Benevolent Deception in Exergame Design

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Abstract. Exergames are becoming increasingly popular as a way of motivating people to exercise. How to use games to increase personal exercise motivation has become an important issue both for HCI researchers and interaction designers. While many exergames can attract users, not all of them have the ability to sustain high levels of motivation over time. The incentive effect of exergames can not only rely on freshness and gameplay, but should adopt other long-term effective means. In most cases, exergames truly reflect the user's status of exercise, as time, speed, heart rate, calorie consumption, etc. In the field of sports psychology, existing research shows that people's cognitive bias in the process of exercise can be manipulated artificially, thus affecting the behavior and exertion of the athlete. However, it has not been found that the designer deliberately integrated benevolent deception into the case of exergame design. As a design concept, benevolent deception has not been widely discussed. We investigate how to apply benevolent deception on exergame design, to verify the possibility of using benevolent deception as a fitness incentive in gym. We developed a set of basic design principles, as promoting fitness by lies is an unusual and dangerous design attempt. Taking the spinning cycle game as an example, we try to introduce benevolent deception into the interactive game design of aerobic exercise. After the design process, we discussed the key impact, main challenge, necessary of drawing on expert opinions.

Keywords: Benevolent deception · Exergame design · Exercise motivation · Spinning cycle game · Design principle

1 Introduction

1.1 Background

Exergames are becoming increasingly popular as a way of motivating people to exercise. Yoonsin Oh and Stephen Yang proposed definition of exergaming as an experiential activity in which playing exergames or any videogames that require physical exertion or movements that are more than sedentary activities and also include strength, balance, and flexibility activities [1]. According to this definition, exergames includes both games designed for fitness purposes, as well as those for entertainment or education, but also allows users to perform physical activities above sedentary levels. Exergames make the fitness process no longer boring. As a means of promoting fitness, exergames with enough exercise intensity can help the weight control effectively.

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Playing active video games significantly increased heart rate (HR), oxygen consumption (VO2), and energy expenditure (EE) from resting. The effect sizes of playing active video games on HR, VO2, and EE were similar to traditional physical activities. Active video game type and the player age were significant moderators for the effects of active video games [2]. Exergames can also play a role in psychological regulation and improve people's mental health. Psychosocial and cognitive impacts of exergames play may include increased self-esteem, social interaction, motivation, attention, and visual spatial skills [3]. Exergame can also be used as a tool for sports assessment. Through the collection of physical activity information in sports through hardware devices, scientific screening and the multi-angle analysis, the computer can evaluate the user's sports indicators to further guide the fitness. Many exergames have the capability to measure activity levels unobtrusively through monitors built into game equipment, and preliminary analysis indicates that exergame measures are significantly correlated with external measures of caloric expenditure, duration of play, and balance [4]. Some exergames are designed for specific people, such as the elderly, children or the blind. The MoveCare Project develops and field-tests an innovative multiactor platform that integrates a robotic system with environmental sensors, smart objects, a virtual community and an activity center to provide assistance, transparent monitoring and activities to the elder at home. Different game modalities, such as playing alone, in competition, or collaboration with other elders of the virtual community will be available [5]. It also needs to be recognized that the potential of exergames in field-based settings might have been underestimated because of a variety of limitations inherent in many published studies. Future research and practice should take into account these limitations to unravel and exploit the maximal efficacy of exergames [6]. With work pressure increased drastically, people are facing the lack of time and energy for exercise. Although the traditional gyms basically meet people's fitness needs, mechanical fitness is still not attractive enough. Sarah et al. identified six superordinate themes contributing to non-participation in a workplace physical activity (PA): self-efficacy for exercise; attitudes towards PA; lack of time and energy; facilities and the physical environment; response to the PA programme and PA culture. Barriers occurred at multiple levels of influence [7]. With the hope of health benefits, exergames began to be introduced into the gym as a serious training method, not just as casual games.

1.2 Need to Improve

While many exergames can attract users, not all of them have the ability to sustain high levels of motivation over time. Those which do show increases in light intensity exercise which although valuable, do not increase the proportion of moderate to vigorous activity required for optimal health benefits. Furthermore, longitudinal studies to date have encountered a plateau effect in physical activity as the novelty of the game wears off [8]. Contrary to intuition, the effect of exergames on user fitness is not always positive. In the long run, it is possible that the interest brought by the game gradually weakens until it disappears, at which point users may become less autonomous for exercise. For example, elementary school children's situational interest during exergame-themed physical education classes declined significantly between the

beginning and the end of instruction [6]. In addition to enough exercise time, sufficient exercise intensity is also important for achieving fitness goals. The incentive effect of exergames can not only rely on freshness and gameplay, but should adopt other long-term effective means.

2 Benevolent Deception as a Motivation Skill in Exergames

Social and competition have been widely used as incentives. Paw et al. implemented a dance exergame and compared the level of participation in the game between two different social groups. It was found that the multiplayer group (playing with peers) played approximately twice as many minutes as the home group (playing alone), and dropout was significantly lower in the multiplayer group [6]. Lindsay et al. concluded that the virtual competitive trainer elicited a greater distance travelled and caloric expenditure, and was rated as more motivating than the cooperation trainer, in a study of virtual trainer designed for competition and cooperation in bicycle riding exergame [9]. Soumya et al. put forward an interactive adaptation of the feedforward method: a psychophysical training technique achieving a rapid improvement in performance by exposing participants to self models showing previously unachieved performance levels and evaluated their method in a cycling-based exergame [10].

In most cases, exergames truly reflect the user's status of exercise, as time, speed, heart rate, calorie consumption, etc. In the field of sports psychology, existing research shows that people's cognitive bias in the process of exercise can be manipulated artificially, thus affecting the behavior and exertion of the athlete. Actually, benevolent deception has been widely used in human computer interaction. Eytan et al. [11] presented the notion of benevolent deception as deception aimed at benefitting the user as well as the developer. A user's interaction with a system is mediated by perception, attention, comprehension, prior knowledge, beliefs, and other cognitive activity. From these, a class of HCI deceits, behavioral deceptions, emerge that take advantage of, and occasionally "fix", the physical, sensory, and psychological limits, capabilities, and learned behaviors of the user. Certain Nintendo Wii games give the user "the benefit of the doubt", however, it has not been found that the designer deliberately integrated benevolent deception into the case of exergame design. As a design concept, benevolent deception has not been widely discussed. Another possible explanation is that even there are such cases in practice, developer rarely disclosed them, in order to maintain user beliefs or avoid moral criticism. We investigate how to apply benevolent deception on exergames design, to verify the possibility of using benevolent deception as a fitness incentive in gym.

3 Related Work

Since there is no existing exergame design case as a reference for benevolent deceptive exergame design, we investigated related research in sports psychology fields as a reference. Many studies have used deception to investigate the theoretical underpinnings of pacing and performance.

Golf players put more successfully to the perceptually bigger hole affected by the Ebinhas illusion. A downward-facing projector displayed a ring of 11 small or 5 large circles around each hole to create an Ebbinghaus illusion. For each hole and illusion combination, participants stood at a computer approximately 1.7 m from the hole and used MS Paint to draw a circle that matched the hole's size. Then, researchers attempted 10 putts from a distance of 3.5 m, and recorded how many balls dropped into the hole. Thirty-six participants put to two different-sized holes, 5-cm and 10-cm. The illusion influenced perceived size of the 5-cm hole, and subsequent putting performance. Participants made more successful putts when the 5-cm hole was perceptually larger. The surrounding circles did not influence perceived size of the 10-cm hole. A likely explanation for this effect is that an increase in the apparent size of the target increased participants' confidence in their abilities, which in turn improved performance [12]. This visual-illusion paradigm could be used to induce the perception that a target looks bigger, which have the potential to be applied in the throwing exergame.

The main contribution of Yuki et al.'s research is to develop a method for alleviating fatigue during handling medium-weight objects and augmenting endurance by affecting weight perception with augmented reality technology. In this paper, researchers propose an augmented reality system that changes the brightness value of an object in order to reduce fatigue while handling the object. They conducted two fundamental experiments to investigate the effectiveness of the proposed system. Their results suggested that the system eliminates the need to use excess energy for handling objects and reduces fatigue during the handling task [13]. In another study, researchers investigated whether this powerful weight illusion could influence real-lift behavior—namely, whether individuals would perform more bicep curls with a dumbbell that felt subjectively lighter than with an identically weighted, but heavier-feeling, dumbbell. Participants performed bicep curls until they were unable to continue with both a large, light-feeling 5-lb dumbbell and a smaller, heavy-feeling 5-lb dumbbell. No differences emerged in the amounts of exercise that participants performed with each dumbbell, even though they felt that the large dumbbell was lighter than the small dumbbell. Furthermore, in a second experiment, researchers found no differences in how subjectively tired participants felt after exercising for a set time with either dumbbell. Researchers did find, however, differences in the lifting dynamics, such that the small dumbbell was moved at a higher average velocity and peak acceleration [14]. These studies demonstrate the feasibility of using benevolent deception to reduce subjective fatigue in weightlifting. But some limitations exist, for example, as it is difficult to really improve the user's muscular endurance performance.

Optic flow on the retina creates a perception of a person's movement relative to their surroundings. A study investigated the effect of optic flow on perceived exertion during cycling. Fifteen participants completed a 20-km reference cycling time trail in the fastest possible time followed by three randomly counterbalanced 20-km cycling trials. Optic flow, via projected video footage of a cycling course, either represented actual speed (TTNORM) or was varied by –15% (TTSLOW) and +15% (TTFAST). During TTSLOW, power output and ratings of perceived exertion (RPE), measured every 4 km, were lower during TTSLOW compared with TTNORM and TTFAST. There were no differences in heart rate or cadence. This study is the first to show that different rates of optic flow influence perceived exertion during cycling, with slower

optic flow being associated with lower RPE and higher power output [15]. In fact, research on deception in the riding process is the most extensive. Pacing strategy is said to be influenced by feedback information from both internal and external cues. Environmental conditions such as gradient, terrain, weather, oxygen content of inspired air, knowledge of the event (e.g. distance or duration), previous experience and competition all equate to external cues. Manipulation of pre-exercise expectations and external feedback during exercise both effect pacing strategy [16].

From these studies, it can be found that deception can really change the user's athletic performance in different exergame condition. The limitation is that these experiments are often one-off behaviors that are carefully designed in the laboratory environment and do not meet the needs of long-term fitness incentives. These deceptions are not all surely beneficial to the user, so it is doubtful whether they can be considered benevolent. For the exergame design, a fun game mechanic is also necessary because the user is not equivalent to the subject.

4 Design Principle

It is necessary to develop a set of basic design principles, as promoting fitness by lies is an unusual and dangerous design attempt. (1) Deception must be beneficial to the user, serving the scientific way of exercising. Eytan et al. proposed that there is a distinction between "successful" and benevolent deception. While each is necessary for use in HCI settings, neither alone is sufficient [11]. For designers, it's important to know the ultimate purpose of using fraud and always consider the core needs of users. For exergame design, it is necessary to ensure that the direction of deception-induced user behavior is in line with the sports science theory. (2) Deception must be sufficiently concealed. Eytan et al. proposed the inevitable risk of being caught by users. When a user will not be able to tell the truth from the deception, there is a chance for benevolent deception [11]. For the exergame using benevolent deception, this is even more important because it is about user confidence in feedback. If the user suspects that the system is cheating, the incentive will disappear. (3) Deception can't reduce the quality of user experience. It is not the ultimate goal to trick users into high-intensity or long-term exercise. The designer must ensure that users can get pleasure and satisfaction from the exergame.

5 Design Process

Spinning cycle exergames, a very universal and typical template, have a great effect in motivating users to insist on aerobic exercise and improving user satisfaction. Researches on deception in the riding process in sports psychology provided enough deception examples for reference. Taking the spinning cycle game as an example, we try to introduce benevolent deception into the interactive game design of aerobic exercise. Riding in a virtual scene is the basic framework for this type of exergames. Typically, gaming devices include a screen (in some cases a VR head-mounted display) that displays a scene, a sensor that captures the user's riding speed and physiological

signal detecting device (in order to obtain physiological indicators, such as heart rate). The game experience is abundant. Some spinning cycle exergames can provide interesting scenery, such as glaciers, deserts or underwater world, from virtual modeling or real-life shooting. Other can achieve multi-player speed competition, just like a real bike tournament. A part of them drew on the traditional parkour video game, in which the user needs to avoid obstacles or hit a specific object to get a score reward. These existing design models have been widely used in homes and gyms and have been proved to be effective incentives. We don't want to overthrow the existing design template, but hope to enter the game design process by combining benevolent deception.

5.1 Investigate Existing Products

In July 2018, we first visited a professional exergames development company in Beijing. Here we experienced exergames designed for spinning bikes, rowing machines, treadmills and aerobics. In particular, we focused on the experience of the VR spinning exergame and recorded the process in the process. Two experiencers each performed two repetitive games.

The user of this exergame plays a motorcycle rider and aims to complete a 3-km ride. In the process, the user needs to control the direction and speed, hit the gold coins and bypass some obstacles such as trees and fences (see Fig. 1). In the left front of the user's perspective, there is a small spherical robot flying to accompany the user. After the game is over, the time of the user's ride and the total number of coins will be displayed on the interface.

Fig. 1. A designer was experiencing the VR spinning exergame

The first play is very immersive and challenging. On curved roads, when attention is focused on trying to control the direction and speed to complete the goal of avoiding obstacles or hitting gold coins, the experiencers can feel the challenge, and get a sense of pleasure when we successfully complete the goal. But the second experience is not as good as the first time. Repeated scenes and roads are no longer attractive and do not provide a sense of freshness or excitement. The location of obstacles and coins is also known to the experiencer, making it easier to achieve goals. This means that the game loses the frequency of stimuli, which causes the experiencer to begin to focus on the ultimate goal of the game. At this point we found that the game has two goals that are

parallel but conflicting, to increase the speed of the ride, and to hit more gold coins. Taking time to hit the gold coin leads to a slight decrease in the speed of riding.

5.2 Further Requirements

Reflecting on this game, we found the lack of incentives, and proposed the requirements for improved design. Firstly, designer must consider the effectiveness of exergames as a long-term incentive to provide a sufficiently varied and always challenging experience. Secondly, the exergame should set appropriate game goals, provide users with enough challenge and stimuli. Finally, the direction of short-term incentives should be consistent with long-term goals.

5.3 Expert Interview

We visited a professional fitness instructor with three years of work experience to seek advice on improved design. We focused on two aspects. One is the practicality of the spinning bike game mentioned above, and the second is how the coach motivates the trainee in his daily work.

7 open-ended questions were used for collecting more detailed information:

- Do you think this exergame can attract fitness people?
- What do you think of the fitness effect of using exergame?
- What is the difference between using this exergame and training under the guidance of a coach?
- How do you usually guide and motivate the trainees?
- How to make a trainee who lacks spontaneous motivation adhere to fitness?
- How can you help him build confidence when the trainee lacks it?
- What do you think can be improved in this game?

Overall, the coach evaluates the exergame as positive and interesting, although he suspected whether it can improve the fitness efficiency and help users build lasting interest. The coach mentioned that he would use frequent encouragement to help trainees build self-confidence, and even deceptive language skills. Due to the lack of subjective confidence and the neurological self-protection mechanism [17], trainees often find it difficult to persist before they reach the physiological limit. The coach will flexibly adjust the timing to help the trainee improve the duration. Frequent positive feedback is also important. When a trainee made small progress, he will praise in time, using some exaggerated languages. His advice to our game design is to exaggerate the user's performance, such as speed and calorie consumption. This feedback must be frequent enough to ensure that the user is given enough encouragement.

5.4 Primary Version

We first removed the gold coins, an antiquated and useless game prop, because users can't get more fun or improve the efficiency of exercise through it in this exergame. In the new exergame, the only task the user needs to achieve is to maintain different speeds in different scenarios. For example, in a glacier scene, users need to ride at high speed to avoid falling from the melted ice. The dashboard provides the speed feedback

and warning in the form of flash color changes (see Fig. 2). We set up richer scenes in order to solve the problem of scene duplication. At the beginning of the game, the user is told to experience cycling in different environments. In each round of the game the user can select any four scenes. Two scenes require high speed (high-intensity) and other two require medium speed (medium-intensity). At the end of each scene, the user was provided a short one-minute break. Although the user is informed that the distance to ride in every scene are same, in fact, the system estimates REP (Rating of Perceived Exertion, HR [bpm] = 69.3 + 6.23*RPE [18]) based on the user's HR (Heart Rate), and terminates the previous scene when the user's fatigue reaches the set limit. In the user's view, a short break is a reward for completing a phased goal. When the user feels tired, the expectation of the next break will support him. At the end of the game, the user will know the time and calorie consumption of the ride.

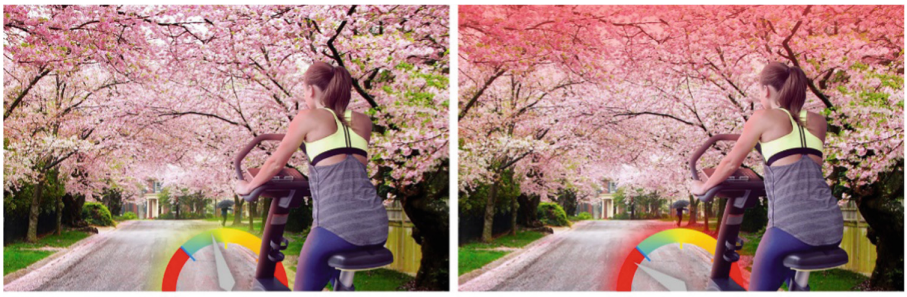

Fig. 2. Visual speed feedback

5.5 Upgraded Version

Although primary program basically satisfies the design principles and further requirements, we still find obvious defects. Maintaining the position of the dashboard pointer does not give the user a sense of accomplishment. Although failure leads to immediate frustration, this incentive creates an increase in psychological stress. Although the scene brings a sense of freshness for a short time, it does not take up the user's attention for a long time. Since the task of maintaining speed does not need to be fully focused at all times, and lacks continuous challenges, users are likely to still focus too much on fatigue. This is obviously not conducive to the cultivation of long-term interests. Although the number of scenes is sufficient, the user may still use the same scene repeatedly, and the deception on the distance may still be recognized.

In the upgraded version, we removed the dashboard to ease the psychological pressure, and designed a new form of speed feedback. Without additional information provided by the dashboard, such as heart rate, mileage, speed, etc., users will judge the distance and speed with the reference given by the visual image, such as character avatars, objects (such as trees, obstacles) or road markings. We simplified the content of the scene so that the user can only judge the speed from a specific object, in this case the road marking.

The task of the game is to control the speed to hit the target, called "wormholes" (a wormhole can be visualized as a tunnel with two ends, each at separate points in spacetime [19]) in this game. The route is fixed and the user cannot change direction autonomously. The end of the ride is a visible point in the distance. The challenge is to determine when the "wormhole" (see Fig. 3) will be on the road marking and control the speed to reach it at the right time. The user gets a short acceleration visual feedback after hitting the "wormhole", which leads to the pleasure of completing the phased goal. In fact, this is benevolent deception provided by the system, the user's speed will not be really improved. Because there is no stable distance reference system in the scene, the user cannot find the truth. In the process of passing through the "wormhole", the user can slow down or stop riding, but still feels accelerated in the visual sense. This provides users with a short break as a staged reward. This challenging task, focusing on estimating the speed of the "wormhole" movement and controlling the speed of riding, takes most of the attention, resulting in that the user ignore the slight fatigue. The total distance of each round of the game will not be explained in advance. At the end of the game, the user will know the time of the ride and the calories consumption.

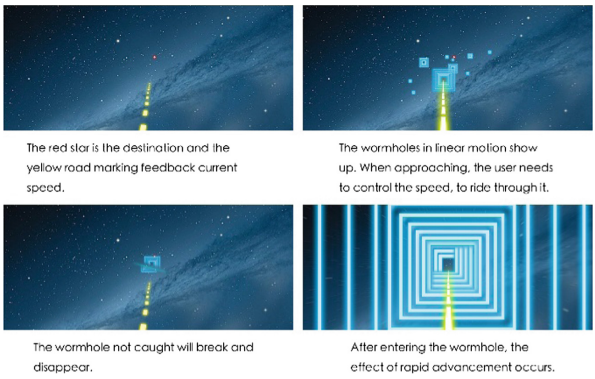

Fig. 3. "Wormhole", a new game mechanic

The system estimates REP based on the user's heart rate. When the user's fatigue is high, the movement speed of the "wormhole" is slowed down, leaving more time for the user. Conversely, when the user does not exert enough effort, the wormhole moves faster and the user needs to speed up the ride as much as possible. Due to the uncertainty, the user will focus on the estimation of the speed of the "wormhole" movement, instead of fatigue and boredom. This game mechanics maintains fatigue at a moderate level and flexibly regulates exercise intensity and time.

6 Conclusion

Through literature research, expert interviews, and design practices, we found the key impact of user predictions on user's performance. The conclusions of psychological research verify this. Highest or most difficult goals produced the highest levels of effort and performance. Performance leveled off or decreased only when the limits of ability were reached or when commitment to a highly difficult goal lapsed [20]. But the particularity of exergame is that fatigue and dynamics change of body perception will affect the user's difficulty prediction. As the exercise progresses, the fatigue increases, the body becomes painful, and the user becomes more and more inclined to lose confidence. The rate of change varies depending on individual physique differences and tasks. Therefore, the aim of benevolent deception in exergames design is to maintain or even enhance the user's confidence during the whole process of sports. Based on the summary of existing sports psychology research and this design practice, we believe that benevolent deception is effective in maintaining and improving user confidence and has the prospect of promotion in different exergames.

7 Discussion

Through an improved design of an existing spinning exergame, we explored the possibility of using benevolent deception to enhance the incentives of exergames. During the design process we found the challenge of using benevolent deception. (1) Avoiding inconsistencies in sensory information. Since human motion perception is direct and sensitive, especially for transient changes, it is not easy to deceive users in motion. (2) Avoiding losing interest. Although the results of sports psychology can be directly applied to exergames, a single, simple task is difficult to bring enough challenging and interesting experiences to users. (3) Considering long-term effective. Deception must not be discovered by users when game is repeatedly played. Taking the primary version as an example, the user is likely to find inconsistencies in the distance between different scenes after several rides. (4) Limitations of equipment form. The form of the device limits the form of interaction.

Drawing on expert opinions has improved our design efficiency, as it increases the speed of data collection and provides key design ideas. Expert experience has a high guiding value due to the rich experience and deep understanding of user behavior. The design of the benevolent deception exergames is a whole new challenge. It is necessary to involve sports physiology, motor psychology researchers and professional coaches in the design process.

The above discussion can provide guidance on the exergame design based on different fitness methods. Further, in the future, it is necessary to explore the limits of the user being deceived and the psychological reaction of the user if deception is found. With the deepening of emotional computing research, the assessment method of emotions, fatigue, and motivation also needs to be considered.

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