perceptions of autonomy are enhanced when gamified systems include leaderboards (Xi & Hamari, 2019), badges (Xi & Hamari, 2019) and challenges (van Roy & Zaman, 2019), as these provide players the opportunity to display flexibility in their game strategies and a choice of tasks and rewards (Ryan *et al.*, 2006). Finally, it has been shown that feelings of social relatedness are evoked by interacting with: leaderboards (Hassan *et al.*, 2020; Xi & Hamari, 2019), as they compare players' performances with the performance of other players (Sailer *et al.*, 2017); challenges (van Roy & Zaman, 2019); and badges and goals (Hassan *et al.*, 2020; Xi & Hamari, 2019), as they enable players to publicly demonstrate their behaviours and compare with others the number of badges/goals they have achieved (Hamari & Koivisto, 2015). Therefore, we propose:

H1: Interaction with achievement and progression-oriented affordances facilitates the satisfaction of the needs for (a) competence, (b) autonomy and (c) relatedness.

Social-oriented affordances, which include elements such as cooperation, competition with others, social networking features and teammates (Koivisto & Hamari, 2019a), also facilitate the satisfaction of basic psychological needs (Deci & Ryan, 2000; Xi & Hamari, 2019). In particular, the need for competence is satisfied when people interact with others through cooperation and/or competition (van Roy & Zaman, 2019; Xi & Hamari, 2019). When players cooperate in a gamified system they gain knowledge and develop skills, which increases their accomplishments (Xi & Hamari, 2019), whereas competition allows them to challenge each other to achieve the best results (Suh *et al.*, 2018), which also results in feelings of competence. Similarly, interaction among users might enhance the processes through which they help one another to create strategies and resources that can help them feel empowered, and to overcome challenges (Ryan & Deci, 2000). Thus, it can be concluded that the individual's perceptions of autonomy are enhanced by social-oriented affordances (Xi & Hamari, 2019). Finally, social-oriented affordances have been associated with the satisfaction of the need for relatedness, as they allow users to interact with other users in the same virtual space. In this sense, the need for relatedness is satisfied when gamified systems include: competition with others (van Roy & Zaman, 2019; Wee & Choong, 2019), as it enables individuals to develop a sense of belonging to a group (van Roy & Zaman, 2019); cooperation, as it allows people to connect with others to achieve a common goal (Wee & Choong, 2019); social networking features (Wee & Choong, 2019), as they enable people to communicate with others, receive information from others and increase their number of contacts (Hamari & Koivisto, 2013; Hassan *et al.*, 2019; Wee & Choong, 2019); and teammates (Sailer *et al.*, 2017), as individuals work together in order to achieve a common goal (Werbach & Hunter, 2012). Consequently, we propose:

H2: Interaction with social-oriented affordances facilitates the satisfaction of the needs for (a) competence, (b) autonomy and (c) relatedness.

Finally, interactions with immersion-oriented affordances, such as avatars or profiles, narrative or meaningful stories, and customization (Koivisto & Hamari, 2019a), also promote the satisfaction of basic psychological needs (Deci & Ryan, 2000). A sense of competence can develop when gamified systems include storylines/ narrative, as these allow users to separate general goals into small tasks/activities with diverse themes (Wee & Choong, 2019); the individuals can then go on to achieve the general goal through specific strategies or techniques applied to each small task. Similarly, previous studies have supported the notion that a sense of autonomy arises when gamified systems contain personalisation (Peng *et al.*, 2012; Kim *et al.*, 2015), as this provides users with a sense of control (Kim *et al.*, 2015), and avatars/personal profiles (Wee & Choong, 2019), as they allow users to visually or textually represent themselves (Sailer *et al.*, 2013). Finally, feelings of social relatedness arise when gamified systems include characters or avatars (Sailer *et al.*, 2017) because they undertake the specific role the user adopts in the activity; and they arise also through meaningful stories, as individuals feel that they have a significant role in the narrative frame (Sardi *et al.*, 2017). Hence, we postulate:

H3: Interaction with immersion-oriented affordances facilitates the satisfaction of the needs for (a) competence, (b) autonomy and (c) relatedness.

SDT proposes that contexts that facilitate the satisfaction of the three basic psychological needs for competence, autonomy and relatedness foster individuals' intrinsic motivation (Ryan & Deci 2000). This relationship has been proved in various settings. Ryan *et al.* (2006) found that games promote feelings of competence, autonomy and relatedness among their players, which results in greater intrinsic motivation to play the games. Similarly, Mitchell *et al.* (2020) demonstrated that employees who satisfied their needs for competence and autonomy using a gamified app at work developed greater intrinsic motivation. Wee and Choong (2019) also found that energy-saving gamified campaigns that satisfy the needs for competence, autonomy and relatedness have a positive impact on individuals' intrinsic motivation to undertake energy-saving behaviours. In the context of sports and health, previous research has identified a positive relationship between the satisfaction of basic psychological needs and intrinsic motivation (Sebire *et al.*, 2013). For instance, Edmunds *et al.* (2007) demonstrated that satisfying the three aforementioned psychological needs results in improved motivation, exercise levels and well-being. Ng *et al.* (2012) also found a positive relationship between the satisfaction of psychological needs and motivation, which resulted in beneficial health outcomes. Finally, Peng *et al.* (2012) analysed exercise-focused games and determined that game components that foster competition and autonomy result in greater motivation among players to continue using the games, greater enjoyment and increased intention to recommend the game to others. Thus, we postulate:

H4: The satisfaction of the need for (a) competence, (b) autonomy and (c) relatedness has a positive impact on intrinsic motivation.

From the earliest gamification-related studies, it has been associated with motivation and behavioural change (Kapp, 2012). This is reflected in the conceptualisation of gamification proposed by Koivisto and Hamari (2019a); that is, that motivational affordances enhance individuals' psychological outcomes, for example, the intrinsic motivation to use a gamified exercise app, which in turn produces more positive behavioural outcomes. Indeed, SDT has largely demonstrated the role that intrinsic motivation plays in inducing certain behaviours (Ryan & Deci, 2000). For instance, previous research analysing gamification has found that individuals who are intrinsically motivated to perform tasks exhibit higher levels of participation (Feng *et al.*, 2018) and persistence (Mitchell *et al.*, 2020; Neys *et al.*, 2014). This is particularly helpful in the context of health and exercise, where individuals tend to procrastinate.

In this specific context, gamification is designed to achieve behavioural outcomes mainly linked to improved health (Johnson *et al.*, 2016), which is defined by the World Health Organization as a state of physical, mental and social well-being. Previous studies have found that using gamified exercise apps helps individuals to continue exercising (Hamari & Koivisto, 2015; Li & Lwin, 2016; Tu *et al.*, 2019). Similarly, the use of wearables has been associated with an increase in users' physical health and psychological well-being (Lunney *et al.*, 2016; Stiglbauer *et al.*, 2019).

As in many other fields, within this context intrinsic motivation is also crucial, as this involves individuals taking pleasure from an activity itself (Ryan & Deci, 2000), which makes them more willing to continue with it. Cechetti *et al.* (2019) argued that gamification offers users the chance to engage with exercise apps, increases their intrinsic motivation and helps them be more successful in their health and exercise activities. Similarly, Liu and Lipowski (2021) demonstrated that individuals who experience higher intrinsic motivation using sport-based gamification perform better during their activities. Smeddinck *et al.* (2019) found that providing rewards for exercising leads to an increase in the user's motivation to exercise and his/her performance. Kaczmarek *et al.* (2017) also demonstrated that the most motivated players of location-based augmented reality games, such as Pokémon Go, use them for longer periods and, as a consequence, are physically more active. In addition to achieving positive physical health outcomes related to feeling physically more active, exercising more, etc., Koivisto *et al.* (2019) found that gamified exercise apps can also enhance mental and social health outcomes as they help their users interact with new people, make new friends and feel mentally more active and less stressed. Thus, users who are more motivated to use these apps will benefit from their advantages. Consequently, we propose:

H5: Intrinsic motivation to use the app has a positive effect on individuals' (a) physical health, (b) mental health and (c) social health.

3. METHODS

3.1. Research design, participants and procedure

To test the model, an empirical study was undertaken in the United States with a sample of Fitbit users, one of the most popular gamified sports apps (Statista, 2021). A careful analysis of the app showed that it features a set of 12 motivational affordances. Following Xi and Hamari (2019), the motivational affordances identified in the Fitbit app were grouped into three categories: achievement and progression-oriented affordances (scores, performance graphs, challenges, badges/trophies, progress bars, rankings/ leaderboards), social-oriented affordances (competition, social networking features and cooperation) and immersion-oriented affordances (profile/virtual identity/avatar, personalisation and virtual/3D worlds).

The data collection was based on a web survey. The respondents were recruited through Amazon Mechanical Turk (MTurk). Only MTurk workers with an approval rating of 95% or higher were allowed to take part in the survey. The respondents were paid \$0.70 for their participation. Attention checks were included in the questionnaire to ensure accurate responses. Ultimately, 53 participants who did not complete the survey, or failed the attention checks, were excluded, resulting in a final sample of 276 individuals. The characteristics of the sample are presented in Table 1.

Table 1
Sample characteristics

Category		Percentage (%)
Gender	Men	60.87%
	Women	39.13%
Age	18-25 years old	10.11%
	26-35 years old	48.38%
	36-45 years old	22.74%
	46-55 years old	13.36%
	> 55 years old	5.05%
Experience with the app	< 3 months	9.42%
	3-6 months	22.46%
	6-12 months	26.45%
	12-18 months	14.49%
	18-24 months	8.33%
	>2 years	18.84%
Weekly use	< 30 minutes	8.33%
	30-60 minutes	36.23%
	1-3 hours	22.10%
	3-6 hours	15.22%
	6-9 hours	9.06%
	> 9 hours	9.06%

Source: Authors.

3.2. Measures

To measure the variables, 7-point scales adapted from previous literature were used (Appendix I). Individuals' interactions with the three types of motivational affordances in the app were assessed using the scales proposed by Xi and Hamari (2019). Satisfaction of the basic psychological needs for competence and relatedness was measured by adapting items from Xi and Hamari (2019), and the need for autonomy was measured using items from Standage *et al.* (2005) and Xi and Hamari (2019). Intrinsic motivation was assessed using the subscale proposed by Guay *et al.* (2000). Finally, health outcomes were measured through an adaptation of the scales proposed by Koivisto *et al.* (2019).

3.3. Common-method bias assessment

As the data were based on self-reported measures and collected through a one-time survey, common-method bias was assessed through various procedures. First, participation in the study was voluntary, and the respondents were assured anonymity and data confidentiality to ensure they gave honest, non-artificial responses (Podsakoff *et al.*, 2003). Second, to prevent the respondents from inferring cause-effect relationships, the dependent and independent variables appeared on different pages of the questionnaire (Podsakoff *et al.*, 2003). Third, a full collinearity test based on variance inflation factors (VIFs) was conducted. The VIF values ranged from 1.432 to 2.520, all lower than 3.3 (Kock, 2015). Thus, common-method bias does not appear to be a significant factor in this research.

4. ANALYSIS AND RESULTS

Partial least squares (PLS) structural equation modeling with SmartPLS 3.0 was used to test the proposed model (Ringle *et al.*, 2015). PLS modeling is appropriate when the conceptual model is elaborate and includes many indicators and latent variables, and constructs with formative indicators (Hair *et al.*, 2011), as in the present study.

4.1. Measurement model analysis

First, the formative measurement model for the first-order dimensions was assessed (Table 2). Following the conceptualisation proposed by Xi and Hamari (2019), interaction with achievement and progression-oriented affordances, social-oriented affordances, and immersion-oriented affordances were conceptualised as second-order formative constructs. In particular, interaction with achievement and progression-oriented affordances was conceptualised as a second-order formative construct composed of six first-order factors: performance graphs, badges/trophies, challenges, progress bars, rankings/leaderboards and scores; interaction with social-oriented affordances was composed of three factors: competition, cooperation and social networking features; finally, interaction with immersion-oriented affordances was composed of three factors: profile/virtual identity/avatar, personalisation and a virtual/3D world. In accordance with Xi and Hamari (2019), each of these first-order constructs was measured formatively by two indicators, frequency of interaction with the affordance and the importance of the interaction with the affordance.

Table 2
Formative measurement model results (first-order constructs)

Construct	Items	Mean	SD	Loading	t-value	Weight	t-value	VIF
Scores	Frequency	5.34	1.45	0.952	22.080	0.681	4.526	1.793
	Importance	5.40	1.46	0.861	12.645	0.408	2.329	1.793
Performance graphs	Frequency	5.26	1.43	0.979	55.195	0.807	9.657	1.704
	Importance	5.54	1.38	0.786	13.945	0.267	2.517	1.704
Challenges	Frequency	4.66	1.70	0.886	18.356	0.391	2.971	2.134
	Importance	4.77	1.61	0.963	38.634	0.678	5.626	2.134
Badges	Frequency	4.32	1.78	0.939	23.203	0.518	3.186	2.508
	Importance	4.17	1.93	0.945	25.985	0.544	3.325	2.508
Progress bars	Frequency	5.15	1.46	0.871	18.188	0.541	6.337	1.453
	Importance	5.14	1.49	0.894	24.873	0.592	6.767	1.453
Rankings	Frequency	3.92	1.94	0.955	20.770	0.548	2.570	2.893
	Importance	4.01	2.03	0.947	22.105	0.503	2.364	2.893
Competition	Frequency	3.98	1.91	0.892	29.014	0.276	2.681	2.854
	Importance	4.08	1.92	0.987	93.922	0.764	8.226	2.854
Social networking features	Frequency	3.71	2.09	0.921	21.838	0.384	2.508	2.908
	Importance	3.70	2.07	0.974	46.852	0.663	4.561	2.908
Cooperation	Frequency	3.81	2.02	0.943	36.380	0.451	3.625	3.197
	Importance	3.80	1.96	0.968	51.783	0.593	4.947	3.197
Profile	Frequency	3.90	1.85	0.956	39.798	0.666	6.235	1.961
	Importance	3.87	1.89	0.880	17.460	0.413	3.643	1.961
Personalization	Frequency	4.87	1.49	0.901	21.488	0.621	7.245	1.417
	Importance	4.99	1.63	0.853	17.833	0.516	5.542	1.417
Virtual world/ 3D world	Frequency	3.70	2.05	0.914	21.020	0.279	1.720	3.438
	Importance	3.82	2.06	0.989	78.670	0.753	5.032	3.438

Source: Authors.

The external validity of the formative measurement model was analysed by assessing the indicators' weights and loadings. The indicators of formative constructs should have high and statistically significant weights. Nevertheless, indicators with non-significant weights, but high loadings (i.e., above 0.50), substantially contribute to the constructs and, therefore, should not be excluded from the model (Hair *et al.*, 2017). In addition, collinearity was assessed by analysing the variance inflation factor (VIF) values. A VIF value of 5, or higher, indicates a potential collinearity problem (Hair *et al.*, 2011). As Table 2 shows, the VIFs ranged from 1.417 to 3.438 (all lower than 5), so multicollinearity was not a threat.

Subsequently, the two-stage approach suggested by Hair *et al.* (2018) was used to assess the second-order formative constructs (Table 3). Following Hair *et al.* (2017) external validity was assessed by analysing the indicators' weights and loadings. In addition, potential collinearity problems were assessed through the VIF values. The "cooperation" indicator was removed from the social-oriented construct, as it had a VIF value above 5. The model was then re-estimated. As Table 3 shows, the VIFs ranged from 1.191 to 2.944 (all lower than 5), which means that multicollinearity was not a threat in this study (Hair *et al.*, 2011).

Table 3
Formative measurement model results (second-order constructs)

Construct	Items	Loading	t-value	Weight	t-value	VIF
Achievement- and progression-oriented elements	Scores	0.692	9.533	0.432	5.407	1.191
	Performance graphs	0.769	13.972	0.332	3.524	1.608
	Challenges	0.679	10.359	0.193	2.000	1.793
	Badges/ trophies	0.570	6.895	0.011	0.105	2.901
	Progress bars	0.733	13.058	0.250	2.572	1.817
	Rankings/ Leaderboards	0.590	6.608	0.211	1.776	2.944
Social-oriented elements	Competition	0.977	39.081	0.741	5.225	2.219
	Social networking features	0.868	14.492	0.319	2.039	2.219
Immersion-oriented elements	Profile/ virtual identity/ avatar	0.810	9.527	0.278	1.606	2.782
	Personalization	0.906	12.844	0.638	4.163	1.408
	Virtual world/ 3D world	0.781	8.885	0.252	1.501	2.646

Source: Authors.

Second, the reliability and validity of the reflective measurement model were analysed (Table 4). To have individual item reliability, all factor loadings must be above 0.60 and statistically significant at 1%. Furthermore, all constructs were internally consistent, as their composite reliability (CR) and Cronbach's *alpha* values were higher than 0.7. The constructs also met the convergent validity criteria, as the average variance extracted (AVE) values were above 0.5. Last, discriminant validity was evaluated through three tests (Hair *et al.*, 2017). First, we verified that all indicators' outer loadings on their associated constructs were greater than any of their cross-loadings on any other construct; second, we showed that, in all cases, the square roots of the AVEs of each construct were greater than the inter-construct correlations (Table 5); third, we verified that all HTMT values were below the limit of 0.90, and that the bootstrap confidence interval did not contain the value 1 (Table 6).

Table 4
Reflective measurement model results

Variables	Items	Mean	SD	Factor loading	CR(i)	AVE(ii)	Cronbach's alpha	Q2
Competence	C1	5.54	1.12	0.829	0.876	0.639	0.811	0.260
	C2	5.63	1.15	0.786				
	C3	5.07	1.39	0.769				
	C4	5.62	1.14	0.813				
Autonomy	A1	5.26	1.28	0.670	0.877	0.642	0.811	0.212
	A2	5.83	1.15	0.867				
	A3	5.79	1.09	0.860				
	A4	5.92	1.12	0.793				
Relatedness	R1	4.36	1.73	0.877	0.950	0.827	0.930	0.391
	R2	4.71	1.68	0.915				
	R3	4.66	1.66	0.920				
	R4	4.76	1.72	0.924				
Intrinsic motivation	IM1	5.46	1.22	0.816	0.904	0.701	0.858	0.391
	IM2	5.44	1.16	0.858				
	IM3	5.26	1.30	0.843				
	IM4	5.63	1.23	0.838				
Physical health	PH1	5.28	1.30	0.817	0.881	0.712	0.798	0.289
	PH2	5.68	1.26	0.866				
	PH3	5.66	1.26	0.848				
Mental health	MH1	5.26	1.44	0.869	0.837	0.633	0.723	0.173
	MH2	4.76	1.63	0.806				
	MH3	5.05	1.58	0.703				
Social health	SH1	3.96	2.04	0.912	0.969	0.886	0.957	0.256
	SH2	4.14	2.00	0.955				
	SH3	4.16	1.99	0.951				
	SH4	4.33	1.92	0.946				

Note: (i) CR: Composite reliability; (ii) AVE: Average variance extracted.
Source: Authors.

Table 5
Fornell-Larcker test

	1	2	3	4	5	6	7
Competence	0.799						
Autonomy	0.665	**0.802**					
Relatedness	0.499	0.161	**0.909**				
Intrinsic motivation	0.721	0.491	0.538	**0.837**			
Physical health	0.682	0.574	0.408	0.633	**0.844**		
Mental health	0.595	0.324	0.471	0.550	0.694	**0.796**	
Social health	0.335	–0.045	0.730	0.407	0.297	0.464	**0.941**

Note: Diagonal elements are the root squared AVE values. (ii) Elements below the diagonal are the constructs' correlations.
Source: Authors.

Table 6
Heterotrait-monotrait (HTMT) ratios

	Competence	Autonomy	Relatedness	Intrinsic motivation	Physical health	Mental health
Autonomy	0.818 [0.718; 0.906]					
Relatedness	0.571 [0.448; 0.683]	0.209 [0.139; 0.291]				
Intrinsic motivation	0.863 [0.769; 0.937]	0.581 [0.438; 0.706]	0.602 [0.478; 0.707]			
Physical health	0.847 [0.719; 0.952]	0.707 [0.578; 0.821]	0.471 [0.330; 0.591]	0.762 [0.637; 0.863]		
Mental health	0.731 [0.612; 0.828]	0.364 [0.232; 0.492]	0.562 [0.409; 0.687]	0.649 [0.512; 0.763]	0.871 [0.757; 0.957]	
Social health	0.373 [0.241; 0.497]	0.166 [0.092; 0.249]	0.771 [0.692; 0.833]	0.445 [0.316; 0.560]	0.336 [0.197; 0.461]	0.574 [0.442; 0.693]

Note: The values in brackets represent the 95% bias-corrected and accelerated confidence interval of the HTMT values.
Source: Authors.

4.2. *Structural model analysis*

To test the hypotheses, a bootstrapping procedure with 5,000 subsamples and one-tail test (Kock, 2014) was used. The model explained 42.8% of the satisfaction of the need for competence variance, 35% of the need for autonomy, 48.5% of the need for relatedness, 56.8% of individuals' intrinsic motivation, 42.2% of physical health, 31.7% of mental health and 29.6% of social health. To assess predictive relevance, the Stone-Geisser test was conducted. The results showed that the Q^2 values for the dependent variables were positive, thereby supporting the predictive relevance of the model (Table 7). Finally, the SRMR (standardised root mean square residual) showed a value of 0.11 close to the cutoff value of 0.10 (Hu & Bentler, 1999).

Table 7 presents the results of the structural model using percentile-based confidence intervals. Testing with confidence intervals provides more information about the estimated path coefficients (Henseler *et al.*, 2009). If a confidence interval for an estimated path coefficient includes the value zero, the coefficient is not significant.

Interaction with achievement and progression-oriented affordances promoted the satisfaction of the needs for competence (β=0.645; CI: 0.544, 0.732), autonomy (β=0.675; CI: 0.576, 0.768) and relatedness (β=0.197; CI: 0.073, 0.302), which supports H1a, H1b and H1c, respectively. While interaction with social-oriented affordances was positively associated with the satisfaction of the need for relatedness (β=0.304; CI: 0.176, 0.431), supporting H2c, a negative effect was found on the satisfaction of the need for autonomy (β=–0.470; CI: –0.626, –0.351), rejecting H2b. Similarly, no significant relationship between social-orientated affordances and the satisfaction of the need for competence was found (β=–0.074; CI: –0.190, 0.021), rejecting H2a. The results showed that interaction with immersion-oriented affordances had a positive effect on the satisfaction of the need for relatedness (β=0.293; CI: 0.130, 0.432), supporting H3c. However, immersion-oriented affordances were not found to have a significant impact on the satisfaction of the needs for competence (β=0.075; CI: –0.071, 0.196) and autonomy (β=0.093; CI: –0.075, 0.261), rejecting H3a and H3b, respectively. The results also showed that the satisfaction of the needs for competence (β=0.525; CI: 0.385, 0.666) and relatedness (β=0.260; CI: 0.166, 0.351) when using the gamified app were positively associated with individuals' intrinsic motivation. Therefore, H4a and H4c were supported. However, no significant relationship was found between the satisfaction of the need for autonomy and individuals' intrinsic motivation to use the gamified app (β=0.100; CI: –0.036, 0.233), rejecting H4b. Finally, individuals' intrinsic motivation while using the gamified app enhanced their physical health (β=0.606; CI: 0.517, 0.680), mental health (β=0.530; CI: 0.442, 0.608) and social health (β=0.452; CI: 0.362, 0.534), supporting H5a, H5b and H5c, respectively.

Table 7
Structural model results

Hypotheses	β	Percentile-based 95% CI
H1a: Achievement and progression-oriented elements → Competence	0.645	[0.544, 0.732]
H1b: Achievement and progression-oriented elements → Autonomy	0.675	[0.576, 0.768]
H1c: Achievement and progression-oriented elements → Relatedness	0.197	[0.073, 0.302]
H2a: Social-oriented elements → Competence	–0.074	[–0.190, 0.021]
H2b: Social-oriented elements → Autonomy	–0.470	[–0.626, –0.351]
H2c: Social-oriented elements → Relatedness	0.304	[0.176, 0.431]
H3a: Immersion-oriented elements → Competence	0.075	[–0.071, 0.196]
H3b: Immersion-oriented elements → Autonomy	0.093	[–0.075, 0.261]
H3c: Immersion-oriented elements → Relatedness	0.293	[0.130, 0.432]
H4a: Competence → Intrinsic motivation	0.525	[0.385, 0.666]
H4b: Autonomy → Intrinsic motivation	0.100	[–0.036, 0.233]
H4c: Relatedness → Intrinsic motivation	0.260	[0.166, 0.351]
H5a: Intrinsic motivation → Physical health	0.606	[0.517, 0.680]
H5b: Intrinsic motivation → Mental health	0.530	[0.442, 0.608]
H5c: Intrinsic motivation → Social health	0.452	[0.362, 0.534]
Control variables:		
Experience → Physical health	0.131	[0.051, 0.2210]
Experience → Mental health	–0.032	[–0.123, 0.066]
Experience → Social health	–0.279	[–0.370, –0.178]
Weekly use → Physical health	0.024	[–0.069, 0.113]
Weekly use → Mental health	0.127	[0.037, 0.222]
Weekly use → Social health	0.174	[0.083, 0.266]
Gender → Physical health	–0.012	[–0.087, 0.065]
Gender → Mental health	0.041	[–0.048, 0.127]
Gender → Social health	–0.071	[–0.160, 0.017]
Age → Physical health	0.032	[–0.052, 0.109]
Age → Mental health	–0.020	[–0.106, 0.062]
Age → Social health	–0.151	[–0.246, –0.067]

Source: Authors.

4.3. Post-hoc analysis of the indirect effects

Considering the importance of psychological need satisfaction and intrinsic motivation underlined in the structural model, this section analyses the potential existence of indirect paths of influence among these variables. We followed Hair *et al.*'s (2017) procedure, which is based on the significance of both direct and indirect effects. The results (Table 8) suggested that the impact of users' interactions with achievement and progression-oriented affordances on intrinsic motivation are mediated by the satisfaction of the need for competence. Likewise, the need for relatedness mediates the impact of users' interaction with achievement and progression-oriented affordances, social-oriented affordances, and immersion-oriented affordances on intrinsic motivation. Finally, intrinsic motivation mediates the impact of both competence and relatedness need satisfaction on physical, mental and social health.

Table 8
Mediation analysis

	Direct effects		Indirect effects		Mediation
	β	95% CI	β	95% CI	
Achievement → Competence → Intrinsic motivation	0.216	[0.07, 0.34]	0.286	[0.18, 0.41]	Partial
Achievement → Autonomy → Intrinsic motivation			0.039	[−0.04, 0.13]	No
Achievement → Relatedness → → Intrinsic motivation			0.033	[0.01, 0.07]	Partial
Social → Competence → Intrinsic motivation	−0.004	[−0.11, 0.09]	−0.032	[−0.08, 0.01]	No
Social → Autonomy → Intrinsic motivation			−0.027	[−0.09, 0.02]	No
Social → Relatedness → Intrinsic motivation			0.053	[0.02, 0.11]	Full
Immersion → Competence → Intrinsic motivation	0.033	[−0.08, 0.15]	0.032	[−0.03, 0.09]	No
Immersion → Autonomy → Intrinsic motivation			0.005	[−0.01, 0.04]	No
Immersion → Relatedness → Intrinsic motivation			0.049	[0.02, 0.10]	Full
Competence → Intrinsic motivation → Physical health	0.314	[0.11, 0.50]	0.107	[0.04, 0.21]	Partial
Competence → Intrinsic motivation → Mental health	0.442	[0.26, 0.62]	0.070	[0.01, 0.16]	Partial
Competence → Intrinsic motivation → Social health	0.096	[−0.04, 0.23]	0.055	[0.01, 0.12]	Full
Autonomy → Intrinsic motivation → Physical health	0.207	[0.07, 0.33]	0.014	[−0.01, 0.06]	No
Autonomy → Intrinsic motivation → Mental health	−0.097	[−0.23, 0.05]	0.009	[−0.01, 0.05]	No
Autonomy → Intrinsic motivation → Social health	−0.214	[−0.32, −0.09]	0.007	[−0.01, 0.04]	No
Relatedness → Intrinsic motivation → Physical health	0.096	[0.01, 0.19]	0.041	[0.01, 0.10]	Partial
Relatedness → Intrinsic motivation → Mental health	0.177	[0.05, 0.29]	0.027	[0.01, 0.08]	Partial
Relatedness → Intrinsic motivation → Social health	0.635	[0.54, 0.71]	0.021	[0.01, 0.06]	Partial

Source: Authors.

5. DISCUSSION

Results of this study showed that achievement and progression-oriented affordances are pivotal in fostering intrinsic motivation to use the app, as interaction with these affordances promotes the satisfaction of the three basic psychological needs for competence, autonomy and relatedness. These results are in line with those of previous studies in educational contexts and with online brand communities (van Roy & Zaman, 2019; Xi & Hamari, 2019).

As expected, the analysis also showed that interacting with social-oriented affordances strongly enhances the satisfaction of the need for relatedness. However, contrary to our predictions, and the findings of previous studies (Xi & Hamari, 2019), this research found that social-orientated affordances had no significant effect on the satisfaction of the need for competence and, even more surprising, found a negative effect on satisfaction of the need for autonomy. A possible explanation for this may lie, in part, with the research context. Although previous research has found that social-oriented motivational affordances satisfy the three psychological needs discussed (Xi & Hamari, 2019), the relations were tested in the context of online brand communities, which are primarily based on a set of social relationships between followers of a brand. Social-oriented affordances in other contexts, such as mobile exercise apps, may be perceived by the users as controlling, and they may come to think that their decisions about what exercise to do, when to do it, and for how long, are being forced. Finally, the results showed that interacting with immersion-oriented affordances in the app facilitates only the satisfaction of the need for relatedness. This result differs from the expectations and from the findings of previous studies where immersion-oriented affordances where shown to foster feelings of competence (Wee & Chong, 2019) and autonomy (Wee & Chong, 2019; Xi & Hamari, 2019). This may be due to the nature of the app analysed. The Fitbit app allows users to post details of their profiles, age, birthday etc., but does not allow them to choose avatars to accompany them during their experiences with the app. In addition, the customisation possibilities may not be enough to make users feel competent and autonomous in their decisions.

The results also indicated that, to the extent that individuals feel competent while using the app, and receive support and recognition from others, they will display greater intrinsic motivation to use the app. In contrast, autonomy need satisfaction did not influence individuals' intrinsic motivation. This result is contrary to the findings of previous research in the context of video games (Ryan *et al.*, 2006), gamification (Sailer *et al.*, 2017) and sports (Sebire *et al.*, 2013). Although all three psychological needs are innate to human beings, their importance is determined by cultural, personal and contextual factors (Deci & Ryan, 2008). Therefore, it is possible that, in the context of health and exercise apps, users are more motivated when they believe they can master all the functionalities of the app, and can interact with other users, than when they are able to decide how to use the app. Finally, the results showed that a relationship exists between individuals' intrinsic motivation while using these apps and their perceptions that they are achieving enhanced physical, mental and social health outcomes. Therefore, individuals who use the apps freely, because they find them enjoyable and/or interesting, tend to feel more active and energised, tend to spend more time outdoors, and are more prone to build relationships with others through the apps. This finding extends the research of Koivisto *et al.* (2019), who analysed the relationships between player orientations and their physical, mental and social health benefits.

5.1. *Theoretical contributions*

The present study makes a number of theoretical contributions to gamification research. First, research on health and exercise apps has mainly investigated the effects of gamification on only a general level or as a research context (e.g., Hamari & Koivisto, 2013; Hamari & Koivisto, 2015; Jang *et al.*, 2018; Kari *et al.*, 2016; Koivisto & Hamari, 2014; Spil *et al.*, 2017; Tsai *et al.*, 2021; Tu *et al.*, 2019). Furthermore, with few exceptions (e.g., Eisingerich *et al.*, 2019; Hassan *et al.*, 2020), most studies have explored a limited number of motivational affordances (e.g., feedback in Giannakis *et al.*, 2013; virtual rewards and social comparisons in Zuckerman & Gal-Oz 2014; leaderboards, medals and levels in Hassan *et al.*, 2019; scoring systems, progress bars and levels, leaderboards and feedback in Cechetti *et al.*, 2019). To bridge these gaps, this research examined simultaneously the effects of the three most common motivational affordances embedded in gamified mobile apps: achievement and progression, social and immersion-related affordances.

Second, prior studies into gamification in health and exercise have mainly focused on the physical health, analysing the continuous use of a platform and/or the increase of exercise and physical activity (e.g., Hamari & Koivisto, 2013; Hamari & Koivisto, 2015; Harris, 2019; Hassan *et al.*, 2019; Ho *et al.*, 2017; Jang *et al.*, 2018; Kaczmarek *et al.*, 2017; Kari *et al.*, 2016; Koivisto & Hamari, 2014; Koivisto *et al.*, 2019; Li & Lwin, 2016; Lunney *et al.*, 2016; Pasco *et al.*, 2017; Peng *et al.*, 2012; Smeddinck *et al.*, 2019; Spil *et al.*, 2017; Stragier *et al.*, 2016; Tsai *et al.*, 2021; Tu *et al.*, 2019; Zuckerman & Gal-Oz, 2014). Similarly, many studies collected objective information, such as biometric variables (e.g., González *et al.*, 2016), measures of physical activity (e.g., Giannakis *et al.*, 2013; Pasco *et al.*, 2017; Tu *et al.*, 2019; Zuckerman & Gal-Oz, 2014), and in-app purchases (Jang *et al.*, 2018), ignoring the users' motivations and attitudes. This study, therefore, extends previous research by conducting a rigorous empirical analysis based on quantitative data obtained from a large sample of actual users through a questionnaire. In addition, it provides new insights into the impact of a variety of motivational affordances on users' physical, mental and social health, thus providing a more complete view of the effects of mobile gamified exercise apps.

Third, the present study also adds to previous gamification-based research by exploring the underlying mechanisms that explain how gamification motivates users and enhances their health. Most prior research in the health and exercise context has failed to provide a holistic view of the effects of motivational affordances on psychological and behavioural outcomes. For instance, Tsai *et al.* (2021) analysed the influence of psychological need satisfaction on perceived playfulness and subsequent behavioural intentions in the context of gamified running apps, while Attig and Franke (2019) analysed the impact of different types of motivation on the dependency to adopt wearable activity trackers. However, these authors did not include the effects of motivational affordances on psychological outcomes in their models. Quintas *et al.* (2020) investigated whether playing an exergame promoted psychological need satisfaction, higher levels of motivation and the flow experience; however, they did not analyse the effects of these psychological outcomes on behavioural outcomes. Similarly, Koivisto *et al.* (2019) analysed what type of players (achievement, immersion or social-oriented) were most likely to perceive health benefits (physical, mental and social) from playing augmented reality games. However, their work focused on player orientations and did not measure their interactions with motivational affordances. Similarly, it did not explore the underlying mechanisms that explain how these interactions lead individuals to perceive health benefits. This study, therefore, contributes to the gamification literature in this context by proposing, and empirically testing, a comprehensive framework that examines the impact of different motivational affordances on the satisfaction of users' basic psychological needs and intrinsic motivations, and their subsequent effects on users' health, by drawing on a well-grounded theoretical model, SDT.

5.2. *Practical implications*

This study also provides practical insights to help mobile gamified exercise app developers in their decision-making in terms of gamification orientations. Results have shown that, above all, achievement and progression-oriented affordances should be integrated into these apps, as they facilitate users' feelings of competence, autonomy and relatedness. Within achievement and progression-oriented affordances, academia and practitioners have largely focused on the "PLB triad" (Werbach & Hunter, 2012), which is based on the use of points, leaderboards and badges. However, as Quintas *et al.* (2020) recently noted, those affordances might only be useful for short-term motivation. Therefore, mobile gamified exercise app providers should consider integrating other achievement and progression-related motivational affordances into their systems. We suggest they design experiences based on different challenges (e.g., walking, running, working out), that users can choose freely; these should be accompanied by clear scoring systems so that the users can feel competent through monitoring their performance and progress and receive feedback about their achievements and goal completion. In addition, being able to compare their results with those of other users will enhance their feelings of social connection. Thus, irrespective of whether the app is being used, and the exercise is being carried out, individually, with a partner or in a group, its users will always feel that they are part of a community.

While integrating achievement and progression-oriented affordances into these apps is highly recommended, adding immersion-related motivational affordances is recommended only where the aim of the gamified app developer is to promote a sense of relatedness; for instance, to create a community of users when the app is first launched. Although immersion-related affordances do not promote competence or autonomy, they can develop a sense of relatedness among users. In particular, allowing users to create their own avatars to represent them in the app, customising some aspects of the app and creating virtual worlds, may make users perceive that they are playing a significant role in the app community.

Finally, when designing mobile gamified exercise apps, managers should define a set of KPIs (key performance indicators), as this can help to examine the development and effectiveness of the apps (Antolín-Prieto *et al.*, 2021; Reyes-Menendez *et al.*, 2020). Thus, we encourage managers of gamified exercise apps to define KPIs to evaluate the gamification system and use this information to improve users' experience with the app or make improvements and adjustments.

5.3. Limitations and future research directions

This study has some limitations that offer avenues for future research. In particular, determining the long-term effects of gamification on individuals was not possible due to the use of exclusively cross-sectional data. Therefore, future research should use longitudinal data, which would help identify the long-term effects of gamification. In addition, the study found that social-oriented affordances motivate individuals through the satisfaction of the need for relatedness, but can also demotivate them due to the reduction of autonomy. Thus, future research should analyse in more depth the effects of social-oriented affordances on individuals' health outcomes. Finally, this study focused on only one mobile exercise app, Fitbit, and users from one country, the United States. Therefore, future studies should replicate the proposed model with other gamified exercise apps and with users from other countries. It would be also interesting to explore the use of gamified apps in other contexts, such as the tourist sector where mobile applications are increasingly employed (Saura *et al.*, 2020).

6. CONCLUSIONS

It can be concluded from this study that gamification is a key tool to increase individuals' motivation and their health perception in the context of exercise apps. Drawing from the self-determination theory (Ryan & Deci, 2000), this study provides new insights about how motivational affordances (i.e., achievement and progression, social and immersion-oriented affordances) embedded within mobile gamified exercise apps impact users' psychological outcomes (i.e., basic psychological need satisfaction and intrinsic motivation) and its subsequent effect on the behavioural outcomes that the gamification targets (i.e., physical, mental and social health). The empirical study carried out with a sample of users of a real gamified exercise app highlights the important role of achievement and progression-oriented affordances to foster feelings of competence, autonomy and relatedness among users. Results also show that gamified exercise apps should focus on satisfying the needs for competence and relatedness because this leads to greater intrinsic motivation towards the app and, in turn, leads to greater physical, mental and social health. The main theoretical contribution of this study refers to providing a holistic view of the effects of motivational affordances on psychological and behavioural outcomes in the context of health and exercise apps, focusing on the subjective experience of users. Finally, the main recommendation for designers and developers of gamified exercise apps would be to integrate achievement and progression-oriented affordances into these apps, as they facilitate users' satisfaction of basic psychological needs.

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APPENDIX

Table A.1
Measurement scales

Construct	Items
Interaction with achievement and progression-oriented elements	**FAE1.** The frequency of interacting with scores **FAE2.** The frequency of interacting with performance graphs **FAE3.** The frequency of interacting with challenges **FAE4.** The frequency of interacting with badges/ trophies **FAE5.** The frequency of interacting with progress bars **FAE6.** The frequency of interacting with rankings/ leaderboards **IAE1.** The importance of interacting with scores **IAE2.** The importance of interacting with performance graphs **IAE3.** The importance of interacting with challenges **IAE4.** The importance of interacting with badges/ trophies **IAE5.** The importance of interacting with progress bars **IAE6.** The importance of interacting with rankings/ leaderboards
Interaction with social-oriented elements	**FSE1.** The frequency of interacting with competition **FSE2.** The frequency of interacting with social networking features **FSE3.** The frequency of interacting with cooperation **ISE1.** The importance of interacting with competition **ISE2.** The importance of interacting with social networking features **ISE3.** The importance of interacting with cooperation
Interaction with immersion-oriented elements	**FIE1.** The frequency of interacting with profile/ virtual identity/ avatar **FIE2.** The frequency of interacting with personalization **FIE3.** The frequency of interacting with virtual world/ 3D world **IIE1.** The importance of interacting with profile/ virtual identity/ avatar **IIE2.** The importance of interacting with personalization **IIE3.** The importance of interacting with virtual world/ 3D world
Competence	**C1.** I think that I am pretty good when I use this app **C2.** I am satisfied with my performance when I use this app **C3.** I feel like an expert using this app **C4.** I feel like a competent person when I use this app
Autonomy	**A1.** In this app I have different options **A2.** I feel free to use this app **A3.** I feel free to decide what activities to do in this app **A4.** When I use this app, it is because I want to use it
Relatedness	**R1.** I feel like other people care what I do **R2.** I feel supported by others **R3.** I feel that I am a valuable person to others **R4.** I feel that I am understood
Intrinsic motivation	**IM1.** I think that this app is interesting **IM2.** I think that this app is pleasant **IM3.** This app is fun **IM4.** I feel good when using this app
Physical health	**PH1.** Feel more energized **PH2.** Feel more physical active **PH3.** Have exercised more
Mental health	**MH1.** Feel more mentally active **MH2.** Feel less depressed and anxious **MH3.** Have spent more time outdoors
Social health	**SH1.** Have made new friends **SH2.** Have interacted more with people **SH3.** Feel more social **SH4.** Feel more connected with others