Gamification Elements in Immersive Virtual Reality Comparing the Effectiveness of Leaderboards and Copresence for Motivation

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***Abstract*—With the ability to present a completely different environment to users through head-mounted displays, immersive virtual reality (IVR) offers many opportunities to enhance users' motivation and learning. Recent research in the sports context indicates that social facilitation effects occurring with real humans do not necessarily arise when users see a virtual human on a 2D screen. However, whether the increased copresence that immersive virtual reality offers a) can provide increased social facilitation effects compared to 2D screens and b) provides enhanced effectivity compared to traditional gamification elements is still unclear. To investigate this research gap, a 2 (copresence: low vs. high) x 2 (leaderboard: no leaderboard vs. leaderboard) between-subjects laboratory experiment is proposed in this research in progress paper. The expected results can contribute to explain the effects of gamification elements in IVR for intrinsic motivation and performance.**

***Index Terms*—virtual reality; copresence; gamification; multi-user; leaderboards.**

I. Introduction

With Immersive Virtual Reality (IVR) technology becoming more and more affordable, new opportunities arise to facilitate learning. IVR has not only the ability to create a high sense of being in a distant environment (telepresence), it can also create a high sense of owning a virtual body (self-presence), being with others (social presence) and being with others in a distant environment (copresence) [1]–[3]. The experiences made in IVR can indeed affect cognition and behavior [4]–[6]. For example, IVR enables users to see a virtual body visually similar to the self doing sports from both first and third person perspective. When the avatar then gains or loses weight according to activity, long-term activity levels of the user can be facilitated [4]. Such designs relying on embodiment of users are not easily possible without IVR.

The characteristics of IVR offer the possibility to design gamification elements used in traditional devices more effectively, especially in relation to learning scenarios with multiple individuals. Gamification describes the use of game elements in non-gaming contexts and requires the use of gamification design elements [7][8]. Gamification design elements are aimed at motivating or engaging users and are instantiated as objects and mechanics (i.e., interaction rules) [8]. Related to other virtual individuals, they can consist in the inclusion of leaderboards, e.g., a list of the top ten users or displaying multiple users in the application [9][10]. Whereas the inclusion of gamification design elements, such as leaderboards, satisfies individuals' need to feel competent and might induce increased feelings of autonomy, displaying multiple users can satisfy the need for relatedness and can serve a social facilitation effect [11]. According to research on social facilitation and inhibition effects, being observed by other humans while doing a simple task can create social facilitation, whereas it inhibits task performance for complex tasks [12].

For collaborative learning situations, especially the ability of IVR to display quite realistic avatars, which create a high degree of copresence, can create a fundamentally different experience compared to traditional virtual learning environments (e.g., 2D screen at desktop computer). Research on comparing the sense of copresence using a large 2D display or a head-mounted display (HMD) to interact with a single virtual human indicates that individuals can feel the same degree of being colocated in a room with a virtual human in both scenarios [13]. However, their perception in which room they were colocated varied, with participants viewing a 2D environment feeling colocated in the actual room, whereas participants with HMD felt colocated in the virtual room. Additionally, it is still unclear how copresence is affected when copresence with multiple individuals should be elicited.

Up to now, whether the higher immersion offered in IVR a) can be used to recreate social facilitation effects present for real humans and b) can compete against traditional gamification elements is still unclear. To address this research gap, this research in progress paper focuses on the area of facilitating engagement in the sports domain in which users located at different places are colocated in a virtual environment and aims at proposing a design methodology to investigate the following research question:

Research Question. *Which collaborative gamification design elements lead to increased motivation and performance?*

The paper is structured as follows. In Section 2, the hypotheses are developed on the basis of self-determination theory and literature on gamification. In Section 3, the methodological approach is described. Finally, Section 4 concludes with the expected contribution of the proposed experiment and suggestions for future research.

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II. Background and Hypothesis Development

This section describes self-determination theory in relation to gamification to develop hypotheses regarding the effect of copresence and leaderboards on motivation.

A. Self-determination theory and Gamification

Self-determination theory [14][15] describes how humans develop extrinsic and intrinsic motivation. It proposes that the satisfaction of three psychological needs, competence, autonomy, and relatedness, is relevant for the development of motivation. Need for competence describes that individual strive to experience feelings of achievement during interaction with their environment [16]. On the other hand, need for autonomy relates to the experience that actions result from individuals' own volition, whereas need for relatedness describes that individuals strive to belong to other individuals [15]. The development of the research model (see Figure 1) for this research-in-progress paper on the basis of self-determination theory is described below.

For the area of gamification, self-determination theory can act as a theoretical lens to explain how different gamification elements motivate. Sailer et al. [9] could show that the inclusion of badges, leaderboards, and a performance graph increased the satisfaction of need for competence and autonomy compared to presenting only points. On the other hand, when users could choose their avatars and are presented with a story, as well as teammates, their need for social relatedness was more satisfied than when they viewed only points. It is therefore hypothesized that the presentation of leaderboards will increase the satisfaction of need for competence and autonomy.

Hypothesis 1. *Using leaderboards leads to higher satisfaction of need for competence than using no leaderboards.*

Hypothesis 2. *Using leaderboards leads to higher satisfaction of need for autonomy than using no leaderboards.*

Additionally, increased copresence should lead to higher satisfaction of need of relatedness than low copresence.

Hypothesis 3. *High copresence leads to higher satisfaction of need of relatedness than low copresence.*

B. Gamification Elements and Performance

Research on the social facilitation effect of virtual humans can be differentiated in whether it has investigated the effects of virtual humans displayed on traditional 2D screens or in IVR with a HMD.

For 2D screens, research has indicated that being with virtual human has similar effects as being with a real human, at least when the task for which performance is measured is a cognitive task. Specifically with regard to inhibition effects, both virtual humans and real humans inhibit performance for female, but not male participants in a pattern recognition and categorization task [17]. Likewise, with regard to facilitation effects, Liu et al. could show that effects are comparable between virtual humans and real humans, but without detecting gender effects [18]. Additionally, Park et al. could show that social inhibition effects arise for both virtual and real humans in a complex task, whereas for easy tasks, a social facilitation effect could be observed [19]. However, the social facilitation effect comparing presence versus absence of a virtual human of Park et al. could not be replicated in a recent study [20]. Surprisingly, when the task is not a cognitive task but a sports-related, effects between virtual and real humans become apparent, as shown by a recent study [21]. Here, cycling performance could be enhanced when competitive individuals were paired with a real human, but not when they were paired with a virtual human.

In IVR, initial research suggests that social inhibition effects are at a similar level for virtual and real humans, whereas no social facilitation effects could be found for virtual or real humans [22]. Additionally, computer controlled agents seem to provide less copresence than human-controlled avatars, and here, inhibition effects could only be found for human-controlled avatars [23]. One paper compared the effect of HMD and 2D screens, which indicated that inhibition arises only when using IVR but not when using 2D screens for robotic agents [24]. However, all of these studies were conducted in the domain of cognitive tasks. As the research in progress paper at hand is planned in the context of the sports domain, it can be assumed, in line with research on cycling performance [21], social facilitation effects will arise. However, as Snyder et al. could only find social facilitation effects for individuals paired with a real human, it is hypothesized that the high copresence condition will lead to higher performance than the low copresence condition.

Hypothesis 4. *High copresence leads to higher performance than low copresence.*

As previous research on gamification elements has shown that leaderboards increase performance [25], the same is assumed for the context of this study.

Hypothesis 5. *Using leaderboards leads to higher performance than using no leaderboards.*

A meta-analysis in the context of self-determination theory could show that satisfaction of the three psychological needs predicts performance [26]. We therefore hypothesize:

Hypothesis 6. *Performance is positively related to satisfaction of need for competence.*

Hypothesis 7. *Performance is positively related to satisfaction of need for autonomy.*

Hypothesis 8. *Performance is positively related to satisfaction of need for relatedness.*

III. Method

In this section, the set-up of the experiment, the gamification design elements, and the planned data analysis is described.

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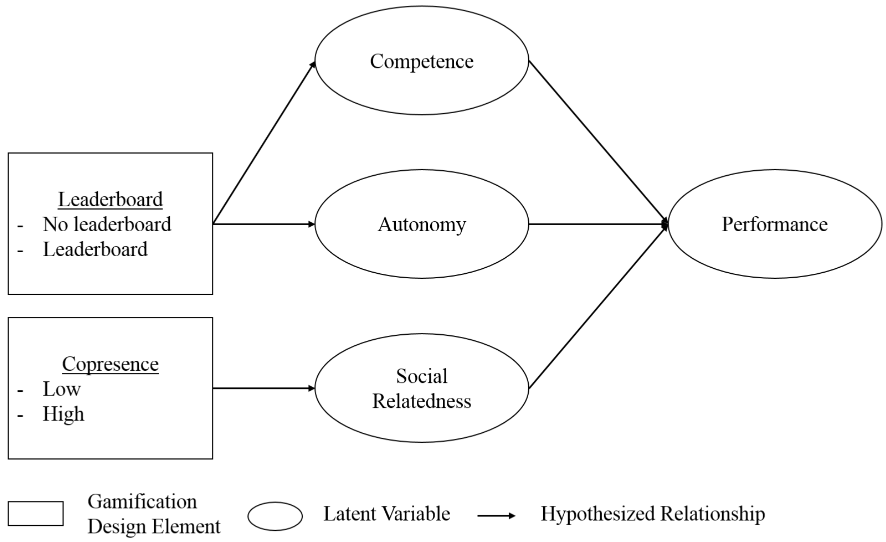

Fig. 1. Research Model

A. *Participants and Design*

I will use a 2 (copresence: low vs. high) x 2 (leaderboard: no leaderboard vs. leaderboard) between-subjects laboratory experiment with 80 student participants recruited from the local university to test the proposed hypotheses.

B. *Materials and Measures*

Virtual Reality. Participants will use a virtual environment programmed with Unity 3D displayed with HTC Vive during the experiment. For body tracking, five HTC Vive Trackers (for hip, both feet and both hands) in combination with Hi5 VR Gloves are used. Avatars will be created in Adobe Fuse.

The measurements for the three psychological needs, the manipulation checks, and the indicator for performance are described below. The scales for the three psychological needs and the manipulation checks are measured on a 7-point scale ranging from “strongly disagree” to “strongly agree”.

Satisfaction of Need for Competence. The need for competence scale is taken from Sailer et al. [9] and adapted to the context of the study. The scale consists of four items. One example item is “During the gamified task I had feelings of success”.

Satisfaction of Need for Autonomy. The need for relatedness scale is adapted from the autonomy in relation to task meaningfulness scale from Sailer et al. [9]. The scale consists of three items and one example item is “It was worthwile doing the task”.

Satisfaction of Need for Relatedness. The need for relatedness scale is adapted from Sailer et al. [9]. The scale consists of three items and one example item is “While doing the task I felt like I was part of a team”.

Performance. For learning performance, the times participants have raised their feet in the marching in place task is counted.

Manipulation checks. For copresence, the copresence scale from Poeschl and Doering [27], as well as the copresence scale from Bailenson et al. [28] are used as manipulation check, consisting of three items each. An example item is “”I was aware that other people were with me in the virtual room.” for the Poeschl and Doering scale and “Even when the ’other’ was present, I still felt alone in the virtual room” for the Bailenson et al. scale. For Leaderboards, we use the item ”I was informed about how other players performed on the task” as manipulation check.

C. *Gamification Design Elements*

Leaderboard. Leaderboards will be implemented by displaying the number of repetitions from five other users. In the no leaderboard condition, an empty leaderboard is presented.

Copresence. In the low copresence condition, participants will see four other virtual humans (2 male, 2 female) who will do the task with them on a television screen. On the high copresence condition, the players will be in the same virtual room as the participants.

D. *Procedure*

One week prior to the first IVR session, we will invite participants to the laboratory to create pictures for the avatars used in the experiment. One week later, when participants enter the laboratory, they will be fitted with the HTC Vive trackers. When they put on the HMD, they will see a room with a large mirror and a large television screen on the wall in front of them. When they look in the mirror, they see the virtual avatar that looks similar to themselves, which they also see from first person perspective. Participants will see their own points above the mirror and television screen. Additionally, participants in the leaderboard condition see a leaderboard displayed above their points, which they will be made aware of by the experimenter.

For participants in the low copresence condition, the television screen will show four participants who enter the room on the screen and train with them. On the other hand, participants

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in the high co- presence condition, the four trainees enter the same virtual room as the participant. Then, they will be instructed on how to do the marching task. In this task, they have to alternately lift their feet to a specific height displayed in IVR for ten training trials in which the experimenter validates that the participants perform the action correctly. Then, they are told that they can do as many repetitions as they want. After they have finished, participants finish the motivation and presence questionnaire in IVR. Afterwards, they are thanked and debriefed.

Data Analysis: The data will be analyzed using four 2x2 ANOVAs for the three psychological needs competence, autonomy, and social relatedness, as well as performance. Additionally, the complete model will be tested using covariance-based structural equation modeling.

IV. Conclusion and Future Research

The proposed experiment can contribute to literature on gamification and IVR and answering the research question in several ways. First, the study helps to gain insight into which gamification elements are most effective in IVR to increase motivation and performance. Additionally, the experiment contributes to explain motivational working mechanisms of gamification elements against the background of self determination theory. Finally, the experiment can contribute to explain conditions under which social facilitation effects arise. On this basis, future research can investigate whether the proposed working mechanisms of this model generalize to other areas in the sport domain, as well as sport-unrelated domains, such as knowledge work, and application areas outside of IVR. From a practice perspective, collaborative gamification elements can then be used to enhance motivation in multi-user scenarios (e.g., applications supporting health behavior). Furthermore, future research can develop algorithms that implement these collaborative gamification elements efficiently.

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