PlayHIIT: Augmenting Remote Exertion Experiences through Playful Interaction

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Abstract

We have observed an uprising trend of remote approaches to group physical activity, yet these strategies lack social dynamics due to the limited communication scope they provide to participants. In this dissertation, we develop a social augmentation to video conference-based group exercise to increase the enjoyability of the activity while motivating users to increase their effort input. In particular, we leverage different social dynamics and balancing methods in exertion experiences, and playful interactive systems. Following a user-centered design approach, our prototype shares performance information between group elements during High-Intensity Interval Training and provides scaffolds for social interactions through the inclusion of playful-oriented elements. We conducted an experimental study to observe the effect of our system in the enjoyment and effort of participants, while providing an in-depth analysis of the playfulness dimensions that were affected. Results show an increase in *Competition* and *Sensation* dimensions of the Playful Experience framework regarding the activity. Regarding enjoyment and effort, results were nonsignificant, while displaying positive trends. Our findings empower interaction designers with implications regarding the design space of video conference group exercise interfaces.
Keywords: Physical Activity, Exertion interface, Social interaction, Playfulness

1. Introduction

One of the consequences of the security measures brought by the COVID-19 pandemic is the number of people being subject to home-confinement. Recent studies suggest that this can be responsible for increasing physical inactivity, with effects such as higher cardiovascular disease rates and other health consequences [8, 20], alongside the absence of the several mental health benefits that exercise provides [24]. In response, there has been an uprising trend of remote approaches to physical activity, with several gyms worldwide providing online group classes and personal trainer coaching sessions through video conference.

The main differences between video-based group and in-person exercise are the limited number of information channels available. In-person, visual body language and spatial hearing allow for easier communication and understanding of the effort by others. When we consider a remote environment, unidirectional sound makes understanding overlapping voices harder and visual feedback is reduced to small parts of the screen. These details contribute to the same issue. **The lack of social dynamics is one of the disadvantages of video-based physical exercise**.

Weighting how balanced exertion experiences lead to more engaging social experiences [4, 11, 16] and sharing individual performance data provides opportunities for social play [17, 25], we leverage user-centred design techniques to develop an exertion interface for augmented group video-based exercise. Additionally, we use established playful design principles [3] as a foundation for our work.

2. Related Work

Park et al. [19] developed a set of guidelines to turn individual exercises into social exertion games. These consist of **obtaining its primitives** (i.e., steps, distance or heart rate for running), followed by **picking what will the primary interaction be**. The authors argue that the primary actions (i.e. running) should be kept as the core mechanic, while other secondary actions should be used with contempt.

People who exercise in their homes often do not own dedicated exercise equipment, as such adaptability to different types of exercise is a requirement to make a feasible way to complement home exercise. We can identify heart rate, a common element between many calisthenic exercises that are easily done at home, as a viable primary measure for our system. Several relevant works make use of heart rate as primary measure [4, 14, 16, 22, 25] although they seldom make use of the ubiquitous nature of this measure, opting instead for focusing on individual exercises. The most common usages of heart rate are systems which primary actions are either cycling [4, 14, 22, 25] or running/walking [9, 16].

When dealing with interactive group experiences, one of the relevant questions is **how to provide a balanced experience to all participants.** A possible approach to achieve this is through social balancing measures. Multiplayer exertion experiences can be balanced either in an explicit or an implicit way [11], depending on whether their balancing mechanisms are known or hidden from its users. Explicit digital balancing provides the advantage of being oriented towards user acceptance due to no information being hidden from users. When considering exertion experiences in a home video conference environment, having users motivated to engage with the activity is essential, as it is not a common way to exercise in a group. We need to create a comfortable experience, as any effort to combat physical inactivity is futile if users do not feel comfortable using it. Some examples of explicit heart rate balancing usage are "Jogging Over a Distance" [16] and "Race by Hearts" [22].

It is also important to consider t**he design concepts of the social dimensions in our work**. Several studies have analysed the effects of having a competitive versus a collaborative setting, as the inclusion of social dynamics is of relevance for any social exertion experience. While there are several studies that rely on competitive [9, 11, 14, 22] or collaborative [9, 15, 18, 21] settings, only a few provide scenarios based on open-ended experiences [16, 25]. Enabling users to chase their personal goals has the advantage of not limiting how much effort or how intense the activity they are engaging with is. While the novelty of providing a more specific goal-oriented activity may be useful in making it more fun and tempting to experiment for the first time, to keep users interested and effectively combat physical inactivity, it is needed to accommodate different needs users might have during several days of training.

One of the design approaches that complements open-ended activities is playful design. Unlike gamification, the broader concept of playfulness can be evoked through a multitude of different methods. To better understand the different avenues that can lead to playfulness, Arrasvouri et al. devised the PLEX framework [2, 3], a product of literature review which defines twenty-two different categories which compose playful experiences.

Some of these categories are easily identifiable in the exertion experience design space when resorting to the definition provided for each of them in the original report regarding the PLEX framework [3]. Dimensions such as *Captivation*, *Fantasy* and *Simulation* are often connected to systems that rely on Virtual Reality and simulated environments [4, 10]. *Competition* and *Fellowship* are contrasting occurrences in interactions that rely on competitive of cooperative social dynamics. *Discovery* and *Sensation* can both rely on the interaction with visual, audio, and tactile elements of many physical activity augmenting systems [9, 11, 14, 15]. Lastly *Challenge* is deeply connected with any physical experience that requires greater exertion than usual, such as examples based on High-Intensity Interval Training [12]. This framework, alongside the work we discussed were crucial in the design and development of our system, which we elaborate in the next section.

3. PlayHIIT

We developed **"PlayHIIT"**, **a system designed to complement video conference-based group High-Intensity Interval Training (HIIT) sessions**. It consists of a mobile and a desktop application to be used during the videoconference. The desktop application is a shared screen between all users that displays performance data to everyone while providing information through visual and audio cues that are connected to different events of the activity such as someone increasing their heart rate in a substantial way. The mobile application is used to connect to an activity tracking band (ATB) that the users are wearing and gather the heart rate, as well as providing a repetition counter for users to wield, sending all this data to a cloud-stored database where the desktop application gets its required information. The design of this system was an iterative process, being tested several times with a focus group that engaged in remote exercise together.

The design philosophy for our system was based on UCD methodologies. In our work, we resorted to **On-site observation** to collect data regarding the environment in which our system would be used. We observed and participated in an online exercise group that performed their training sessions through video conferences for one month. In a later stage of our project, we used **Iterative Design**, by alternating prototyping and testing phases with a focus group of users. We also performed **Semi-structured Interviews** to understand the impact that our work was having on the users, and we participated in these testing sessions ourselves to have first-hand information regarding our prototypes.

We determined several design goals that we aimed to achieve with the "PlayHIIT" system during this research phase: (i) Leveraging the fact that HIIT training is compatible with adequate exercises for home equipment, (ii) encouraging adequate effort level while not inducing overexertion, (iii) facilitating social interactions between the group, (iv) using intelligible visuals to allow users to easily check information during exercise, and (v) careful usage of sound cues to only provide the necessary information without disturbing the sounds identifying the workout progress.

We also framed our main goals regarding playfulness according to the PLEX elements that we want to focus on: (i) *Competition*, by providing users with the metrics needed for them to compare with each other; (ii) *Nurture*, by facilitating performance awareness between elements of the group; (iii) *Discovery*, by providing visual and auditory rewards depending on their efforts to promote curiosity; (iv) *Humor*, by highlighting opportunities for users to tease each other and cheer their performances; and (v) *Fellowship*, by providing a sense of communality between participants.

3.1. Architecture

Two main components comprise our system. The first one is a **mobile application** responsible for handling the received heart rate and repetition input data of participants. The second one is a **Unity desktop application** that shows the main display to all users in each exercise session. To use our system, each user must have a Xiaomi Mi Band 3 **fitness band**, to which our mobile application will connect via BLE. This application is responsible for gathering the heart rate of the user through the BLE Heart Rate service of the fitness band. Besides receiving inputs from the user through a numeric touchpad, the application has the task of sending both these data types to a **cloud-stored database** hosted through Google's Cloud Firestore service. During each session, the heart rate values of all users are registered, to be then used by the desktop application, through Firestore's REST API services. The final prototype accommodates up to three users at the same time.

3.2. Mobile Application

The three essential features that we aimed to accomplish with our mobile application are (i) connecting to the ATB through BLE, (ii) displaying the user's heart rate on the screen, and (iii) saving this data in a remote database.

We then added an exercise repetition counter, providing an intelligible metric suitable for comparison, that would be adequate to ease perception of effort in strength-training exercises.

The primary user interface challenge comes from the fact that during HIIT activities resting times can be as short as ten seconds, only allowing a very reduced time frame for users to input the number of repetitions they have done in the previous set. Our solution was a simplified numerical pad which acts as an input for users to annotate their repetition counts throughout the physical exercise sessions, by automatically consuming any input that is made after three seconds.

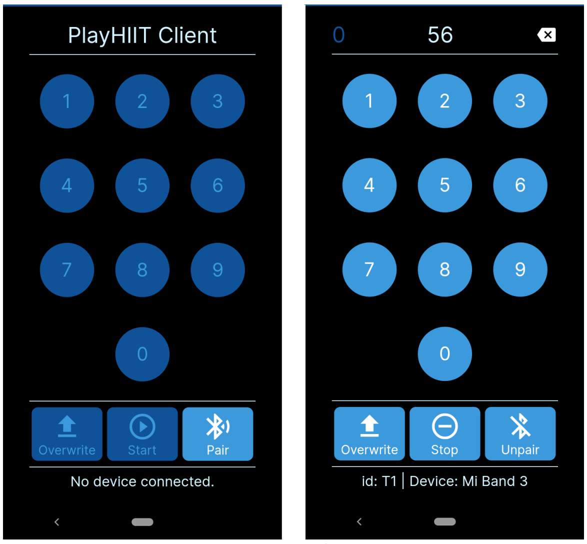

Figure 1: Initial and main screen of the Mobile application component.

The main screen contains the numerical pad, three additional buttons, and a text prompt displaying if there is any device connected underneath. When starting the application, the only available button is the "Pair" one which displays an overlay with all compatible devices scanned nearby. Pressing "Pair" pairs the application to the device, and starts listening for updates in the BLE Heart Rate Service of the band. After connecting, the numerical pad and the "Start" button become available, and a new display appears above the pad featuring a backspace button and the current repetition number registered. The "Start" button initializes the heart rate measuring, sending the data to the database through an internet connection. We added an "Overwrite" button to allow corrections in case of mistakes while registering the repetition number. Whenever the input value is updated, a request is made to update that value on the database.

3.3. Desktop Application

The main component of our system is a display shared by all users, meant to be used simultaneously as the videoconference software of their choice. Regarding its development, the first metric that we decided to use as a measure of effort was the heart rate, which we opted to continuously display on the screen, providing an unobtrusive way of delivering the information. We used a simple balancing mechanism, estimating the maximum heart rate of each user based on the Karvonen formula as featured in Stach et al. [23] and presenting the heart rate not only as an absolute number but also as a percentage of the maximum heart rate. The heart rate is represented as **coloured bars** set side by side on the screen. The size of the bars is proportional to the percentage of heart rate of each user, and we coloured them according to their interval, with gradually warmer colours until red. In order to fetch heart rate data from our cloud located database in real-time during its usage, the system uses REST API requests.

A **training timer** allows us to input the amount of time dedicated for set preparation and duration, resting intervals, and the number of sets and cycles per set, featuring sound effects to signal the start of work and rest intervals and colour-coded borders that match with each different workout phase. Regarding the **repetition counter** display, as we want to aim for social balance, we opted to keep the heart rate as the primary measure through the size and colour of each bar and present the input only as a number inside it. To counterbalance the competitive focus of our system, we also displayed the group average heart rate and total repetitions between all users, in order to provide more options to spark social interactions with a cooperative theme between users, such as commenting or cheering for each other to achieve a higher group average.

The last two features of our system were based on the *Discovery* and *Humor/Fellowship* PLEX dimensions. The first of these is a **set of badges** that provide a visual representation of the heart rate percentage of each user through a chosen metaphor. We picked several vehicles of increasing speed to represent distinct intervals, alongside a warning sign to represent the highest interval, to provide a visual warning for overexertion. The main objective of this feature is to stimulate and reward curiosity from users regarding our system. The second feature is the inclusion of **voice lines** whenever a particular user raises or lowers his heart rate across a certain threshold. Whenever this happens, a voice line is played, and a **speech balloon** is displayed. The functional objective of this feature is to allow us to grab the attention of the remaining users for more relevant events during the activity. The social objective is to provide scaffolds for users to tease and cheer each other by commenting on the interventions made by the system itself.

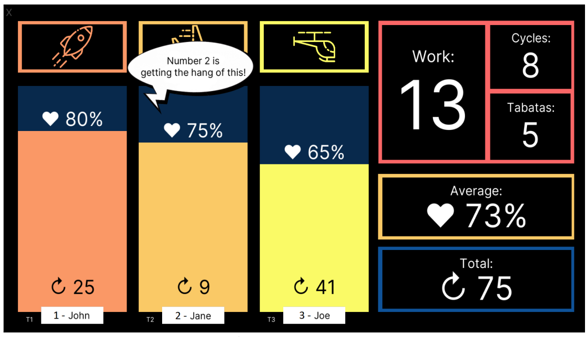

Figure 2: Main screen of the Desktop application component.

4. Evaluation

In order to validate our prototype, we conducted an experimental study with a set of participants. The main objectives of our system are to provide a more enjoyable remote physical experience and to increase the effort of its users. From these dimensions, we can derive our two **hypotheses** for our study: **(H1)** The integration of social-oriented playful features in group videoconference exercise increases the enjoyability of the activity. **(H2)** The integration of social-oriented playful features in group videoconference exercise increases the effort of participants during the activity.

Furthermore, we also want to provide an analysis of the possible effects our system has on the experience. We can separate the dimensions we want to analyse in three distinct **research questions**: **(RQ1)** What facets of playfulness does our system influence in a group videoconference exercise session? **(RQ2)** Are user perceptions of effort affected during physical activity? If so, how? **(RQ3)** Does the system affect the social behaviours of users?

4.1. Experimental Design

The independent variable of our study is the test condition, which has two possible values: (i) participating in a videoconference group physical exercise session while using our system, and (ii) in a control variant of the session that did not feature our system. The study was within-subjects, and participants performed one training session under each condition in groups of three people, in a counter-balanced order between groups.

Regarding our dependent variables, we chose to analyse the effects of our system regarding enjoyment, through the results of the PACES questionnaire [13], effort through average heart rate, playfulness through the PLEXQ survey [5] and perceived effort through the BSPE scale [6]. We also performed a thematic analysis to a semi-structured interview to observe differences in the social interactions that occur during the activity.

4.2. Participants

Twelve participants were recruited as groups of three people who already knew each other beforehand. They were required to sign a consent form and did not receive any compensation. All participants were male, with ages between 19 and 23 years old ($\overline{x} = 20.33, \sigma_x = 1.18$). From these, three of them performed physical exercise six or more times per week (25%). Only one performed physical exercise either 2 to 3 times per week (8.33%) and another one 4 to 5 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%).

Regarding the degree of connection in groups, we asked participants to report it through the Inclusion of Other in the Self Scale [1]. The sum of the answers for each group range from 6 to 42, which correspond to the least and greatest degree of connection. The results for each of the four groups were 37, 32, 24, and 18 out of 42.

4.3. Apparatus

Users are required to wear a Xiaomi Mi Band 3 activity tracker on their wrists, and to have a mobile phone each with Internet access, Android operating system updated to at least version 9.0, and BLE connection. Besides this, each user also needs a device capable of running videoconference software. The main difference from the base architecture detailed before is that instead of having one of the users sharing the desktop application on their screen, the application is shared from a desktop handled by the researcher supervising the study.

Other relevant materials used include the surveys referred in the Experimental Design subsection, the IOS Scale and a demographic survey containing age, frequency of physical exercise, and familiarity with HIIT training, activity tracking bands, and videoconferencing software.

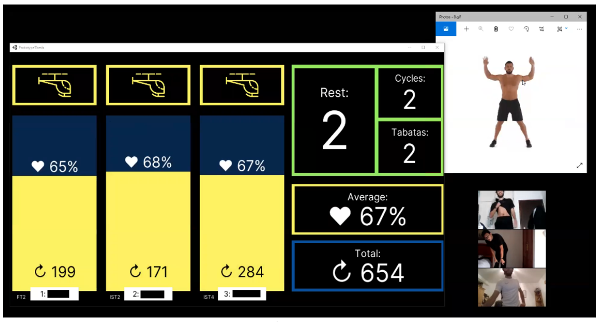

Figure 3: Display example of the screen shared to participants during our user study.

4.4. Procedure

The first step was delivering all required material to participants, including the consent form for our study. Between the recruitment and the scheduled sessions, we asked them to fill a survey regarding their demographic data. On the day before the exercise sessions occurred, we held an introductory session with each group, in which we guided them through the technical setup for their fitness bands.

At the beginning of the initial session, we explain to the group what a HIIT training session consists of, and showed the program that they will perform in each session. We then inform them that they are free to interact with each other during the session and that during the resting phases, they will be asked to self-evaluate their effort through the Borg Scale of Perceived Exertion.

After each training session, we provided a link for each group to fill an online survey containing both the PLEXQ and PACES questionnaires. After the last session, the semi-structured interview was held with all participant of the group. Finally, we give participants a last survey containing the IOS scale to evaluate the closeness of the social relations of each participating group.

4.5. Data Analysis

Regarding enjoyment, we analysed the histogram of the PACES difference scores between conditions. As these were approximately symmetrically distributed, we did a Wilcoxon signed-rank test to the total scores of both conditions.

To analyse the heart rate, we had to address the inconsistent time between values, due to the varying sampling rate of the ATB we used. We aggregated values through data binning, with each bin representing the average of each three-second interval in our session. Through inspection of the boxplot, no outliers were present in the data, and the differences between the average heart rate were normally distributed, as assessed by Shapiro-Wilk's test ($p = 0.344$), allowing us to perform a paired samples t-test to the average heart rates of participants.

Regarding the PLEXQ and average BSPE results, considering that all answers were not approximately symmetrically distributed, we performed a Sign test between both conditions. Finally, a thematic analysis [7] was made to the transcripts of all four semi-structured interviews conducted after the last session of each group.

5. Results

Regarding the median **PACES** score, there was a statistically nonsignificant increase ($2.50\ pts.$) after subjects performed a physical exercise session while using our developed system

(96.00 $pts.$), when compared with the control condition (92.50 $pts.$), $z = 0.490, p = 0.624$.

Moving on to the **heart rate** of participants, the average rate throughout the whole session was higher while our system was being used ($\overline{x} = 114.06, \sigma_x = 6.29$) than during the session in which our system was not featured ($\overline{x} = 112.60, \sigma_x = 12.48$). In terms of differences between conditions, usage of our system resulted in an increase of 1.47 (95% CI, -4.63 to 7.56) BPM in the average heart rate. There was not a statistically significant mean increase in the average heart rate after exercising while using our system, $t(11) = 0.53,\ p = 0.61,\ d = 0.15$.

When analysing the results of the **PLEXQ**, three out of the 51 items registered a significant increase in their median score:

Competition: Nine participants answered higher to the item "I felt competitive.", while none registered a lower score. There was a statistical significant increase in the median score with our system (3 $pts.$ to 4 $pts.$), $z = 2.667,\ p = 0.004$.

Sensation: Seven participants answered higher to the item "I enjoyed the visuals.", while none registered a lower score. There was a statistical significant increase in the median score from the control condition to the one with our system (3 $pts.$ to 4 $pts.$), $z = 2.268,\ p = 0.016$. Six participants answered higher to the item "I felt pleased by the quality of it.", while none registered a lower score. There was a statistical significant increase in the median score from the control condition to the one with our system (3.5 $pts.$ to 4 $pts.$), $z = 2.041,\ p = 0.031$.

Regarding the remaining results, albeit not being statistically significant, some other noticeable trends in the answers gathered were:

Challenge: No participant higher to the item "It was a true learning experience.", while five registered a lower score. There was a non-significant decrease in the median score with our system (3 $pts.$ to 2 $pts.$), $z = -1.789,\ p = 0.063$.

Nurture: Seven participants answered higher to the item "I enjoyed following its development.", while one registered a lower score. There was a non-significant increase in the median score with our system (3 $pts.$ to 4 $pts.$), $z = 1.768,\ p = 0.070$.

Completion: Five participants answered higher to the item "I managed to master a task.", while none registered a lower score. There was a non-significant increase in the median score from the with our system (2 $pts.$ to 3 $pts.$), $z = 1.789,\ p = 0.062$.

Suffering: Five participants answered higher to the item "I felt angry.", while none registered a lower score. There was a non-significant increase in the median score with our system (1 $pt.$ to 1.5 $pts.$), $z = 1.789,\ p = 0.062$.

Regarding the **perceived effort** of participants, after calculating the average rating for each user in each condition, there was no statistically significant median increase in their ratings from the control condition ($M = 14.5$) to the one with our system ($M = 14.6$), $p \simeq 1.000$.

Finally, the results from the thematic analysis [7] done to the semi-structured interviews were categorised in three themes that consist of **Motivation**, **Social Relationships**, and **Playfulness**, and a separate category featuring relevant comments regarding issues and limitations of our study design.

Motivation: Participants referred to the act of tracking their repetitions as one of the most relevant aspects in increasing their motivation. Out of the twelve participants, nine of them directly referred or agreed with this. Some participants also showed a desire to compete with themselves. When asked what contributed to him being focused on competing with his partners, P6 answered: *"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"*.

Although most participants saw this as a positive feature, three of them shared that it had an impact on how relaxing physical exercise was for them. 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."*

Competition was also a motivation source for some participants. Regarding one of their partners that had consistently higher repetition numbers than him, P3 said amidst laughter: *"Whenever I could do one more rep than P2 I got all pumped up! It happened twice in the last set!"*.

Social Relationships: Some participants mentioned a change in the trending themes of their conversations. P3 mentioned: *"I think that in the first one [With System], our conversation was much more competitive. In this one it [Control] it was more normal stuff"* to which P2 added: *"Yeah, more like idle talk"*. All participants identified the session featuring the system as being a more competitive experience.

Several participants also pointed out that some of the features provided opportunities to comment and tease each other. P7 reported: *"I definitely noticed a difference, in this session [with System] 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"*. When asked to comment on the voice lines, P2 cited them as being a cause for interactions in the group:

"(The voice lines) allowed us to mess and tease with each other. Usually when the woman spoke were the times I took the chance to tease someone like "You're almost dying, man!" and stuff like that". P7 referred to the voice lines as also being an important agent in improving social awareness: *"Besides finding them a bit funny, I think they were cool because they pointed us to specific things amid all visual information available, you see?"*.

P7 also added that this awareness brought some inherent social pressure: *"There was a bit of social pressure, and I personally felt a bit guilty for being out of shape, although honestly, I don't think that made a big difference. I think the pros of having the information available to stimulate participation ends up compensating that pressure, but only because I'm doing this with people I already knew"*.

Playfulness: Regarding the badge icons, two users in different groups went ahead and exposed their curiosity. As soon as he was asked what he thought regarding the badges, P10 replied: *"Which was the last one? I just really want to know what was the last one. The plane was like around 70%".* On the other hand, five participants mentioned that they did not notice the badges until later in training, or at all. When asked to comment on the feature P8 replied: *"I just noticed them in the end! I thought they were funny, but I didn't pay much attention, In the end, I was just busy being tired!"*

When commenting on the voice lines feature, four users referred to them as a positive addition that made them excited to work more. This feeling was not shared by all participants, as two of them mentioned that they used them to check if they could slow down the pace of the exercise. Quoting P5, *"I noticed that whenever I got positive feedback, my heart rate started to slow down, maybe it's because I started to relax."*.

Overall, ten users replied that they found the session featuring the system more enjoyable. This was mostly due to competition making the activity more fun. When asked to justify their preference, P2 and P3 said: *"P3: Fun, the amount of exercise I think I did, and how happy I am with my efforts. I felt much more accomplished [System] than in the first one [Control], and I had a lot more fun. - P2: I think the only factor for me was motivation, and that is the source for all others, I feel motivated, then I train more, and I feel better about it. - P3: And then you can poke fun at the others, which makes it more fun. - P2: Yeah, It's like a snowball effect."*

Limitations: Two participants from different groups shared displeasure regarding the feedback the heart rate values were providing them, as they felt it did not match the effort they were putting in. Regarding this, P5 said: *"There was one time when I was giving all that I had, I was super tired, and it started saying that I was slowing down, and I was slightly annoyed cause I knew that wasn't true".*

When asked about which of the sessions felt more challenging, all participants replied that their respective first session felt more challenging, due to them not knowing beforehand what they were going to do, making it difficult to compare. When asked which was the most challenging condition, P6 stated: *"I think it was the first one, both due to both not being used to exercise for a while and because in the second one I already knew what I was expecting. I already knew how to manage the course of the exercises."*

5.1. Discussion

Despite there being a slight positive trend, results regarding enjoyment were heterogeneous. These results lead us to not accept the first hypothesis (H1) we proposed. The main reason we identified for results not being generally more positive was that the experience became heavily more competitive to not only participants who are fond of this type of interaction but also the ones who are not. Even though the repetition counter was not the most highlighted feature of the screen, it is possible that being bundled with the highly contrasted heart rate coloured bars was enough so that it took over the group-centred information displayed at its side. Nevertheless, ten out of the twelve participating users still found the system providing a more enjoyable experience to them, making us believe that the pending issue is linked to the visual balancing of the chosen features and not to limitations of the concept itself.

Regarding the **effort** participants put into the activity, results were mixed. These lead us to also not accept the second hypothesis (H2) we proposed. Despite this, the second half of the planned activity displayed a more notable increase in heart rate than the first half. One possibility for this is some exercise activities being more prone to competition than others. In this case, a more comprehensive study in which users could use the system multiple times would be relevant to dispel existing doubts. The competitive role that the activity took while featuring our system also might have negatively impacted the performance of participants who are not prone to competing with each other, rendering more polarised results as we observed.

Moving on to our research questions, in order to answer the first one (RQ1), we performed an analysis of the **different playfulness facets of the activity**. We observed the most notable effect in two categories. In *Competition*, an item had a significant increase (*"I felt competitive."*) and another had a positive trend (*"I enjoyed competing against it."*). The engagement of having users counting their repetitions was unanimously referred during the interviews as being the dominant reason for this. The second is *Sensation*, with two items that displayed a significant increase. These were (*"I enjoyed the visuals."* and *"I felt pleased by the quality of it."*). Users found the system to be visually pleasing, which is consistent with the referrals that were made to the visuals during the interview, having accomplished the objective of balancing the display of information while making it easy for users to check what they want quickly. Also within the theme of easing the transmitting information, we found the voice lines feature to have accomplished its objective of highlighting relevant events within the activity, being praised by several users as helpful to this regard. Generally, users also found the system to be a pleasant addition to the activity according to the corresponding PLEXQ item, not contradicting the positive trend of the answers given to PACES questionnaire.

Participants were keen to keeping track of their repetitions and checking how they were performing over time. The positive trend noticed in one of the *Nurture* items (*"I enjoyed following its development."*) reflects this detail. One of the items in *Completion* (*"I managed to master a task."*) also displayed such trend, in line with the reported feel of satisfaction with the amount of work participants put into the activity. The *Challenge* dimension featured an item with a negative trend ("It was a true learning experience."), unlike what we intended. This outcome may be a negative consequence of the competitive focus of our system, moving the focus of users to the competitive dimension instead. We observed an increasing trend in an item from *Suffering* (*"I felt angry."*). We can interpret this item as related to the feeling of dissatisfaction for lagging behind, which is a consequence of the competitive tone of the activity.

We were not able to answer our second research question (RQ2) due to the results of our evaluation of the **way users perceive their effort** being mostly inconclusive. All participants perceived their effort being a lesser amount in the second sessions that they participated in, independently from the condition. Some participants also referred that already knowing the difficulty of the task in the second session allowed them to prepare themselves for the activity better.

Lastly, concerning **the social aspect of our system** and our third research question (RQ3), participants noted that despite some not being fond of competition, almost all of them still preferred the session with our system, mainly due to the comfort of doing the activity as a group that already knew each other. One notable aspect was that participants who mostly referred the opportunity to comment and tease each other as an advantage of using our system belonged to the groups with the higher closeness between elements (G1 with 37, and G3 with 32, out of 42).

5.2. Design Goals

We can summarise what we have learnt regarding the design space of video conference group exercise interfaces in the six following lessons:

Using Sound for Immediate Feedback: The large number of different exercises that do not allow users to look at a screen or other visual display are an issue. If the information immediately delivered to the user is an essential element of an interactive experience, using auditory cues is an appropriate option to solve this issue.

Using Visuals for Continuous Feedback: On the other hand, 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, using a non-intrusive display allows this to happen.

Using Individual Measures for Competition: Providing users with measures regarding their performance in a comparable way facilitates competitive behaviour, allowing users that enjoy this type of social dynamic to have a more enjoyable experience even without established objectives for an activity.

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.

Provide Easily Explorable Elements: If the system is designed to appeal to the playfulness of its users, the limited possible ways to interact while performing different exercises can be an issue. Despite this, revealing hidden contents or visual treats depending on something as simple as the effort of users promotes their curiosity, without needing additional movements or interactions.

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.

5.3. Limitations

The main limitation of our study is its limited participant amount. A larger participant amount would be useful in better understanding the strength of its impacts on the different research topics and to further study whether the observed trends would be significant or not. This may also be the reason for no significant changes or trends being observed regarding the *Humor* and *Fellowship* dimensions, despite the positive comments regarding social interactions. The lack of more sessions per group also reduced our ability to deal with the learning bias inherent to performing the physical exercises for the second time, which may have been exacerbated by our demographic being composed by people who do not perform physical exercise frequently. Regarding technical aspects, the inability to control the sampling rate of the tracking bands, alongside its reliance on optical heart rate sensors may affect the quality of the gathered data, as some participants questioned its precision during the activity.

6. Conclusions & Future Work

This dissertation attempts to turn group video conference-based physical exercise into a more enjoyable and fun experience. In order to accomplish this, we developed a composite application for desktop and mobile devices simultaneously that aims to provide a social augmentation to this activity. This application shares performance information regarding HIIT to the elements of a group, while providing social opportunities for groups to interact, tease, and cheer each other through several included playful-oriented elements.

We also provided an experimental study that aimed to analyse the different effects of this system in the user experience of group video conference exercise, regarding how much effort users put into the activity, their level of enjoyment, and the different playful interactions that our system allows users to take part during the activity. Results of this study showed nonsignificant positive trends for both the level of enjoyment and the average heart rate of participants. Regarding playfulness, both the *Sensation* and *Competition* dimensions of the PLEX framework had a significant increase in some of their items, while nonsignificant positive trends were seen in items of the *Challenge*, *Nurture*, *Completion*, and *Suffering* dimensions. This in-depth analysis provides a thorough understanding of the effects of our system regarding playful interactions.

Despite existing positive trends for both enjoyment and effort, and having stimulated different types of playful interaction, the inability to provide a balanced dynamic between cooperation and competition depending on different preferences remains as the core issue in our work. Further research would be needed to improve on the current issues in order to reevaluate its effects on remote exercise groups.

For future work, a possible option to solve the unbalanced social dynamic is the analysis of different customisable displays for users of this type of system, providing details tailored to their individual preferences instead of a single global view. Further analysis with larger samples would also need to be done to understand better the effects of our system on the amount and type of social interactions that are held throughout the activity. Regarding recruited participants, including more people who are used to practising regular physical exercise would also provide for a more appropriate representation of the possible target audience for this category of systems.

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