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Effectiveness of cooperative and competitive gamification in mobile fitness applications among occasional exercisers

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ABSTRACT

Physical activity (PA) is critical to health, but PA level declines dramatically in young adulthood. This study aims to compare the effectiveness of different social gamification designs (i.e. cooperation and competition) in mobile fitness applications among occasional exercisers among young adults. A mobile fitness application featuring competitive, cooperative, or individualistic gamification was designed and their effectiveness in promoting PA behaviours and socio-cognitive factors among occasional exercisers was compared through a four-week (i.e. one week for baseline and three weeks for use) field experiment involving 49 participants. The participants used one of the gamified applications with one or more friends in daily life during the experimental period. The results showed that cooperation and competition stimulate different types of social support: cooperation improves companion support, whereas competition improves appraisal support. Both gamification significantly increased daily steps in the first week, but after three-week usage, the increase of the cooperation groups reclined, whereas that of the competition groups was maintained. The application usage in cooperation also declined significantly after three weeks, while that of the other two conditions did not change significantly. The current study provided insights into gamification design for occasional exercisers among Chinese young adults.

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KEYWORDS
Gamification; cooperation; competition; mobile fitness applications

1. Introduction

Physical activity (PA) promotes both physical and psychological health (Chodzko-Zajko et al. 2009; Penedo and Dahn 2005). However, due to the transition in living arrangements and social roles, the PA level declined during young adulthood (Corder et al. 2019; Kjønniksen, Torsheim, and Wold 2008). According to the report of the State Sport General Administration of China (2014), only 13.7% of young adults take physical activities regularly. Various evidence shows that occasional exercisers make up a large proportion of Chinese young adults, i.e. from 35.1% to 64.9% across studies (Ding, Hong, and Zhang 2019; Hou and Liu 2004; Song and Zhao 2007; Zhang et al. 2018). Prior research suggests that people in different PA status have different attitudes and needs about exercise, and their exercise behaviours are affected by different socio-cognitive predictors (Aaltonen et al. 2014; Burton, Shapiro, and German 1999; Eyler et al. 2003; Hoare et al. 2017; Williams et al. 2008). Therefore, more efforts are needed to develop measures to improve the PA of occasional exercisers among young adults.

Understanding the socio-cognitive characteristics of occasional exercisers may be beneficial for designing PA persuasive strategies for them. PA research has found that people in different stages to develop PA habits were different in attitudes and perceptions of exercise (Elezim et al. 2019; Marcus, Rakowski, and Rossi 1992a), self-efficacy (Elezim et al. 2019; Marshall and Biddle 2001), and social support (Elezim et al. 2019). According to behavioural change theories, such as the transtheoretical model (TTM) (Prochaska, Diclemente, and Norcross 1992), occasional exercisers are likely to be between the stage of preparation to change and the stage of behaviour maintenance. On the one hand, their consciousness about the positive outcomes of PA is high enough to make the decision to engage in physical activities, and have taken some actions. On the other hand, they may not have developed sufficient confidence and skills, as regular exercisers do, to sustain

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regular physical activities and avoid relapse back to the sedentary status (Bautista et al. 2011; Eyler et al. 2003; Iso-Ahola et al. 2006). It is suggested that social influence and support are particularly important for people in such transitional states (Prochaska, Diclemente, and Norcross 1992). Hence, interventions supporting social interactions may be particularly effective for occasional exercisers.

To increase PA engagement, many mobile fitness applications adopt a range of game mechanics and elements, e.g. using badges and leader boards, or designing story narratives, to make PA more playful and enjoyable. As social influence has been identified as an influential factor in motivating PA (Cavallo et al. 2014; Okun et al. 2003), increasing mobile applications, e.g. Nike+ and Fitbit, incorporate social gamification to engage their users (Almutari and Orji 2019; Chen and Pu 2014; Mazeas et al. 2022). Two commonly used designs are cooperative and competitive gamification (Halko and Kientz 2010; Peng and Hsieh 2012). Mobile fitness applications featuring cooperation gamification often invite users to form a team with a shared goal. Competitive gamification, on the other hand, motivates users by competing with each other to win a reward, e.g. top ranking in a leaderboard or badges (Ahtinen, Huuskonen, and Häkkilä 2010; Foster et al. 2010).

Despite the high popularity of social gamification in mobile fitness applications, which social gamification mechanism is more effective in improving PA engagement, however, remains unclear. Most of the published studies on the effectiveness of social gamification compared a specific application featuring either cooperation or competitive gamification against a non-gamified design (Almutari and Orji 2019; Anderson et al. 2007; Mazeas et al. 2022; Shameli et al. 2017; Toscos et al. 2008). Only limited studies carried out direct comparisons between the two (Chen and Pu 2014; Peng and Crouse 2013; Staiano, Abraham, and Calvert 2013), and these studies differed significantly in both experimental design and results. Given the limited evidence and inconsistent findings, no conclusion can be drawn so far for the relative effectiveness of cooperative and competitive gamification in promoting PA. Furthermore, existing gamification research focused mainly on outcomes such as step increase and application usage, but neglected the socio-cognitive factors, which reflected the psychological changes behind observable outcomes and are associated with long-term PA behavioural changes. Therefore, the mechanisms of how social contexts created by cooperative versus competitive gamification produce behavioural outcomes remains unclear. Finally, these studies did not distinguish individuals at different PA stages. As discussed above, individuals at different PA stages are motivated by different socio-cognitive factors and processes (Aaltonen et al. 2014; Burton, Shapiro, and German 1999; Eyler et al. 2003; Hoare et al. 2017; Williams et al. 2008). These differences may confound the effect of social gamification. Given that occasional exercisers make up a large proportion of Chinese young adults, and that they are more likely to be influenced by social support and recognition from helping relationships, more granular research focusing on this specific group is called for.

This study aims to compare the effectiveness of cooperative and competitive gamification of mobile fitness applications on boosting PA, with a particular focus on occasional exercisers. Designing a mobile fitness application featuring competitive, cooperative, or individualistic gamification, the study compared their effect in promoting PA behaviour (counted in daily steps) and socio-cognitive factors, as well as participants' application usage, through a four-week field experiment involving 49 participants. Our findings provide empirical evidence on the relative effectiveness of the two social gamification among occasional exercisers, revealing their working mechanisms, and thereby providing practical implications for the design of mobile fitness applications for occasional exercisers.

2. Literature review

2.1. Individualistic vs. collectivistic consumption of gamified services

Gamification design allows users to engage in activities collectively with the aim to boost user motivations and enjoyments (Dindar, Ren, and Järvenoja 2021; Jang, Kitchen, and Kim 2018; Rosário 2022; Schöbel, Janson, and Sollner 2020; Whelan and Clohessy 2020). In collectivistic gamification, at least two users are involved and they were encouraged to interact with others. Most studies allowed people to take activities cooperatively or competitively with each other to form a collectivistic environment, compared to conditions where people act individually.

A number of studies have identified the advantage of collectivistic gamification over individualistic design in many contexts, such as business (Rodrigues, Oliveira, and Costa 2016; Rosário 2022), health (Cheng et al. 2019; Westhoff et al. 2012), and education (Dindar, Ren, and Järvenoja 2021; Su and Cheng 2015), etc. Bovermann et al. (2019) compared the influence of individual and collectivistic gamified learning environments on perceived motivation, relatedness, and effort. He found that the collectivist condition yielded more

perceived motivation than the individual condition, although no significant difference was revealed between the two groups. Landers, Collmus, and Williams (2019) added competition to a brainstorming task and they reported improvements in both the creativity and quantity of brainstorming compared to the control group. Riar et al. (2022) conducted a review of 51 studies on the effect of cooperative gamification on increasing motivation. They found that the majority of studies reported positive results. The effectiveness of collectivistic gamification, however, can be reduced by the occurrence of social loafing (i.e. individuals put less effort into the job when they are a part of the group, as compared to when they are working alone) (Voyles, Bailey, and Durik 2015) and social overload (i.e. individuals perceive too many social demands to deal with, which take too much time and attention) (Huang and Zhou 2020).

In the field of motivating PA, most of the published studies compared a specific application featuring either cooperative or competitive gamification against a non-gamified design. In both gamification designs, mutual performance evaluation and recognition from others were observed and were deemed as important encouraging experiences (Chen and Pu 2014; Consolvo et al. 2006; Foster et al. 2010; Firtz et al. 2014). Regarding cooperation, studies generally reported positive comments (Ahtinen, Huuskonen, and Häkkilä 2010; Chen and Pu 2014; Consolvo et al. 2006), except Lin et al. (2006), which found anonymous cooperation makes users feel awkward to contact. Studies evaluating competitive applications, however, reported mixed feedback from users: whereas most studies showed that users in the competition are motivated (Ahtinen, Huuskonen, and Häkkilä 2010; Consolvo et al. 2006; Foster et al. 2010; Peng and Crouse 2013; Toscos et al. 2008), several studies reported negative effects of competition: users felt demotivated when their pace was not equivalent to their team partners (Chen and Pu 2014; O'Brien and Mueller 2007). Some users also worried that competition may hurt their friendship with their teammates (Toscos et al. 2008). Despite the wide applications of cooperative and competitive gamification in motivating PA, it is not clear which is more effective.

2.2. Cooperation versus competition gamification

Regarding the differences between cooperation and competition, social interdependence theory (SIT) was the by far most employed theory. SIT stated that the two motivational strategies differ in the structure of goals, which results in distinct interdependent relationships between individuals. SIT posits that competition creates a negative independent goal structure (i.e. one can achieve his or her goals only if the others cannot achieve their goals). By creating a contest situation in which users strive for superiority or victory, competition can induce high levels of motivation, according to the goal-setting theory (Landers et al. 2015; Locke and Latham 1990; 2019; Morschheuser, Hamari, and Maedche 2019; Wood and Locke 1990). Competitive gamification, however, is more likely to induce negative feelings, including frustration (for the laggards), the feeling of unfairness (for those who believe that the criteria is not impartial), and even anxiety and anger (when the goal is too important or the opponent is too aggressive). In some worst cases, oppositional interaction (i.e. obstructing other's success to obtain personal goals, e.g. misleading others, less communicating and sharing) may occur. On the contrary, cooperation builds a positive interdependent goal structure (i.e. people in one team share the same goal). The social environment built by cooperative gamification is friendlier, in which people could develop meaningful relationships and are encouraged to put effort for team responsibilities. The effectiveness of cooperative gamification, however, can be reduced by the occurrence of social loafing (i.e. individuals put less effort into the job when they are a part of the group, as compared to when they are working alone) (Voyles, Bailey, and Durik 2015) and social overload (i.e. individuals perceive too many social demands to deal with, which take too much time and attention) (Huang and Zhou 2020). Based on this theoretical foundation, cooperation was supposed to induce promotive interaction and to yield better performance and teamwork outcomes than the competition, as evidenced by a couple of meta-analyses of research on the relative merits of the two group dynamics in various domains, e.g. education, psychotherapy, and organisation/community development (Gillies 2016; Johnson 2003; Johnson and Johnson 2005). The review result shows that cooperation induced a higher level of effort to achieve, promoted positive relationships among individuals, and resulted in greater psychological health and self-esteem, as compared with the competition.

Such relative merits of cooperation versus competition, however, are not so well supported in recent studies on social gamification via information technologies. Considerable variations exist in studies that compare the effectiveness of technology-mediated cooperative and competitive group dynamics in shaping target user behaviours, such as the adoption of new technology and services (Bräuer and Mazarakis 2022a; Huang and Zhou 2020), engagement in learning tasks

(Dindar, Ren, and Järvenoja 2021; Landers et al. 2015; Ren 2019), and contribution in innovation crowdsourcing (Landers, Collmus, and Williams 2019; Leclercq, Hammedi, and Poncin 2018; Morschheuser, Hamari, and Maedche 2019). Some research found that both cooperative and competitive gamification has a positive effect on user engagement in learning and brainstorming tasks, but there is no significant difference between the two social gamification (Bräuer and Mazarakis 2022b; Dindar, Ren, and Järvenoja 2021; Ying Jie 2021). Some other studies, however, showed that competitive gamification is more beneficial in terms of behavioural measures (e.g. shorter task time, better learning outcome, higher engagement in contribution) (Lei and Rau 2023; Morschheuser, Hamari, and Maedche 2019; Wolf et al. 2021). For example, Wolf et al. (2021) proposed two pathways, that is striving for success and fear of failure, to link the two social gamification with self-improvement goal pursuit and competition was found to be the stronger trigger for both pathways. In other studies, whereas, cooperation gamification leads to better psychological outcomes (e.g. social relatedness, willingness to recommend the application to others, etc.) (Bräuer and Mazarakis 2022a; Cao et al. 2022; Morschheuser, Hamari, and Maedche 2019; Ren 2019). Cao et al. (2022) used cooperative and competitive gamification to motivate participants' pro-environmental behaviours. They found that the effect of cooperation is more significant than competition and that cooperation could stimulate norms whereas competition could not.

Only a small number of studies directly compared cooperative and competitive gamification in terms of their effects on motivating PA (Chen and Pu 2014; Jiang 2019; Peng and Crouse 2013; Staiano, Abraham, and Calvert 2013). Two of them examined social gamification of video fitness games and provided opposite findings. Peng and Crouse (2013) invited college students to play an exergame (i.e. videogames requiring gross motor activity), either cooperatively in the same physical space, or competitively in separate spaces. The results showed that parallel competition in separate spaces resulted in higher exercise intensity and future play motivation than cooperation in the same space. Staiano, Abraham, and Calvert (2013) invited overweight high-school students to join a 20-week exergame intervention, in which they played the game every school day in exercise sessions organised by experimenters. The results showed that cooperative players lost significantly more weight and increased self-efficacy as compared to the control group, whereas no significant improvement was found for the competitive players. This relative merit of cooperation over competition was also supported by Chen and Pu (2014). They designed three social gamification settings (i.e. competition, cooperation, or hybrid) in a mobile application and conducted a two-week in-situ user study to understand how users interact in different groups. The results favoured the design of cooperative gamification, which led to more exchange of messages among paired users and the biggest increase in step counts among all groups.

The conflicting findings from these studies can hardly be compared due to the compelling difference in study design (e.g. in laboratory or in-situ, participants take exercise sessions organised by experimenters or take exercise autonomously, the experiment is nonrecurring or last multiple weeks). Furthermore, a possible reason for the disparate findings is the difference lies in the task structure involved in studies. Cooperation or competitive gamification in gamification studies were often embodied as interdependent or dependent goal structures, but actual social interdependence among individuals is also influenced by task interdependence, i.e. whether team tasks are segmented into independent units or dependent units (Malone and Lepper 1987; Üçgül 2006). With independent tasks, competition and cooperation are exogenous to the activity, e.g. comparing individual scores (competition) or combining independent scores of members to form a total team score (cooperation). With dependent tasks, competition and cooperation are endogenous to the activity, such as working on dependent tasks with conflicting goals (competition) or working interdependently to achieve a common goal (cooperation). Most of the research investigating social gamification applications adopted the exogenous approach (Chen and Pu 2014; Toscos et al. 2006), e.g. participants in both conditions could perform the task with no interference from the others. Such independent task structure may lessen the effects of cooperative gamification more than that of competitive gamification (Malone and Lepper 1987). Furthermore, Morschheuser, Hamari, and Maedche (2019) suggested that the general social structure of the context (e.g. crowd creating has a cooperative context in general) may play a role in moderating the effect of social gamification. This calls for gamification research focusing on specific target activities, such as PA (Seaborn and Fels 2015).

2.3. Socio-cognitive factors of PA engagement at different PA status

Researchers have found a number of socio-cognitive factors are associated with PA engagement. Among these factors, control beliefs and social support have

been widely identified as determinants of PA behaviour change (Courneya et al. 2000; Okun et al. 2003; Rhodes, Jones, and Courneya 2002; Saunders et al. 2004).

Behavioural change theories, such as TTM, suggest that social support is particularly important for moving people from the stage of preparation to change to the stage of action and maintenance (Prochaska, Diclemente, and Norcross 1992). This statement is supported by several PA research, which found that social support, or the lack of it, is a key determinant of behavioural change from preparation to action/maintenance of PA behaviour (Gibbison and Johnson 2012; Hayotte et al. 2020; Kirk, MacMillan, and Webster 2010). In particular, Gibbison and Johnson (2012) found that friends are a valued source of social support, particularly for people in the preparation and maintenance stage. Specific to the PA context, social support includes recognition of good performance and progress (appraisal support), co-participation in PA (companionship support), and knowledge assistance (information support) (Chogahara 1999). The impact of different types of social support on PA intentions and behaviours has been examined in a number of studies (Cavallo et al. 2014; Courneya et al. 2000; Gibbison and Johnson 2012; Okun et al. 2003; Rackow, Scholz, and Hornung 2014). The results show relatively reliable evidence for the positive effects of esteem and companion support on PA intention and behaviours, whereas the effect of information support is often insignificant or of a small magnitude.

The level of control that one believes that he or she has over the behaviour plays an important role in determining whether one's behaviour engagement can be sustained over time (Cavallo et al. 2014; Parkinson, David, and Rundle-Thiele 2017; Wang and Zhang 2016; Williams et al. 2008). Such beliefs include, on the one hand, perceived ease or difficulty over constraints (i.e. perceived behavioural control) to take PA (Hagger, Chatzisarantis, and Biddle 2002; Jackson, Smith, and Conner 2003; Muschalik et al. 2018; Rhodes, Plotnikoff, and Courneya 2008; Rovniak et al. 2002) and, on the other hand, one's confidence in his/her own ability to execute behaviours in the face of impediments, i.e. self-efficacy (Bandura 1977). The two constructs differ in that perceived behavioural control emphasises facilitators and impediments from the environment, and that self-efficacy reflects one's belief in one's own ability. Both self-efficacy and perceived behavioural control were identified as important predictors of PA intention, and they contribute to an account for the gap between intention and behaviour, i.e. individuals have high intentions to adopt the behaviour but fail to act or to sustain the action (Steve, Godin, and Lydi-Anne 2012).

By definition, occasional exercisers are in the transitional stages between the preparedness and action/maintenance stages. They have the intention to engage in PA and may take some steps, but they may not have developed as strong self-efficacy and skilful behavioural control as regular exercisers. Support from helping relationships, such as reminders from others, appraisal of their progress, and companionship, can play a key role in motivating them to move to the next stage.

3. Hypotheses

Prior research suggests that occasional exercisers are more likely to be influenced by social support. Thus mobile fitness applications featuring social gamification may be particularly effective for occasional exercisers (Ferron and Massa 2013; Hayotte et al. 2020). It remains unclear, however, which social gamification design is more effective than the other in promoting PA behaviours. No conclusion can be drawn from the limited available literature in this vein, not to mention that none of these studies took participants' current PA status into consideration. In addition, the existing gamification research did not examine socio-cognitive predictors of PA (e.g. social support, perceived behavioural control, and self-efficacy) identified in PA research (Cavallo et al. 2014; Ren et al. 2020). This leaves the working mechanisms of social gamification on PA engagement unexamined. Furthermore, given that mobile fitness applications are used in a voluntary manner in real life, users' interest in gamification and frequent usage is a prerequisite for social gamification to exert influence. Yet no study has considered application usage together with PA behavioural change. To address these gaps, the current research aims to compare the effectiveness of competition and cooperative gamification on occasional exercisers' application usage, socio-cognitive predictors, and PA behaviours.

By definition, gamified fitness applications aim to motivate users to engage in PA by making the activity more enjoyable and playful. The majority of studies incorporating social gamification in fitness applications reported positive user feedback (Almutari and Orji 2019; Anderson et al. 2007; Jiang 2019; Mazeas et al. 2022; Toscos et al. 2008), and some found a positive impact of participants' motivation to use applications (Ahtinen, Huuskonen, and Häkkilä 2010; Foster et al. 2010; Lin et al. 2006). Such positive experience promotes users' adherence to fitness applications, thereby enhancing PA intention and behaviours (Baretta, Perski, and Steca 2019; Marker and Staiano 2015). Thus, we expected that both cooperative and

competitive gamification would lead to an increase in both PA behaviours and application usage, as compared to the single-player mode.

- H1. Both cooperative and competitive gamification would increase PA behaviours of occasional exercisers as compared to individualistic gamification.
- H2: Both cooperative and competitive gamification would lead to occasional exercisers' higher application usage as compared to individualistic gamification.

Regarding the relative merits between cooperation and competition, SIT posited that the different goal structures between cooperation and competition yielded better performance and psychological outcomes of cooperation compared to competition. This was empirically verified by a couple of research in various domains, e.g. education, psychotherapy, and organisation/community development (Gillies 2016; Johnson 2003; Johnson and Johnson 2005). In the field of PA, studies incorporating cooperative gamification generally received positive user feedback, whereas those incorporating competitive suggest that the user experience was influenced by factors such as unbalanced opponents and worries to hurt relationships (Chen and Pu 2014; O'Brien and Mueller 2007; Toscos et al. 2006). Since users' attitude is positively associated with their application usage as well as PA behaviours (Baretta, Perski, and Steca 2019; Muschalik et al. 2018), we expected that cooperative gamification will perform better than competitive gamification in terms of both PA behaviours and application usage.

- H3: For occasional exercisers, cooperative gamification would lead to more PA behaviours as compared to competitive gamification.
- H4: For occasional exercisers, cooperative gamification would lead to higher application usage as compared to competitive gamification.

Since cooperative and competitive gamification create an environment where users can see the status of each other and communicate with each other, these interactions may include approvals of each other and co-participation of exercise. Staiano et al.'s research on exergame (2013) found that both cooperation and competition players increased in peer support compared to the control group. Huang and Zhou (2020) found that both cooperation and competition affordance in green IT services improves social recognition. Based on these evidence, we anticipate that both cooperative and competitive gamification would lead to higher appraisal support and companionship support compared to gamification where no social interaction exists.

- H5.1 For occasional exercisers, both cooperative and competitive gamification would increase companionship support more than individualistic gamification.
- H5.2 For occasional exercisers, both cooperative and competitive gamification would increase appraisal support more than individualistic gamification.

Furthermore, we hypothesised that the positive effect on social support is larger in cooperative gamification than in competitive gamification. SIT posits that the positive interdependence of goals in cooperation positively influences individuals' sense of social relatedness and the willingness to interact with others (Gillies 2016), and this has been consistently confirmed in social gamification research on learning and co-creation behaviours (Bräuer and Mazarakis 2022a; Dindar, Ren, and Järvenoja 2021; Morschheuser, Hamari, and Maedche 2019; Ren 2019). In a couple of qualitative studies on social gamification on mobile fitness applications, users reported that they prefer the social atmosphere in cooperation more than that in competition (Ahtinen et al. 2009; 2010; Lin et al. 2006; Toscos et al. 2006). Chen and Pu (2014) found that cooperative gamification leads to more messages exchanged between users than competitive gamification. Therefore, we propose the following hypothesis:

- H5.3 For occasional exercisers, cooperative gamification would increase companionship and appraisal support more than competitive gamification.

Furthermore, we expected that both social gamification has a positive effect on self-efficacy and perceived behavioural control. There are two reasons. First, cooperation and competition are designed to motivate users and they are by definition approaches that aim at making the user experience less struggling and more enjoyable. By supporting mutual communication and interactions, cooperation and competition lower the constraints of participating in exercise and provide opportunities for users to achieve difficult and challenging goals that they could not achieve individually (Cavallo et al. 2014; Li et al. 2018; Okun et al. 2003; Ren et al. 2020). Thus, both cooperation and competition gamification may help to strengthen the perceived ease of exercise (i.e. perceived behavioural control) as well as the confidence to perform exercise (i.e. self-efficacy). Second, both social gamification were expected to increase social support, and social support, particularly appraisal support, has been found to contribute

to perceived behavioural control and self-efficacy (Li et al. 2018; Okun et al. 2003; Ren et al. 2020). Thus, we suspect that the two gamification could promote the two control beliefs by increasing social support.

- H6.1 For occasional exercisers, both cooperative and competitive gamification would increase perceived behavioural control more than individualistic gamification.
- H6.2 For occasional exercisers, both cooperative and competitive gamification would increase self-efficacy more than individualistic gamification.

In terms of the comparison between cooperation and competition, we suspected that cooperation would result in more perceived behavioural control and self-efficacy than competition. The primary reason is the interdependent relationships between individuals in the two conditions. According to SIT, the goals of people in cooperation are positively connected and their interactions are generally promotive and encouraging. Competition, however, creates a negative independent goal structure and people in competition are likely to be demotivated when the rules are not designed well. Therefore, we believed that cooperation could have a stronger effect on increasing control beliefs than competition. In addition, as we expected that cooperation increases appraisal and companion support more than competition, we also hypothesised that cooperation increases self-efficacy and perceived behavioural control more than competition.

- H6.3 For occasional exercisers, cooperative gamification would increase self-efficacy and perceived behavioural control more than competitive gamification.

4. Experimental system design

4.1. Application design and interfaces

A mobile fitness application, named *SportAdventure*, with three versions, featuring cooperative, competitive, and individualistic (i.e. the single-player mode) gamification respectively, was designed. We chose to deliver *SportAdventure* as a WeChat Mini Program, due to the dominant role of WeChat among Chinese young adults, to help to increase users' familiarity and enable direct utilisation of the users' social networks. *SportAdventure* retrieves users' activity data, mainly the number of steps and the duration of jogging time, from *Ledongli*, a motion-tracking application. We chose *Ledongli* because it can automatically and accurately detect and track and identify physical activities such as walking, running, and cycling, and these activities are the main activities for occasional exercisers. Among these data, *SportAdventure* counts steps from walking and running to calculate game points. It provides an open application programming interface (API) that allows third parties to access its activity data. In addition, *Ledongli* supports both Android and iOS mobile phone systems.

The design of *SportAdventure* follows the guidelines of persuasive technology proposed by Oinas-Kukkonen and Harjumaa (2008), with special attention to the features that have been found effective in persuasion, including goal setting, progress monitoring, performance-based feedback and rewards, and sharing of goals and status (Chen and Pu 2014; Consolvo et al. 2006). We chose to design an adventure game, in which players take on a virtual space, dig for treasures along the trip, and endeavour to reach the trip destination fast, as shown in Figure 1a,b. Each week, a player starts a new trip within. Each trip is designed with a different adventure storyline in a different environment (i.e. a sailing expedition to search for a mysterious liquid, a space adventure to look for the aliens, and a silk-road adventure). The accumulated number of steps that each player takes in the real world during the week is mapped into the distance the player travels in the virtual space. Each adventure trip is divided into multiple milestones. The player needs to accumulate enough steps by taking PA in reality, to move his/her character forward and to collect energy beans/stones (special rewards in the game world, and the collecting rule is explained in Section 3.2).

Players can monitor their own progress (i.e. goals, steps, and goal completion rate) in their main interfaces, as shown in Figure 1a,b. With cooperative and competitive gamification, players can check the progress of their game partners, who play the role of opponents or team members in the moment interface, as in Figure 1c. In this interface, they can also check the status posted by their exercise companions and send love hearts or other emoticons to encourage their companions. Each player's status update will be broadcasted to all game partners in the same group and the sent emoticons will be displayed on the receivers' main interface as pop-ups in the main interface (Figure 1e,f).

4.2. Goals and points

To motivate users to exercise and to increase the fun of the game, we designed the following rules.

- *Points for achieving daily step goals.* At the beginning of each trip of one week, *SportAdventure* provides a

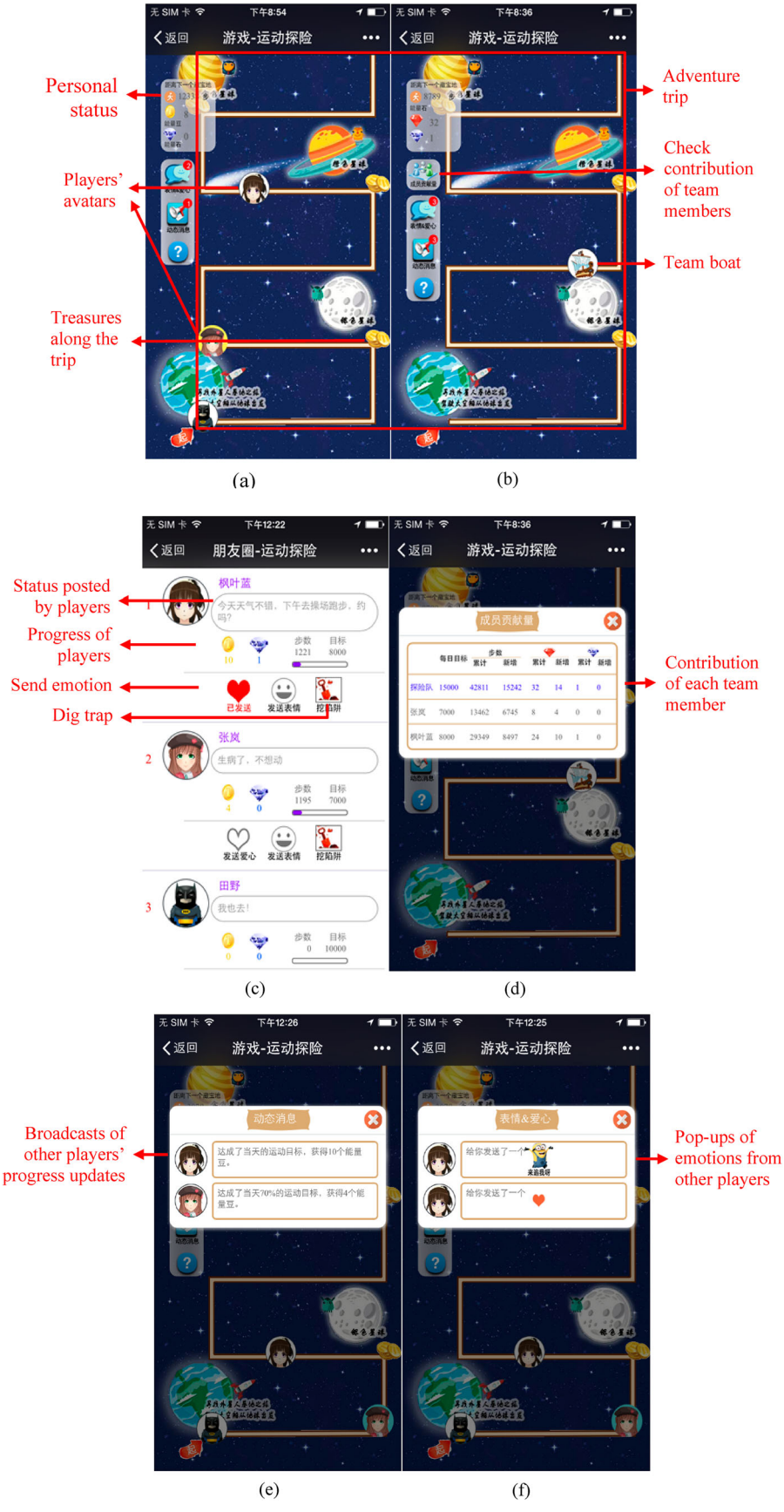

Figure 1. (a) Main interface of competition; (b) Main interfaces of cooperation; (c) Moment interface; (d) Contribution of each team member; (e) Pop-ups of emotions from other players; (f) Broadcasts of other players' progress updates.

personalised daily step goal for each user based on his/her daily step count in the last week and shows his/her progress toward the goal during the day. With competitive gamification, the points obtained from daily goal completion are represented as energy beans, whereas with cooperative gamification, the points are represented as energy stones (the use of energy beans and stones will be explained in Section 3.3). The user can get 10 points when he reaches the daily step goal; otherwise, he/she can get 5 points for 70% of the goal completion rate or 2 points for 50% of the completion rate at the end of the day. The user gets no points if the completion rate is below 50%. The individual goals are established by recording participants' daily step count for one week and taking the second-highest count to round to the next thousand as the daily step goal for the next week. This design follows the method proposed by Consolvo et al. (2006). The second highest count is chosen to reduce the possibility for the goal setting to be biased by a highly active, and unrepresentative, day in the previous week.

- *Points for jogging time.* For every 10 min of jogging, the user can get 1 energy stone.
- *Treasure digging upon completion of each milestone.* When the user reaches a milestone in a trip, he can 'dig' with a certain chance to get a treasure of the game, which is designed to be a real postcard of the corresponding trip theme. During the experiment, the user gets a notification about the digging result, and he/she will collect the postcards from the experimenter at the end of the experiment.

4.3. Gamification design

In this study, we designed competition and cooperation to be endogenous with the aim to provide stronger motivations. In the competition condition, users compete with their partners for limited treasure and have conflicting goals; in the cooperation condition, 2 to 4 users form a team, in which they work interdependently towards a common goal. In the competitive and individual conditions, one player is represented by a specific avatar of his/her choice (Figure 1a); In the cooperation condition, team members advance on the trip as a whole, e.g. on a single boat (Figure 1b) and users can check the contribution of team members in the main interface (Figure 1d). The detailed design of the three conditions is demonstrated in Table 1.

5. Method

A four-week experiment was conducted to compare the impact of different gamification, i.e. cooperative, competitive, and individualistic gamification, on occasional exercisers' socio-cognitive outcomes and PA behaviours. Three groups of Chinese young adults who exercise occasionally were invited to use one of the three versions for 3 weeks, after 1 week of baseline activity monitoring. Their behaviours (counted in daily steps) and feelings (control beliefs and social support) were collected after using *SportAdventure* for 1 and 3 weeks. In addition, their usage of *SportAdventure* was tracked and compared.

5.1. Participants

Participants were recruited from a large university in Beijing by posting advertisement messages on the campus via popular online communities among college students and young people (newsmth.net and renren.com). In the advertisement, we mentioned that participants could sign up and take part in the experiment with their friends or individually. Those who agreed to participate were administered an online survey to collect information about their demographic information, their PA status (e.g. the frequency of moderate or vigorous PA in the last three months, duration of current PA status, etc.), and their usage of and attitudes towards

Table 1. The design of three gamification in SportAdventure.

	Competitive gamification	Cooperative gamification	Individual gamification
How the distance	• The user's cumulative steps in the week.	• The sum of the steps of team members.	• The user's cumulative steps in the week.
Treasure digging	• Only the first user arriving at a milestone can dig for treasure belonging to that milestone. • The late comers get nothing.	• Spend 10*N energy stones to dig for the treasure.	• No.
Trap digging	• A user needs to spend 20 energy beans to dig a trap for their competitors. • The user who falls into the trap cannot continue the trip, unless he/she (1) completes his/her daily step goal; (2) or consumes 3 energy stones, which is equivalent to jogging for 30 min.	• No.	• The traps were set at two random times during a week by the system.

mobile phones and motion-tracking applications. At the end of the questionnaire, respondents were asked to indicate if they would like to participate in the experiment individually or collectively. If the latter, they were asked to bring up to three friends to form a team in the game.

The collected information was used to screen for suitable participants. Young adults who took exercise occasionally and whose attitudes towards mobile phones and motion-tracking applications were neutral-to-positive (i.e. corresponding ratings were no less than 4, the neutral point) were selected. According to the State Sport General Administration of China (2008), 'exercise regularly' refers to participating three times or more of 30 min of moderate PA or 20 min of vigorous PA in a week. Adults who achieve the criteria were grouped as regular exercisers. People who take part in less than or equal to twice a month of 30-minute moderate exercise or 20-minute vigorous exercise were classified as sedentary individuals, and people whose activity levels were between the above two groups were classified as occasional exercisers. This classification is similar to previous studies from Western countries (Bautista et al. 2011; Eyler et al. 2003; Iso-Ahola et al. 2006). Among the 87 respondents to our recruitment advertisement, 50 were recruited. Except for one dropout, 49 participants completed the four-week experiment. They were all students of the university. The sample aged from 18 to 25, and includes 32 females and 17 males. Forty-six participants were occasional exercisers, and 3 were regular exercisers. Regular exercisers were allowed to participate due to the consideration that some occasional exercisers may prefer to ask their regularly exercising friends as exercise companions. Among the three regular exercisers, one was distributed in the cooperation condition and the other two in the competition condition, and their data were excluded from the analysis of the result.

A total of 35 participants signed up with their friends. They formed 14 groups and were assigned to the two social gamification conditions with considerations for the balance in gender, group size, and baseline PA status across the two conditions. The remaining 14 participants who signed up individually were assigned to the individual group. The descriptive information of participants in the three conditions is shown in Table 2. The Chi-square test (for nominal variables) and Kruskal–Wallis test (for continuous variables) were carried out to examine the difference across conditions. The result showed that there was no significant difference in gender ($\chi2$ (2) = 0.70, $p = 0.70$), age ($\chi2$ (2) = 1.00, $p = 0.60$), average daily steps during the baseline week ($\chi2$ (2) = 5.11, $p = 0.08$), the strength of intention to actively exercise in the next month ($\chi2$ (2) = 1.87, $p = 0.39$), and their experience of motion tracking products ($\chi2$ (6) = 3.48, $p = 0.75$) among the three conditions.

Table 2. Descriptive statistics information of participants.

	Cooperation	Competition	Single-player
N	17	18	14
Four-member group	1	1	
Three-member group	1	2	
Two-member group	5	4	
Gender			
Male	7	5	5
Female	10	13	9
Age	*M* = 21.88	Mean = 21.72	*M* = 21.36
	SD = 1.11	SD = 1.45	SD = 2.10
Daily steps on average during the baseline week	*M* = 5676 SD = 3210.99	*M* = 5631 SD = 2423.21	*M* = 6707 SD = 2918.31
Regular exercise intention	*M* = 5.47 SD = 1.06	*M* = 5.93 SD = 0.67	*M* = 5.88 SD = 0.95
No. of participants using motion tracking product			
Mobile phone	6	8	3
Smart band	1	2	3
Other	1	0	1
No experience	9	8	5

5.2. Procedure

After signing an informed consent, participants were introduced to the research purpose and the experimental task, were asked to register *Ledongli* so that their PA data could be monitored, and were instructed to get familiar with *SportAdventure*. The experiment consists of two phases i.e. a one-week control phase and a three-week experimental phase. In the control phase, participants were asked to keep their usual lifestyle as much as possible to provide a baseline of their activity status before using *SportAdventure*. During the three-week experimental phase, the participants used *SportAdventure* with their partners or individually. Data were collected in both phases. (see Figure 2). This study considered three groups of variables: (1) PA behaviours; (2) application usage; (3) socio-cognitive factors. The number of daily steps was chosen as the indicator of the PA behaviours for the reasons that accurate daily step data can be conveniently obtained from mobile devices and that step data is indicative of most physical activities of occasional exercisers, such as walking, climbing stairs, and running. It is also the most used indicator of PA in prior research (Ahtinen, Huuskonen, and Häkkilä 2010; Chen and Pu 2014; Lin et al. 2006). The usage behaviour was measured by the average number of daily logins, which was obtained from the server. Socio-cognitive factors were measured by questionnaires. Four variables were considered: appraisal

support, companionship support, perceived behavioural control, and self-efficacy. See Appendix 1 for details.

- Appraisal support was measured by adapting Chogahara's scale of social influence (Chogahara 1999) (Cronbach's $\alpha = 0.81$). Two items were used, asking how often the participants' exercise were recognised by their friends, colleagues, and family.
- Companionship support was measured by adapting the *social support assessment scale* (Sallis et al. 1987) (Cronbach's $\alpha = 0.84$). Five items were used and examples included 'How often did your friends invite you to exercise together in the last month' and 'How often did you participate in PA with your friends'. Both above two variables were rated on a seven-point scale from 'never' (1) to 'almost every day' (7).
- Perceived behavioural control was measured by adapting Rhodes's *exercise controllability scale* (Rhodes, Jones, and Courneya 2002) (Cronbach's $\alpha = 0.84$). Three items were used, to assess participants' perceived difficulty in taking exercise.
- Self-efficacy was measured by adapting the scale of Marcus et al. (1992b) (Cronbach's $\alpha = 0.84$). The scale included three items, asking the extent of participants' determination to exercise facing bad weather, lack of time, and bad mood. Both control beliefs were rated on seven-point Likert scales.

At the end of the experiment, the participants were invited for a post hoc interview. All the participants were interviewed for 20–40 min about their PA, usage of *SportAdventure*, social interactions with partners, the impact of cooperative or competitive gamification as well as the reasons behind it. The questions asked were shown in Appendix 2. All the content was audio-recorded and transformed into text for analysis. Finally, we gave each participant a sports wristband as an incentive. The experiment was approved by the research ethic board at X University.

6. Result

6.1. PA behaviours

The daily steps of 46 participants in 28 days were collected. Because the last three days of the experiment were holidays in China, many participants travelled around and their PA levels increased abnormally. Thus, we removed the data from these three days and took the last seven days before the holidays as the last week of the experimental phase. Besides, two participants in the cooperation group were sick in the last week; one participant in the single-player group had problems with Ledongli, the activity tracking application; and another participant in the single-player group joined a jogging campaign launched by the university from the second week of the experimental phase. All these situations distorted the step data from these participants. Thus, their data were excluded from the analysis of steps.

Table 3 shows the average daily steps in the control phase, in the first and the third week in the experimental phase. We first compared participants' average daily steps in the first and last week of the experimental phase against that in the control phase for each of the three groups respectively. The data did not meet the assumptions for ANOVA tests. Thus, paired *t*-tests were used whenever the data met the parametric assumption for paired comparisons. Otherwise,

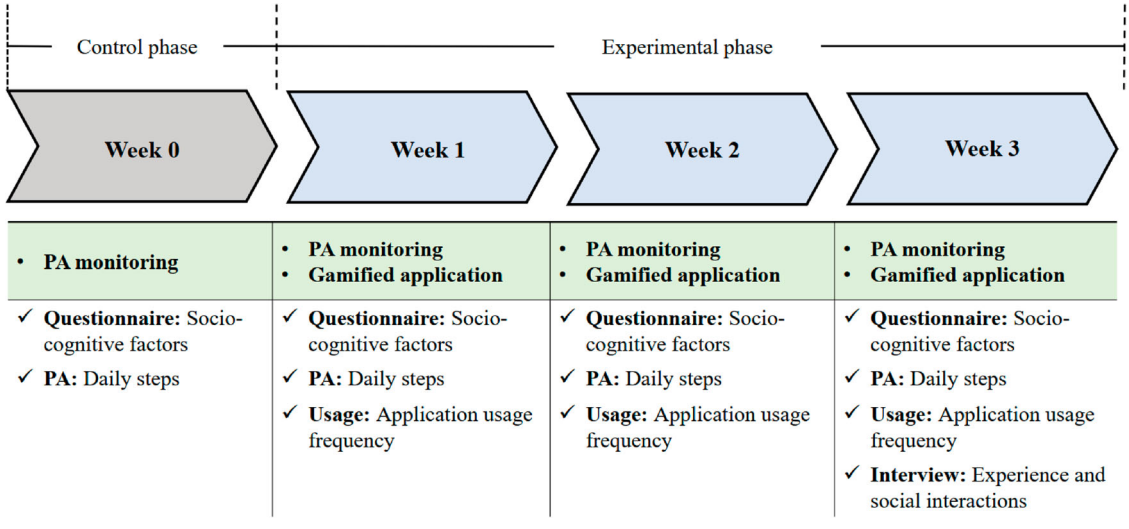

Figure 2. Data collection and time line.

Table 3. Average daily steps of participants in the three groups.

				Experimental phase			
		Controlled phase		The first week		The third week	
Group	*N*	*M*	SD	*M*	SD	*M*	SD
Competition	16	5311	2378.42	6844	3113.63	7851	3049.79
Cooperation	14	4949	2782.07	6250	2962.63	6004	3007.81
Single-player	12	6770	2345.13	7338	2638.30	6874	2684.19

Wilcoxon rank tests were used. Sidak correction (Šidák 1967) was used to control the familywise error control for multiple comparisons.

Both the competition and the cooperation groups saw a significant increase in average daily steps during the first week of using the gamified application, as compared with the control phase. The competition group had a 28.9% increase (t (15) = 4.14, p = .003) and the cooperation group had a 26.3% increase (t (13) = 3.66, p = .01). In the last week of the experimental phase, the competition group enjoyed an even larger significant increase (47.8%, t (15) = 6.14, p = <.001) as compared with the control phase. The daily steps of the cooperation group in the last week of the experimental phase, however, reclined to a level not significantly higher than the control phase (t (15) = 6.14, p = .07). The daily steps of the single-player group were slightly boosted (8.4%) in the first week of the experimental phase, but the difference was not significant. In the last week of the experimental phase, the figure reclined to essentially the same level as in the control phase. H1 was partly supported.

We then examined whether a significant difference existed among different gamification designs. Being aware that individual differences in lifestyles and consequently baseline daily steps may confound this comparison, we used the step increase from the control phase as the metric for comparative analysis across conditions. This increase of daily steps in three conditions were shown in Figure 3. Two one-way ANOVA tests were conducted to compare the difference among the three conditions in the first week of the experimental phase and in the last week of the experimental phase, respectively. The results showed no significant difference in step increase among different gamification designs in the first week of the experimental phase (F (2, 39) = 2, P = .148), in the last week of the experimental phase, however, a significant difference was found (F (2, 39) = 9.23, p = .001). Post hoc comparisons using Tukey tests showed that the step increase in the competition condition (M = 2541, SD = 1656.57) was significantly larger than that in the cooperation condition (M = 1055, SD = 1555.75, p = .03), and larger than that in the single-player condition (M = 104, SD = 1249.87, p < .001) and no other significant results. H3 was not supported.

6.2. Application usage

Table 4 shows the average number of daily logins in the three conditions in the three-week experimental phase. The differences between the average number of daily logins over the three weeks of each condition met the normality assumption. We compared application

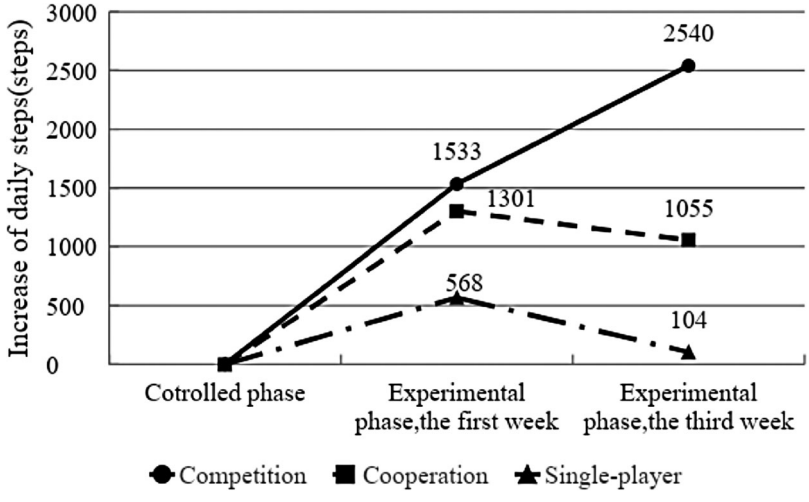

Figure 3. Increase of daily steps in three conditions.

Table 4. Average number of daily logins of participants in three conditions.

		Experimental phase					
		The first week		The second week		The third week	
Group	*N*	*M*	SD	*M*	SD	*M*	SD
Competition	16	1.85	1.05	1.54	0.74	1.33	1.08
Cooperation	16	1.50	0.89	1.07	1.17	0.64	0.52
Single-player	14	1.57	0.86	1.32	0.80	1.01	0.58

usage across the three weeks for each condition. The results showed no significant difference in use frequency in the competition and the single-player condition, though a slight decline can be observed. The participants in the cooperation condition, however, showed a significant decrease in daily login frequency in the third week ($M = 0.64$, SD = 0.52) as compared with the first week ($M = 1.50$, SD = 0.89, t (15) = −4.47, $p = .01$). H2 was partly supported, while H4 was not supported.

6.3. Socio-cognitive factors

Because one participant in the cooperation condition did not answer the questionnaire, his data were excluded. Paired *t*-tests were used to examine the difference in appraisal support, companionship support, perceived behavioural control, and self-efficacy reported at the end of the control phase and that reported at the end of the experimental phase, if the data met the normality assumption. Otherwise, Wilcoxon rank tests were used instead. One participant in the cooperation group failed to complete his questionnaires in the controlled phase, and his data were excluded from the analysis. Results are shown in Table 5.

As shown in Table 5, the single-player group showed no significant changes in any measured socio-cognitive factors before and after the experimental phase. The two groups adopting social motivation strategies reported a significant increase in social support after the experimental phase, but the type of social support being improved differed. Whereas the participants in the competition group reported a significant increase in appraisal support after using the gamified application for three weeks (control phase: $M = 3.31$, SD = 1.29, experimental phase: $M = 4.29$, SD = 1.23, t (15) = 4.10, $p = .001$), the participants in the cooperative condition reported a significant increase of companion support (control phase: $M = 3.29$, SD = 0.80, experimental phase: $M = 4.15$, SD = 1.28, t (14) = 2.73, $p = .027$). No other significant differences were found between before and after the experimental phase. H5.1 and H5.2 were partly supported, while H6.1–H6.3 were not supported.

6.4. Interview results

We conducted a thematic analysis to capture information about participants' behaviours and feelings as well as the reasons behind them. We devised and defined themes based on the literature and the purpose of the study, and also allowed new themes to emerge. The final themes and corresponding examples were shown in Appendix 3. Post hoc interviews provided insights to understand the participants' perceptions and motivations for their overt behaviours.

First of all, participants from both the cooperative and competitive conditions reported more social support exchange triggered by the gamification design, but the type of social support differed. On the one hand, the cooperation groups were more likely to exercise together offline than the competitive groups. Six out of 7 cooperative groups reported that they met with group members offline and exercised together at least once a week since they joined the game, whereas only 2 competition groups reported such behaviours. On the other hand, the competitive groups evaluated and discussed each other's progress more openly and frequently than the cooperative groups. All of the seven competitive groups reported that they discussed each

Table 5. Psychological factors of participants in the three groups.

		Controlled phase *M* (SD)	Experimental phase *M* (SD)	Statistic	*P*-value
Competition	Companionship support	2.94 (1.03)	3.52 (1.05)	$t = 1.56$	0.14
($N = 16$)	Appraisal support	3.31 (1.29)	4.29 (1.23)	$t = 4.10$	.001***
	Perceived behavioral control	5.04 (1.09)	5.39 (1.18)	$w = 263$	.924
	Self-efficacy	4.84 (1.23)	5.00 (1.24)	$w = 270$	.835
Cooperation	Companionship support	3.29 (0.80)	4.15 (1.28)	$t = 2.73$	.027**
($N = 15$)	Appraisal support	3.24 (0.72)	3.71 (1.00)	$w = 257$	.315
	Perceived behavioral control	4.82 (1.35)	4.98 (1.17)	$t = 0.55$	.593
	Self-efficacy	4.47 (1.01)	4.53 (1.19)	$t = 0.25$	.803
Single-player	Companionship support	2.52(1.26)	2.88 (1.09)	$t = 1.21$	.248
($N = 14$)	Appraisal support	2.69 (0.96)	2.69 (0.96)	$t = 0.00$	1.000
	Perceived behavioral control	5.27 (0.79)	5.36 (1.01)	$t = -0.91$	.381
	Self-efficacy	4.81 (1.16)	4.81 (1.10)	$t = 0.00$	1.000

**$p < 0.05$, ***$p < 0.001$.

other's progress nearly every day and such discussion spurred them to catch up with others and gave those front runners a feeling of honour; In the cooperative groups, however, such open discussion of each other's progress was limited to only one group and participants consider monitoring or reminding others about their progress not necessary or even not proper.

Second, 4 cooperation groups (out of 7 in total) reported that the feeling of being responsible for the group performance started to decline as early as the second week of using the application, which may partly relate to the reported reluctance to openly discuss group members' progress. Some participants ($N = 5$) believed that their individual effort did not influence their group performance so much. Some participants ($N = 4$) reported a decrease in accountability when they found other members did not make their goals either. Furthermore, when one member was obviously free-riding, other members may give up the game to avoid being the sucker who took all the responsibility ($N = 3$). These issues contributed to the observed social loafing effect, e.g. a decrease in individual effort when performing in groups (Latané, Williams, and Harkins 1979).

Third, though all of the participants considered the gamified application exciting and interesting in the first week, 15 participants in the cooperation groups (out of 17 in total) reported that their interests declined after the second week. After the initial freshness and curiosity, they found the cooperative game not so stimulating and engaging, and the feeling became more justified when they found their partners also lost interest. This problem, however, did not occur in the competitive groups. In particular, six of 18 participants in the competitive group used the app more often in the last week than in the second week. Interview results indicated that the competitive social interaction and the variable performance of partners added to the randomness and challenge, and consequently the fun, of the game.

7. Discussion and conclusions

With the research question 'Which social gamification, cooperative or competitive, is more effective in promoting PA among occasional exercisers?', this study conducted a longitude field experiment, designed endogenous cooperative and competitive gamification, and compared the two social gamification directly without extra external reinforcement during the experiment, regarding not only PA behaviours but also socio-cognitive factors and usage data. We found that (1) both gamification effectively increase PA in the first week, but this increase was only maintained in the competitive gamification after three weeks; (2) cooperation improves companion support, whereas competition improves appraisal support; (3) in the competition, the application usage did not decline significantly after three weeks, while that of the cooperation dropped. These empirical findings provide meaningful theoretical and practical implications for designers to craft a mobile fitness application with maximised social potential in promoting PA engagement.

7.1. Theoretical implications

First, our findings confirmed the effectiveness of social gamification in motivating PA behaviour, in line with prior studies (Ahtinen, Huuskonen, and Häkkilä 2010; Anderson et al. 2007; Chen and Pu 2014), whereas further elaborated that such effect was significant for both gamification only in a short period when people were attracted by the excitement brought by the innovative experience of using gamification. The application usage data also showed that participants' usages were highest in the first week and then declined in all conditions.

After the first week, however, two gamification differed: the motivational effect of cooperation could not sustain, while that of competition kept. By examining interview results, socio-cognitive factors, and application usage data, our analysis showed that competitive gamification maintained its effectiveness by setting high levels of challenge and uncertainty and by encouraging instant and mutual performance evaluation. On the one hand, the interview results indicated that the uncertainty and challenges, which plays a key role in making games fun and engaging (Anselme 2010; Ozcelik, Cagiltay, and Ozcelik 2013; Uhm, Kim, and Lee 2022), help competition maintained this motivational effect over time. This was also supported by the application usage data: participants' usage of competitive gamification in the last week was nearly as high as in the first week, whereas the other cooperative gamification experienced a significant drop. Participants using cooperative gamification found it repetitive and less stimulating, and the dark side of cooperation (i.e. social loafing effect) was observed. On the other hand, competition makes people more aware and concerned about their comparative performance against other group members. Participants in the competitive condition discussed their performance nearly every day. Such mutual performance evaluation lead to enhanced recognition and appraisal support of the competitive groups, in line with previous studies (Consolvo et al. 2006; Foster et al. 2010; Peng and Crouse 2013; Toscos et al. 2008). Therefore, this study provides empirical evidence on the relative merits between cooperative and competitive

gamification and reported that competitive gamification is more effective in the long term. This result, however, is different from prior studies evaluating the long-term effectiveness of the two gamification (Chen and Pu 2014; Staiano, Abraham, and Calvert 2013).

One possible explanation of our findings is the endogenous gamification design of our study. In our game, competitive players competed against their partners for a limited treasure and had conflicting goals. Such a win-or-lose design appears to have effectively cultivate peoples' winning spirits in PA. Competitive participants increased their awareness of their partners' PA status, discussed each other's progress, and made efforts to maintain their lead (for front-runners) or catch up with others (for laggards). These factors further heightened the competitive nature of the game and brought uncertainty and challenges for players accordingly. Different from our design, previous studies designed competition as exogenous, with competitors working independently (Chen and Pu 2014; Staiano, Abraham, and Calvert 2013). Our results suggest that endogenous gamification design may contribute to the sustainability of the motivational effect of competition over time.

The influence of endogenous gamification design on our target population, occasional exercisers, may be particularly pronounced. These individuals are often inhibited by barriers such as bad weather, laziness, and lack of motivation (Bautista et al. 2011; Eyler et al. 2003; Iso-Ahola et al. 2006), and therefore they rely heavily on rewards and social support to sustain their exercise behaviour (Prochaska, Diclemente, and Norcross 1992). Our competitive gamification, with its mutual performance evaluation and appraisal support, may be particularly effective in addressing these needs. Prior research on gamification and PA motivation did not differentiate between people at different levels of physical activity, potentially confounding the effect of social gamification with individual differences in needs. Therefore, our study, which specifically focused on occasional exercisers, has important implications for the design of gamified fitness applications for this population.

In addition, cultural factors may account for our findings. Previous studies conducted in Western countries have shown that team members frequently evaluated and openly discussed each other's performance in both cooperative and competitive settings (Chen and Pu 2014; Consolvo et al. 2006; Foster et al. 2010; Fritz et al. 2014). However, our study on Chinese participants did not yield similar results. In China, where harmony collectivism is emphasised, individuals have a strong desire to avoid conflicts (Hook, Worthington, and Utsey 2009; Wu, Kim, and Collins 2021). This desire prevented our cooperative groups from openly discussing their team members' unsatisfactory performance, leading some participants to privately complain and reduce their own effort on the task. Interestingly, participants in competitive groups discussed each other's progress more frequently. This is likely because a competitive environment naturally encourages comparison and evaluation of others, while such behaviour may be considered aggressive and damaging to interpersonal relationships in cooperative gamification. This finding is consistent with recent studies on learning achievement, recognition impact, and application usage behaviours among Chinese individuals, indicating that competitive design may be more effective in motivating this population (Huang and Zhou 2020; Jang, Kitchen, and Kim 2018; Ren 2019).

Our findings also indicate that, despite the lack of significant long-term improvement in daily steps in our experiment, the potential of social motivation through cooperative gamification should not be underestimated. One major benefit of cooperative gamification is the opportunity to establish real-life social connections, which can lead to lasting positive effects such as emotional and instrumental support (Gibbison and Johnson 2012; Rackow, Scholz, and Hornung 2014). However, both usage data and interview results suggest that cooperative gamification may become monotonous or repetitive over extended periods of use. To address this issue, a potential solution is the implementation of cooperative competition (i.e. 'coopetition'), where team members work together to achieve team goals while also competing for individual rankings. Research has shown that coopetition stimulates knowledge exchange, enhances interpersonal relationships, and has positive effects on team member behaviour, such as service delivery (Maxwell 2020), idea creation (Renard and Davis 2019), and learning performance (Wu, Kuo, and Yu 2017). Further studies are needed to explore the potential impact of coopetition in increasing PA behaviours for occasional exercisers.

7.2. Practical implications

The current study yields direct practical implications for designing mobile fitness applications. A major challenge in promoting PA is to stimulate and support those who have initiated to engage in PA but have not developed a regular exercise habit, i.e. occasional exercisers. Our study found that social gamification should be incorporated into mobile fitness applications to keep this group stimulated and supported. In particular, competitive

gamification should be preferred for its effectiveness in sustaining user interest in the application and improving PA behaviours over time. Cautions need to be taken to ensure a similar level of abilities and motivations among competitors, and the competition should be made endogenous to the activity, e.g. working on dependent tasks with conflicting goals. Furthermore, competitive gamification elements, such as badges and leaderboards, should be deployed to enhance users' awareness of their performance relative to others and serve as a source of appraisal support.

Our study implies that cooperative gamification should be applied when the aim is to develop exercise companions among users. The supportive rather than competitive context should be preferred for user groups who have an aversion towards competition (e.g. females are found to have higher competition aversion than males) (Garratt, Weinberger, and Johnson 2013; Preece and Stoddard 2015) and in situations when it is difficult to ensure equivalent abilities among competitors. It is important, however, to prevent social loafing in cooperation. Prior studies on cooperative learning groups suggest that explicitly structuring and visualising individual accountability can reduce social loafing (Archer-Kath, Johnson, and Johnson 1994; Hooper and Hannafin 1988). In addition, our results emphasise the importance to encourage, or even reinforce, open and honest discussion of members' performance. This may be particularly important for users with a cultural background that values harmony in groups, such as China (Wei et al. 2013; Wei and Li 2013). Combining competitive elements in cooperative groups may be helpful.

Last but not least, our results highlight the important role of uncertainty in keeping gamified applications attractive and stimulating over time. Research on game design has found that goals with uncertain outcomes motivate individuals to give more effort to achieve (Arias-Carrión and Pöppel 2007; Shen, Fishbach, and Hsee 2015; 2019). In gamification research, uncertainty is a key element of game fun, and the motivational benefits of gamified applications often decay due to the loss of uncertainty over time (Malone 1980; Mazeas et al. 2022; Ozcelik, Cagiltay, and Ozcelik 2013). For competitive gamification, making a competition with equivalent peers endogenous to the activity can sustain such uncertainty by weaving the unpredictability and randomness in peer players' behaviour into users' goals. For cooperative gamification, however, extra gamification design is needed to keep such uncertainty in repetitive usage. Possible techniques include increasing randomness, providing variable difficulty levels, and use of hidden information in creating storylines (Campbell, Ngo, and Fogarty 2008; Denisova et al. 2020; Malone 1980).

7.3. Limitation

Before the results are to be generalised to a larger population, several limitations need to be considered. First of all, most participants in our study were from one of the top-tier universities in China. They can be considered high-performing students and tend to be competitive in general, regardless of their physical activity abilities (Baumann et al. 2021). Prior research suggests personality traits, e.g. competitiveness, can influence the effectiveness of competition (Halko and Kientz 2010). People who are competitive themselves naturally may gravitate to competitive games, whereas those who are less competitive may be intimated by the psychological burnout in intensive competition, as shown in the mixed user feedback towards competitive gamification in prior research (Anderson et al. 2007; Lin et al. 2006; Toscos et al. 2008). As we did not measure the competitiveness of our participants, we were not able to rule out its confounding effect. Whether competitive gamification is effective for less competitive users needs to be further examined. Second, the current study was carried out among Chinese people. Cross-cultural differences in value beliefs about interpersonal relationships (e.g. Chinese culture values harmony in groups) may influence the effectiveness of different mechanisms as well. Third, stabilising behavioural change is a long-term process. Though our experiment proved that competitive gamification can motivate participants to engage more in PA over a three-week period, it remains unclear how long such improvement can last after the experiment. This may also contribute to the lack of significant findings related to perceived behavioural control and self-efficacy. Such beliefs need a long and complex process to change (Bandura 1977). In addition, this study compared the effectiveness of cooperative and competitive gamification among occasional exercisers, without considering a combination of the two gamification (i.e. coopetition). Further research including all three gamification is expected.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

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Appendices

Appendix 1. Measurements

Companionship support	
COM1	In the past month, how often have your friends, classmates, or colleagues invited you to exercise with them (1) never (7) almost every day
COM2	In the past month, how often have you taken PA with your friends, classmates, or colleagues (1) never (7) almost every day
COM3	In the past month, how often have your family members encouraged you to take PA? (1) never (7) almost every day
COM4	In the past month, how often have your friends, classmates, or colleagues encouraged you to take PA (1) never (7) almost every day
COM5	In the past month, how often have your family members reminded you to take PA? (1) never (7) almost every day
Appraisal support	
APP1	In the past month, how often have your sports achievements been recognised by your friends, classmates or colleagues? (1) never (7) almost every day
APP2	In the past month, how often have your sports achievements been recognised by your family members? (1) never (7) almost every day
Self-efficacy	
EFF1	I believe I can take regular PA even if the weather is bad. (1) strongly disagree (7) strongly agree
EFF2	I believe I can take regular PA even if I am very busy. (1) strongly disagree (7) strongly agree
EFF3	I believe I can take regular PA even when I am in bad mood. (1) strongly disagree (7) strongly agree
Perceived behavioural control	
PBC1	It is very easy for me to take PA regularly (1) strongly disagree (7) strongly agree
PBC2	I believe that I have time, place, good physical condition and other resources to take PA regularly (1) strongly disagree (7) strongly agree
PBC3	As long as I want to take PA regularly, I can do it (1) strongly disagree (7) strongly agree

Appendix 2. Questions in interview

Topic	Description
Reasons for unusual figures	(1) (If there are unusual figure of PA) The steps on this day is different from others. What happened that day? (2) During the four-week experiment, are there any special circumstances that affect the amount of daily exercise (e.g. physical discomfort, course work, completion, and trip)?
Use and experience	(1) (If changes in usage was found) Why did you change your usage of the game? (2) Did the game influence your daily activities? Please describe in detail. (3) (For cooperative groups) Did you feel you are in a team and incorporate with your team members? Why? (4) (For cooperative/competitive groups) How did you feel when you fall behind or take priority? (5) After using four weeks, do you think the game is useful or interesting? Why?
Social interactions	(1) During the experiment, did you and your partners discuss about the game or exercise? What did you talk about? (2) During the experiment, did you and your partners exercise together?

Appendix 3. List of themes

Theme	Subtheme	Example
Co-participation in exercise behaviour	Group members in cooperative gamification exercise together.	*I check whether he has completed his goal at 10pm every day. If he has not done so, I will ask him to take a walk together.*
	Group members in competitive gamification exercise together.	*My partner and I exercised together once.*
Information exchange behaviour	Information exchange between cooperative group members	*We talked about our exercise situation and see how many steps we have to go.*
	Information exchange between competitive group members.	*Sometimes I see the exercise status of my partners and laughed at him, hahaha . . . .*
Information exchange content	Experience sharing	*We talked about the exercise yesterday.*
	Remind each other to exercise	*If he did not reach his goal I would remind him to run.*
Influence of information exchange (for people in competitive gamification)	Spur competition to catch up with the competition	*If I find that his steps increase, I will ask him whether he exercises and what kind of exercise he does. We would discuss and share some tips then*
	A feeling of honour	*I always got the treasures ahead of him. He often complained that you exercise so much that all the treasures are dug by you. His envy gives me a feeling of achievement.*
Influence of information exchange (for people in cooperative gamification)	Not necessary	*Though we sometimes make appointments to work out together, I would not suggest or encourage him to exercise more. We are all adults and should know how to make the arrangement for ourselves*
	Not proper	*Sometimes I accomplished my goal whereas others did not. I would not care or express anything about it. They must have their reasons, e.g. being busy lately*
Reason for the decline in team responsibility	Individual effort makes little influence	*My PA level is in the middle of our group. So, my activity amount will not make a big contribution to the group and I did not have much pressure to achieve my goal.*
	Decrease in the accountability	*In the first week I felt guilty for not achieving my daily goal and getting the 10 energy stones for my team. But then I found that my partner sometimes also loosened requirements for himself and did not make every goal. Then, I felt relaxed and not guilty anymore*
	Avoid to be the sucker	*He walked hundreds of steps a day. No matter how hard I try, we can never get the treasure. Thus, I just gave up and did not want to play the game later*
Reason for the changes in interests	Not so stimulating and engaging	*The game is always like that. I think it is not so interesting as I thought before.*
	Increase in randomness and challenge	*Although I won in the first two weeks, I increased my exercise in the last week because my partner said she would be ahead of me.*