PlayHIIT: Augmenting Remote Exertion Experiences Through Playful Interaction

Francisco Teotónio
Instituto Superior Técnico,
University of Lisbon, Portugal
francisco.teotonio@tecnico.ulisboa.pt

Tomás Alves
INESC-ID & Instituto Superior Técnico,
University of Lisbon, Portugal
tomas.alves@tecnico.ulisboa.pt

Hugo Nicolau
ITI / LARSyS & Instituto Superior Técnico,
University of Lisbon, Portugal
hugo.nicolau@tecnico.ulisboa.pt

***Abstract*—The recent uprising trend of remote approaches to group physical activity has shown how these strategies lack social engagement. Following a user-centred design process grounded on the Playful Experience (PLEX) Framework's dimensions, we developed an augmentation of video conference-based group exercise to enhance the social dynamics of high-intensity interval training. We conducted a user study (N = 12) to analyse the effect of our approach on the perceived playfulness of the experience, enjoyment, and effort of participants. Results show an increase in the PLEX Framework dimensions of *Competition* and *Sensation*. Additionally, our findings suggest positive trends in the participants' enjoyment and effort, thus raising new design implications related to the design space of videoconference group exercise interfaces.**

I. Introduction

The recent lockdowns and social distance behaviours have led to an uprising trend of remote approaches to physical activity [1]. While in-person group exercise offers easier communication and understanding of exertion levels through visual body language and spatial hearing, videoconference-based group exercise is restricted by a smaller number of information channels available, rendering overlapping voices in unidirectional sounds as well as poor visual feedback with small screen sizes. However, remote group exercise opens new design opportunities for technology-mediated solutions, particularly on making these social experiences more enjoyable. Although research on social dynamics in group exertion experiences often focus on competition [2], [3] or collaboration [4], [5], we believe that it is important to leverage open-ended experience scenarios [6], [7] to allow an organic development of the enjoyment and the effort by the participants. Moreover, playful design elements may complement this open-ended nature by prompting participants to freely interact with one another through the videoconference interface. In this work, we developed an exertion interface that provides scaffolds for social interactions with a group in a High-Intensity Interval Training (HIIT) setting. HIIT is a form of interval training, using a cardiovascular exercise strategy that alternates short periods of intense anaerobic exercise with less intense recovery periods. The prototype shares performance data in real-time during the activity through features inspired on the PLEX framework [8], a set of dimensions representing playful aspects of user experience.

II. PlayHIIT

We present "PlayHIIT" (Figure 1), a system designed to augment a videoconference interface and complement remote group HIIT sessions. "PlayHIIT" is compatible with multiple exercises and activities, including calisthenic exercises, since it uses heart rate (HR) as the primary indicator of effort across different aerobic exercises. Thus, it is not dependent on type of movement (cycling, push-ups, sit-ups) or equipment. Additionally, we designed a repetition counter, providing an adequate comparison alternative for strength-based exercises that do not have as much direct impact on the HR.

Through design iteration over the course of one month, we resorted to active participant observation [9] and semi-structured interviews with an online physical exercise group to define design goals: (i) encourage an adequate physical effort below the overexertion; and (ii) create opportunities for playful social interactions by leveraging performance information.

"PlayHIIT" is composed of two components. The first component is a **mobile interface** that gathers data from each user. In particular, its main features are (i) gathering the HR from an activity tracking band (ATB), (ii) displaying it in real-time on the screen, and (iii) providing an exercise repetition counter through a simplified numerical input interface where each user can keep track of the performed repetitions for each exercise during a training session. The other component is a **desktop application** which consists of a shared screen between all active users during a videoconference exercise session. HR is displayed continuously on the screen as a percentage of each estimated maximum HR value based on the Karvonen formula as featured in Stach et al. [10], as well as a coloured vertical bar where higher HR corresponds to gradually warmer colours. We chose to display HR as a relative value to provide an explicit balancing [11] mechanism for differently skilled users to avoid feelings of unfairness during the activity. That is, more experienced users have to engage in similar levels of effort (i.e., an individual measure of effort provided by HR) to keep up with less skilled users. We also included a repetition counter as a number and icon in the lower half of the coloured bars, which is updated in real-time based on the inputs made on the mobile application. Particularly, we included the individual performance statistics to stimulate playful interactions related to the PLEX *Competition* dimension, which relies on the

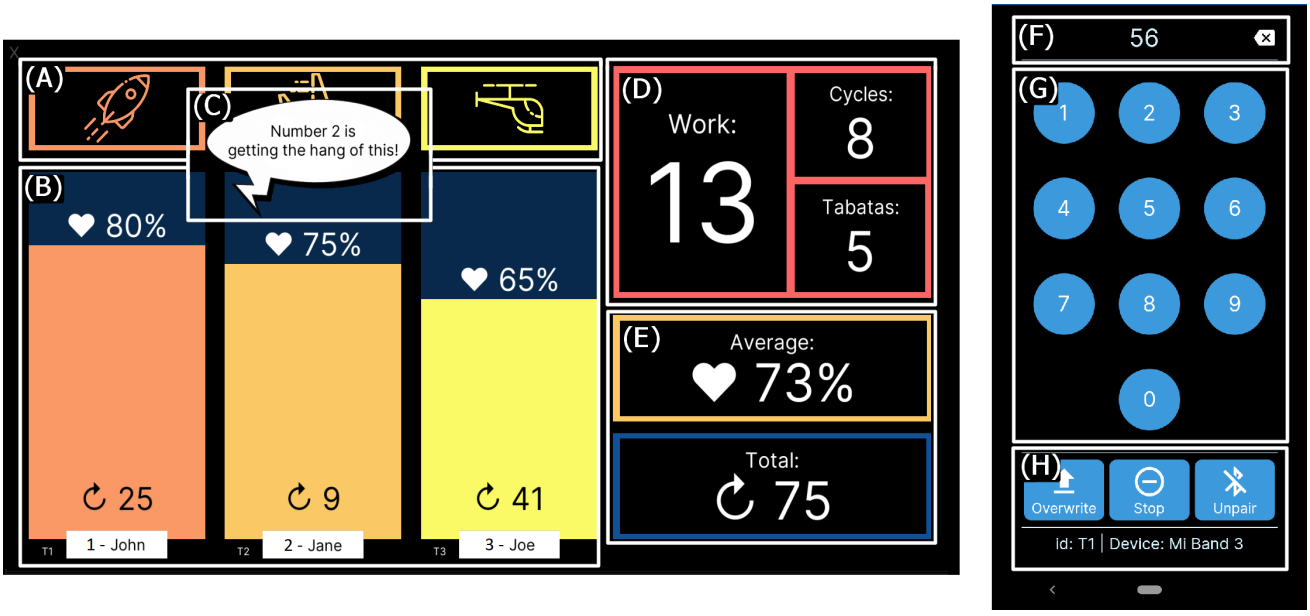

Fig. 1. Main screen of the desktop application, featuring (A) the displayed badges and (B) colored heart rate bars for each participating user, an (C) example speech balloon shown alongside its voice lines, the (D) workout timer and (E) statistics for the whole group. On the right side the interface for the mobile application featuring the (F) current repetition count, (G) numerical pad interface for repetitions and (H) remaining interface for connecting and starting to measure heart rate.

existence of comparable measures during an experience [8]. Additionally, the average HR of all users and the sum of their current repetition counts are also displayed on the lower-right corner of the screen to provide a common goal, directed at groups that are not keen on competitive activities.

Based on the PLEX *Discovery* dimension, we include a set of badges to stimulate and reward curiosity by providing a visual metaphor for the HR percentage of each user displayed above each of the coloured bars. Several vehicles of increasing speed represent distinct intervals up to 90% of the estimated maximum HR of each user, alongside a warning sign used to provide a visual warning for overexertion. There is also a training timer on the upper-right corner where users can check the remaining time for both working and resting periods and the number of remaining sets and cycles per set. The border of the timer varies depending on the current workout phase (resting or working). "PlayHIIT" provides auditory feedback that signal each working and resting interval through two sound effects. Moreover, whenever someone raises or lowers their HR across a certain threshold, different voice lines illustrated by a speech balloon are played either cheering or teasing the corresponding user, e.g. "Number one is getting warmed up!" and "Number one is slowing down." Besides prompting the participants to acknowledge relevant events during the activity, we expect people to use these scaffolds to tease and cheer each other with comments, thus supporting the PLEX dimensions of *Humor* and *Fellowship*.

III. Experimental Study

We conducted an experimental study to analyse whether the usage of social-oriented playful features in remote group exercise increases the **enjoyability** (**H1**) and the **effort** (**H2**) of the participants in the activity. Furthermore, we also want to study **which facets of playfulness does our system influence in a group videoconference exercise session?**

A. Experimental Design

We conducted a within-subjects study where participants performed in groups of three, one session with "PlayHIIT" system and another without it, in a counter-balanced order between groups. We analysed the effects of "PlayHIIT" through (i) enjoyment, following the PACES questionnaire [12], (ii) effort, through the average HR in the session, and (iii) playfulness, using the PLEXQ survey [13]. We also performed semi-structured interviews with each group to gather qualitative insights.

B. Methodology

Twelve participants were recruited through standard convenience sampling procedures including direct contact and through word of mouth as groups of three people who already knew each other beforehand. All participants were male with ages between 19 and 23 years old ($\overline{x} = 20.33, \sigma_x = 1.18$). Three performed physical exercise six or more times per week (25%). Only one participant performed physical exercise two to three times per week (8.33%) and another one between four to five times per week (8.33%). Seven answered that they engaged in physical activity one time per week or less (58.33%). Only three had already performed a HIIT exercise session before (25%), two had already used an activity tracking band at least once (16.67%), and all were familiar with videoconferencing software before our study (100%).

On the day before the exercise sessions, we held an introductory session with each group to guide them through the technical setup of the fitness bands. Each participant needed a laptop/desktop computer capable of running the videoconference software (Zoom) and a mobile phone for the application. We started by explaining what a HIIT training session consists of by showing the set of exercises for the session. The display of the desktop application was shared from a desktop controlled by the researcher supervising the study. We then informed them that they were free to interact during the session and resting phases. We held a total of four sessions, one per group, with a duration between 30 and 40 minutes. After each session, we provided a link for each group to fill an online survey containing both the PLEXQ and PACES questionnaires. After the last session, we conducted semi-structured group interviews.

IV. Results

We used Wilcoxon signed-rank tests to analyse the effect of "PlayHIIT" on the enjoyment and effort of participants, as well as on the playfulness dimensions of the physical activity.

A. Enjoyment

Regarding the median **PACES** score, there was a statistically nonsignificant increase ($2.50\ pts.$) after subjects used our system ($96.00\ pts.$), when compared with the control condition ($92.50\ pts.$), $z = 0.490, p = 0.624$, which leads us to refute H1. Based on the interviews, we believe that the experience leaned strongly towards a competitive setting independently of the condition, specially in the session featuring the system. As an example, P3 (Participant 3) mentioned, amidst laughter, one of his partners that had consistently higher repetition numbers than him: *"Whenever I could do one more rep[etition] than P2 I got all pumped up! It happened twice in the last set!"*. Although most participants saw this as a positive factor, three of them shared that it had an impact on how relaxing physical exercise was. In the words of P7, *"There was a part of this session that was more competitive, which was kind of stimulating, but for me personally, took away a little bit of the relaxing part of doing exercise."* Some participants mentioned a change in the trending themes of their conversations, e.g. *"I think that in the first one [With System], our conversation was much more competitive. In this one [Control], it was more normal stuff"*.

Even though the repetition counter was not the most highlighted feature on the desktop screen, it is possible that its proximity to the bars with high contrast resulted in the group-centred information being overlooked in comparison to the individual measures. Nevertheless, ten out of the twelve participating users still found the system providing a more enjoyable experience to them, leading us to believe that the pending issue is linked to the final visual layout and not to limitations of the concept itself.

B. Effort

As we mentioned, effort was measured through the **heart rate** of the participants. We did not find a statistically significant mean increase in the average HR while using "PlayHIIT", $t(11) = 0.53,\ p = 0.61,\ d = 0.15$, compared to the control session. In the light of this, we refute H2. Nevertheless, 75% of the participants referred to the act of tracking their repetitions as one of the most relevant aspects in increasing their effort. Some participants also mentioned the desire to compete with themselves. When asked what contributed to him being focused on competing with his partners, P6 added: *"I think it was the number of repetitions. It was also [competing] with myself as I thought "Okay, if in this set I did this number of repetition, in the next one I'm going to try to do a number close to that"*. Despite the mixed results overall, the second half of the planned activity displayed a more notable increase in HR than the first half, showing that our system resulted in an increase of 1.47 ($95\%\ CI$, -4.63 to 7.56) beats per minute in the average HR compared to the control session.

C. Playfulness

We found that three items of the **PLEXQ** registered a significant increase in their median score. For **Competition**, there was a statistical significant increase in the median score of "I felt competitive" with our system ($3\ pts.$ to $4\ pts.$), $z = 2.667,\ p = 0.004$. All participants felt more competitive using our system, mostly based on the repetitions counter, as stated in the interviews. The other relevant dimension was **Sensation** with statistical significant increases in the median scores of "I enjoyed the visuals" ($3\ pts.$ to $4\ pts.$, $z = 2.268,\ p = 0.016$) and "I felt pleased by the quality of it" ($3.5\ pts.$ to $4\ pts.$, $z = 2.041,\ p = 0.031$) from the control condition to the one with our system. The interviews revealed that users found the system to be visually pleasing, since it provided a fine balance between the amount of information displayed on the screens and how easy is was to quickly check it. Generally, users also found the system to be a pleasant addition to the activity.

We also found some interesting non-significant trends. The competitive focus of our system may have shifted users against group engagement since no participant highly rated the item "It was a true learning experience" of the **Challenge** dimension, while five registered a lower score. There was a non-significant decrease in the median score with our system ($3\ pts.$ to $2\ pts.$), $z = -1.789,\ p = 0.063$. Moreover, for **Nurture**, seven participants answered higher to the item "I enjoyed following its development", while one registered a lower score. As such, this non-significant increase in the median score with our system ($3\ pts.$ to $4\ pts.$), $z = 1.768,\ p = 0.070$, reflects that participants were keen to keep track of their repetitions and checking how they were performing over time, e.g. *"I definitely noticed a difference, in this session [with "PlayHIIT"] we were commenting each others' results, which was something that you couldn't do in the other session [Control] because they simply didn't exist"*. The voice lines feature was referred as being an important factor in highlighting relevant events, being praised by several users as helpful in improving group awareness. Regarding **Completion**, there was a non-significant increase in the median score of "I managed

to master a task" by using our system (2 $pts.$ to 3 $pts.$), $z = 1.789,\ p = 0.062$. This item is in line with the reported feel of satisfaction with the amount of work participants put into the activity. Finally, **Suffering** also showed a trend with the item "I felt angry" showing a non-significant increase in the median score with our system (1 $pt.$ to 1.5 $pts.$), $z = 1.789,\ p = 0.062$. We can interpret this item as related to the feeling of dissatisfaction for lagging behind, which is a consequence of competition.

D. Design Implications

Overall, we can summarise our findings regarding the design space of videoconference-based group exercise interfaces in six lessons: (i) **Using Sound for Immediate Feedback**. The large number of different exercises that do not allow users to look at a screen are a limitation in this context (e.g. push-ups). If the information immediately delivered to the user is an essential element of an interactive experience, auditory cues are an appropriate approach; (ii) **Using Visuals for Continuous Feedback**. Visual feedback allows for the display of continuous information throughout time. Whenever something should be shown to the user only as much as they want to monitor it, we recommend a non-intrusive display; (iii) **Using Individual Measures for Competition**. Providing performance metrics in a comparable context promotes competitive behaviour, allowing users that enjoy this type of social dynamic to have a more enjoyable experience even without established objectives for an activity; (iv) **Balance Individual and Global Measures**. Striking a balance between the relevance given to individual measures and aggregated ones for the whole group is an essential factor in guaranteeing that the experience may not alienate users who dislike either competition or cooperation; (v) **Provide Easily Explorable Elements**. If the system is designed to appeal to the playfulness of its users, the limited possible ways to interact with it while performing different exercises can be an issue. Revealing hidden contents or visual treats depending on simple factors such as the effort of users promotes their curiosity, without needing additional movements or interactions; and (vi) **Use Events as the Foundation of Social Interactions**. Highlighting events that users may overlook, such as someone significantly increasing or decreasing their physical effort in an activity, may create opportunities for users to comment upon the funny, awkward, or perhaps intentionally unfair judgment provided by the system. This, in turn, can encourage users to tease and cheer on their peers whose actions were highlighted.

E. Limitations

Although we use a small sample size, results shed light on the potential of playful interaction to enhance remote physical activity. Moreover, we only conducted two sessions per group, further longitudinal studies are needed to assess its effects for longer periods of time. In addition, no female participants were recruited which may introduce a gender bias. Regarding technical aspects, while using mainstream sensors have clear benefits, the inability to control the sampling rate of the tracking bands, alongside its reliance on optical HR sensors, may have a negative effects on accuracy.

V. Conclusions & Future Work

In this paper, present "PlayHIIT" and we contribute with an understanding of its effects in remote physical activity. Namely, we explored how "PlayHIIT" influences the user experience regarding their level of enjoyment, how much effort people put into the activity, and the different playful interactions that it stimulates. Results show positive trends for both the level of enjoyment and the effort of the participants. In addition, "PlayHIIT" leads to increases in the *Sensation* and *Competition* dimensions of the PLEX framework. Future work includes leveraging user preferences in the design process, applying the proposed design implications, and conducting further longitudinal user studies with larger samples.

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