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Enjoyment, Immersion, and Attentional Focus in a Virtual Reality Exergame with Differing Visual Environments

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Figure 1: *The barren, rural, and urban visual environments, with boxes to collect for bonus points, and cannons that fire cannon balls for extra motivation.*

Abstract

Virtual reality exergames provide a compelling distraction from the possible discomfort and negative perception of exercise by immersing users in three dimensional virtual worlds. Prior studies have looked at the effects of immersion in exergames, from the technologies used, to gameplay elements, to sensory stimulation. This study examines the level of immersion and distraction caused by various visual environments, including urban, rural, and desert landscapes, and the effects on users' performance, enjoyment, and motivation. The environments were found to have little effect on the user. It appears that the core gameplay elements have a far greater effect, being essential for the immersion a user experiences.

CCS Concepts

•***Computing methodologies*** → ***Virtual reality;*** •***Human-centered computing*** → *Virtual reality;* •***Applied computing*** → *Computer games; Health informatics;*

1. Introduction

One of the most important factors for health, well-being, and longevity is to exercise on a daily basis. It is recommended that a person does at least thirty minutes of moderate intensity cardiovascular exercise five days per week, or at least twenty minutes of high intensity cardiovascular exercise three days per week [GBD*11]. Unfortunately, only a minority of the adult population does reach that level of physical activity. For example, a large study in the European Union showed that two thirds of the adult population (people aged 15 years or more) do not reach recommended levels of activity [CKR06]. One major reason for this is the lack of intrinsic motivation to exercise, i.e. the activity is not enjoyable in itself [KHB05].

Exergames are a way to combat this by combining video games, a popular form of entertainment, with physical activity. Exergames range from simple movement games that can be played with a console in the living room, to performance based games incorporating exercise equipment as would be found in a gym [WJNW10, GGMS14, GCPP15]. By combining gameplay features with physical activity, exergames aim to motivate a user to exercise and increase the enjoyment they have of the activity. Additional objectives are to promote dissociation to reduce thoughts and realisation of physical discomfort and fatigue [LWE09] and to increase self-efficacy [dBGM16].

We are interested in the role that the visual environment has on the user experience. We extended an existing immersive exercycle-based exergame [SWL*15a] and changed the visual environment as described below. The game allows for the same physiological

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effects as in traditional exercise, with a user encouraged to exert themselves. We designed two graphically rich environments, one rural and one urban, and used a graphically devoid barren environment as a control condition (see figure 1). The rural environment consists of many trees and greenery, while the urban environment has many large buildings and is mostly gray. Both of these environments have similar visual characteristics such as foreground-background ratio, brightness, and spatial frequency. The barren environment, on the other hand, is desert-like, and differs significantly from the other two environments with regard to these visual characteristics.

In this paper we investigate the effect that these three different visual environments have on the motivation, enjoyment, attentional focus, and immersion of a user while playing an exergame. The attentional focus of a person while exercising can be broken down into two categories, association and dissociation. Association refers to paying attention to the bodily effects of the exercise activity, while dissociation refers to paying attention to things that take the mind off those effects [LWE09]. The psychological literature suggests that distraction from the physical activity can lower perceived exertion and increase enjoyment [NP13]. By using immersive technologies such as a VR headset and an exergame, these effects can potentially be enhanced [AOCT10].

Another important contributor to motivation and enjoyment is immersion. We are interested in what effect the visual environment does have on users' immersion and their performance, motivation, and enjoyment of the game. Having a better understanding of this relationship will enable developers of exergames to design graphical content not only based on aesthetics, but also on their effect on the effectiveness of the exergame. In particular we want to investigate potential negative effects, such as rural environments being too relaxing and reducing exercise performance, or urban environments inducing stress reducing enjoyment. Sound is an important aspect of the immersive experience and has been shown to both increase immersion and perceived usability [MVHV03, Jør08, Gal13]. In order to make the game realistic we use some sound effects, e.g. when scoring points or hitting an obstacle. Sounds effects are identical in all three conditions. We do not use any background music since its influence on exercise behaviour is highly dependent in individual preferences [KP12, Kar16].

2. Related Work

2.1. Exergames

Exergames have been shown to achieve physiological benefits in the same manner as traditional exercise. Peng et al. [PLC11] evaluated the physiological effects of exercise in relation to an exergame. They found that exergames were able to offer light to moderate intensity exercise, significantly increasing heart rate and energy expenditure of users in the same way as traditional exercise. Hoda et al. [HAES13] used a qualitative questionnaire and did a quantitative study to measure user's perception of exergames and their motivation to exercise when the exercise was combined with games. They found positive results, both in the enjoyment of the exercise, and in the intensity of effort. Finkelstein et al. [FNL*11] looked at the immersive aspects of an exergame. They saw that users had positive experiences playing the game, and had a significant increase in their heart rate by the time they finished playing. They also discovered that the exergame positively motivated users to exercise by making them want to play the game and that by increasing the gameplay the exergame felt less like exercise and more like a game.

2.2. Attentional Focus

Lind et al. [LWE09] surveyed the existing literature on association and dissociation. They note that it has been theorised that the potentially negative perceptions caused by exercise, such as displeasure and discomfort, could be lessened by directing attentional focus towards an environmental stimulus, rather than towards the body. Such an effect could be tremendously beneficial for sedentary people and exercise beginners, increasing enjoyment and thus motivation. The literature however has not been entirely clear, with results showing this strategy has been both effective in some cases and ineffective in others. A dissociative strategy seems to be more effective when the exercise intensity is low to moderate, with the perception of exertion lowered, but as the exercise intensity increases an associative strategy might be more suitable, with the bodily effects, such as heavy breathing, much more evident. In introducing an additional activity that is potentially very engaging, exergames have the potential to accentuate this dissociative effect, allowing for greater exercise intensity before association takes over.

Baden et al. [BWEL04] studied runners' perception of exertion in relation to expected distance that they would run. They found that the rate of perceived exertion was lower when a runner thought they would be going further, and their level of dissociation was higher, showing that perceived exertion and dissociation were inversely correlated. The authors noted that dissociative thoughts were unconscious by nature, with the mind drifting into daydreams or sensory perceptions of the environment. A measure of dissociation is thus inherently difficult, asking a study participant what they are thinking would jolt them out of the dissociative thought, and possibly render them unable to report what they were thinking about, or even that they were dissociating. They may lack the awareness that they are dissociating.

Hutchinson and Tenenbaum [HT07] looked at the role of intensity in determining whether an associative or dissociative strategy was used. The authors found that when the intensity was high attentional focus was almost entirely associative, with physiological cues dominating what the study participant was aware of. They had participants express what they were thinking about verbally during the experiment, and the recorded thoughts were later classified into associative and dissociative. As Baden et al. pointed out, this could potentially lead to reporting of more associative thoughts, as the participant would be less aware of the dissociative ones, or more likely to have associative thoughts as they were tasked with reporting thoughts. Conversely, Brewer et al. [BVRL96] developed a questionnaire to measure the level of association, dissociation, and distress of participants. Their experiment had similar results to prior studies, with higher performing participants more likely to use associative strategies and less likely to use dissociative strategies, and female participants more likely to report feelings of distress. Annesi [Ann01] used a modified version of this attentional focus questionnaire in their study on the effects of different forms of entertainment on distraction, adherence to exercise, and performance.

Mestre et al. [MDM11] measured dissociation in their exergame study looking at the effects of both visual and auditory stimulation on exercise performance. They concluded that the visual stimulation seemed to have a dissociative effect on a user, lessening their awareness of exercise intensity, but only while the stimulus maintained novelty. They also noted that visual stimulus appeared to have less effect when exercise intensity increased. They used a one to ten scale measure of association and dissociation often used in the psychology literature.

2.3. Immersion

Jennett et al. [JCC*08] investigated the meaning of the term immersion and designed two questionnaires to measure the subjective experience of it. The authors state that immersion has three prominent features, including the player lacking an awareness of time, becoming unaware of what is happening in the real-world around them, and having a sense of being in the game environment. The authors report that performance and ability to perform a task had an effect on the level of immersion, and that the level of reported immersion was more due to the level of cognitive activity required by the game than the amount of graphical engrossment. They did also note that participants would report a higher level of immersion than expected.

Exergames not only incorporate immersive gameplay, but also immersive technology. Finkelstein et al. [FNL*11] used a stereoscopic monitor setup to simulate a 3D environment, and users wore a backpack with tracking wires to track their movement. Gameplay included dodging planets hurtling towards the player, as well as tapping gold suns and firing lasers. With more gameplay, and with the immersive technology, participants reported it felt less like exercise and more like a game. Shaw et al. [SWL*15b] investigated some of the design issues in implementing an exergame with immersive technologies, including a virtual reality headset and motion tracking.

3. Design

3.1. Exergame Design

Our study extends a virtual reality exergame presented in [SWL*15a]. The game incorporates an exercycle, with the user riding the cycle to move in the game along a track. A first person perspective is used to increase immersion [DC15]. The game is able to facilitate moderate to high intensity exertion. The user is able to move their body from side to side to move to the left and right of the track, and make a ducking motion to make the virtual character duck under beams hovering over the track. These movements are captured with a motion tracking camera, which provides for intuitive controls. The aim of the game is to score as many points as possible, by avoiding obstacles including sand pits, cannon balls, and beams hanging over the track, and collecting boxes. Riding through a sandpit causes the exercycle resistance to increase, until the player moves out of the sandpit. Cannon balls push the player backwards. Boxes could give a score bonus, or may remove resistance for a period of time. The track is procedurally generated, and allows for potentially infinite gameplay, though the game ends after a set time. In our implementation players cannot loose lives and cannot fall off the track, since thus would disrupt the game play and exercise flow and hence be detrimental to the exercise goal. Additionally, terrain was added to the game, and the three environments as discussed below.

3.2. Environment Design

The three environments used in this study are shown in Figure 1. The *barren* visual environment consists of a sandy terrain, the skybox, and the track. It is intentionally devoid of visual complexity, and was used as a control condition.

A green grassy looking terrain was used for the *rural* environment. Models of various trees were sourced from the Unity3D Asset Store. These models were placed into the game procedurally, with adjustments made to scale and rotation to provide more variation. An algorithm was designed for placement of trees in grid-like clusters, allowing easy adjustment of how many layers deep the trees would be placed away from the track, as well as the likelihood of them being placed in any particular grid square. The number of trees placed in any one area could also be adjusted. To lessen the effect on the horizon of trees being placed, the algorithm would place them further from the track, and underneath the terrain, before slowly moving them to their position, rather than having the trees pop into existence as the player approaches.

A grey gravel terrain was used for the *urban* environment. Like the models for the trees, free building models were sourced from the Unity3D Asset Store. The same algorithm used in the rural environment was used to place the buildings, with slight adjustments made to their position to remove a flickering effect (due to depth buffer "z-fighting") where buildings would intersect.

3.3. Minimisation of Confounding Factors

It was important that the two visual environments we were investigating were visually similar to each other, and the control condition sufficiently different. The visual appearance of the environments was analysed by three criteria: coverage, brightness, and spatial frequency. In order to be similar, the rural and urban environments should cover a similar amount of the foreground, and the barren environment should cover less. It was important to measure brightness, as a brighter environment could have positive effects on the user in spite of what was portrayed in comparison to a darker background, or vice versa. Looking at the spatial frequency of each environment gave an indication of the graphical complexity, which could contribute to a greater cognitive load or to a greater level of immersion in the game. Screenshots of the game were taken at angles ranging from straight ahead to 45 degrees to the right.

To measure the coverage of each of the environments they were rendered in magenta. The images were then analysed using histograms. In every one of the images tested the magenta background in the barren environment covered a larger portion of the image. The rural and urban images were much closer in background coverage in every image tested. Screenshots were taken with the same camera position in each of the related images.

Brightness was measured by converting the screenshots from the RGB to HSV colourspace, with the value parameter giving the brightness of the image. The brightness values for the rural and urban screenshots are similar in all images, while the barren environment screenshots are consistently brighter.

The spatial frequency was measured by running a smoothing algorithm on the image and then comparing the result with the original image. This was repeated with a 3*x*3, 5*x*5, and 7*x*7 smoothing algorithm. In all cases in these results, the barren environment had the lowest graphical complexity. The rural and urban environments had similar spatial frequency, which was significantly higher than for the barren condition.

4. Methodology

We conducted a user study to measure motivation, enjoyment, attentional focus, and immersion in each of the visual environments, as well as the relationship between these variables and the performance of the user and their perception of exertion. A within-subject design was used, with each of the participants undergoing each of the conditions.

4.1. Measurements

At the beginning of the user study, a questionnaire was used to gather demographics, including age, body mass index, and other information regarding level of fitness and amount of time spent playing games.

The Intrinsic Motivation Inventory [RCD*97] was used to measure the motivation and enjoyment of a user. They questionnaire has a modular design, of which the interest and enjoyment section, and the pressure and tension section, were chosen for use after each of the conditions. The perceived competence section and the effort and importance section were selected as a measure of self-efficacy and was given at the end of the experiment. Each of the variables for the IMI were averaged to give a value out of seven.

One of the common methods for investigating the attentional focus of a participant is to have a facilitator question the participant regarding what they are thinking about while they perform the activity, or to let the participant self-report their thoughts. This was not appropriate for our study as it would be too much of a distraction and would also effect the immersion of the game. There is also potential for this approach to cause the participant to associate more than they otherwise would. Another common method is to have the participant record their attentional focus at the end of a task, with dissociation being at one end of the scale and association the other. This scale however did not seem to provide enough information for our purposes. The Attentional Focus Questionnaire, developed in [BVRL96] was selected. After conducting a trial run it was found that some of the questions were not appropriate for our use. While some of the questions relating to dissociation were relevant (e.g. whether a participant was focusing on the environment), many were specific to general exercise and unlikely to occur while playing an immersive exergame (e.g. whether a participant was meditating). It was decided to modify the questionnaire in the same manner as [Ann01], removing the twelve questions relating to dissociation, and regarding dissociation as an inverse of association. After modifying the questionnaire there were eleven questions relating to association, with a total possible score of seventy-seven, and seven questions regarding distress, with a total possible score of forty-nine.

To measure the immersion of participants we selected the second questionnaire from [JCC*08]. After a trial run, twelve of the questions were found to not be relevant for our use and were removed. Some of these questions related to real-world distractions, which were limited by the set-up (head phones) and immersive nature of our game, while others were not relevant to our specific game, such as wondering about how to complete the game, when our game was potentially infinite. After modifying the immersion questionnaire there were nineteen questions and a total possible score of ninety-five.

As a dissociative strategy while exercising is known to lower the perception of exertion during the activity, the Borg scale of physical exertion [Bor85] was used to measure participants' perceived exertion in each condition.

All of the questionnaires were administered through Google forms. In addition, variables regarding the performance of the participants were recorded from the exercycle and the game and written to a file. These variables included the participants' heart rate, speed, resistance, distance, and score in the game.

4.2. Participants

The study had 22 participants (14 male, 8 female, age 18-24). The average body mass index of the participants was 23.25 (*SD*=3.87). Two of the participants were obese, with a BMI greater that 30, two were overweight, with a BMI between 25 and 29.9, and one was underweight, with a BMI less than 18.5. The average number of exercise hours per week was 3.80 hours (*SD*=2.55). 10 participants reported more than 3.5 hours exercises per week (a frequently recommended level of physical activity)

4.3. Procedure

The study took approximately one hour. On arrival participants were asked to look over the Physical Activity Readiness Questionnaire as well as the safety guidelines. They were then given an ethics information sheet to read and sign. Next, participants were instructed to fill out a questionnaire to gather demographic information, including their body mass index, as well as other questions such as fitness level and gaming preferences. They were then given instructions for the exergame and an introductory session of the game to learn the controls and game mechanics, and to allow them to warm-up for exercise. Initial questions were addressed and a short rest break given. The game condition for this warm-up session consisted of the track and game-play elements with an empty environment composed of only the sky. The Latin square method was used to select the order of game conditions for the following three sessions. The first of the three game conditions was then undertaken, lasting for five minutes, followed by a one minute cool-down period with the participant still on the bike.The participant was then asked to complete a survey, consisting of the Borg scale

Table 1: *Summary of the Performance Variables with Mean and Standard Deviation*

		Score	*Distance*	*MaxHR*	*AvHR*	*MaxSpeed*	*AvSpeed*	*AvResistance*
Barren	*Mean*	15707.27	1.93	169.52	155.56	107.82	88.95	4.38
	StdDev	5284.15	0.5	19.45	17.07	25.45	17.35	0.48
Rural	*Mean*	14020.91	1.88	169.33	153.64	110.41	88.11	4.26
	StdDev	4452.3	0.51	19.11	18.91	28.39	18.61	0.75
Urban	*Mean*	14040	1.88	164.91	152.7	109.36	89.21	4.3
	StdDev	5580.2	0.54	24.32	20	29.22	22.57	0.35

Table 2: *Summary of the Experiential Variables with Mean and Standard Deviation*

		RPE	*Association*	*Distress*	*Immersion*	*Interest/Enjoyment*	*Pressure/Tension*
Barren	*Mean*	13.86	46.14	17.82	70.23	5.19	2.5
	StdDev	2.02	11.46	7.12	11.47	1.19	0.92
Rural	*Mean*	14.09	47.43	17.35	71.09	5.29	2.43
	StdDev	1.89	10.25	7.36	11.26	1.08	0.93
Urban	*Mean*	13.55	46.43	17.96	69.7	5.35	2.26
	StdDev	2.26	10.33	5.95	12.19	1.24	0.92

for rate of perceived exertion, the Attentional Focus Questionnaire, the immersion questionnaire, and the two sections of the Intrinsic Motivation Inventory regarding interest and enjoyment, and pressure and tension. This process was repeated for each of the remaining game conditions. An additional survey was administered after the third game condition, with a further two sections of the Intrinsic Motivation Inventory regarding perceived competence, and effort and importance, as well as some general questions about the environment, including preferences and whether they noticed an effect from the different environments.

5. Results and Discussion

Table 1 shows a summary of the performance variables from the experiment, including the average value of each of the variables, and the standard deviation. Table 2 shows a summary of the experiential variables from the experiment. The results show that our game was highly immersive, with values of 70.23, 71.09, and 69.7 out of a possible seventy-seven. A one-way repeated measures ANOVA was used to test the effect of the visual environment on each of the dependent variables. No significant effects of the visual environment on any of the dependent variables were found.

5.1. Participant Comments

Participants were asked for any comments at the end of the study regarding the environment, as well as for their preference of the rural and urban environments. 62.5% reported that the urban environment was more stimulating, 66.7% that the rural was more relaxing, 58.3% that the urban was more motivating, 54.2% that the rural was more enjoyable, and 58.3% that the rural was more immersive. The comments were varied and included "the desert one was a bit boring so I feel like I felt the strain of the exercise more", "the forest one was most relaxing, it was enjoyable looking through the trees", "Interesting environments were more distracting - wasn't so focused on cycling in the city environment", "trees made everything look better, it encouraged me to try harder", "the urban environment gave me a sense of speed, while the rural one just continued the same forever", and "urban felt to grey to me, so after a while of cycling I didn't pay much attention to the buildings than I did with the rural environment". Some participants did not notice much of a difference: "I'm not sure I noticed [the environment], I was focused on the track and avoiding the sandpits and cannons" and the environment was "not overly significant or noticeable since most attention was on track".

5.2. Correlations

Figure 2 shows a plot of some of the correlations between the variables, with *b* denoting the barren environment, *r* denoting the rural, and *u* denoting the urban environment. The blue dots indicate a positive correlation, with the darker and larger dots indicating a stronger correlation, while the red dots show a negative correlation. The plot was ordered by hierarchical clustering, where the strongest correlations are grouped together. Correlations were tested for significance and removed if $p < 0.05$ (empty cells).

There was a high correlation between similar variables across conditions, particularly the performance variables such as speed, distance and heart rate. There were also strong correlations between the interest and enjoyment variables (*b.interest*, *r.interest*, *u.interest*), and the immersion variables (*b.immersion*, *r.immersion*, *u.immersion*), with the participants who were most interested in the activity and enjoying it the most reporting the highest levels of immersion. The variable for the effort and importance for a participant is also strongly correlated with immersion and interest and enjoyment. The significant correlation with interest and enjoyment and immersion shows that the participants who put more effort into the task, and who took the task seriously, were the participants who were most immersed, most interested in the game, and enjoyed themselves the most. Many of our participants reported that they were fatigued or of low condition prior to the user study.

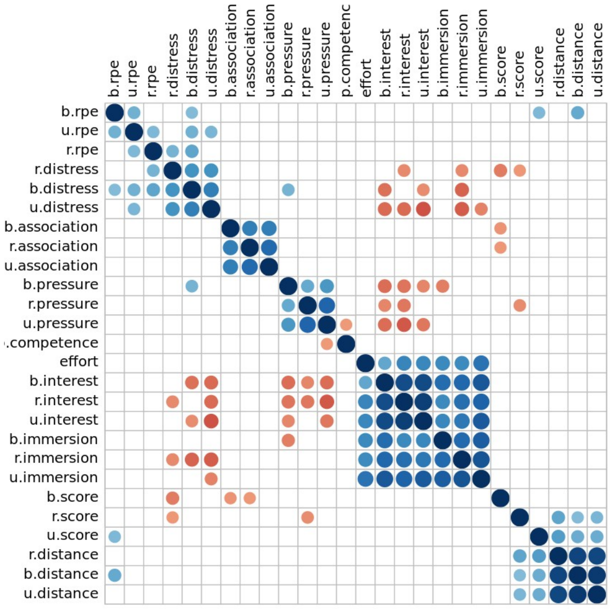

Figure 2: *Correlations between the experiential variables as well as score and distance, with significance values less than 0.05*

The effect was reflected in the strong negative correlation between *current.condition* and *effort*, $r(20) = -.47, p < .05$.

All three distress variables were significantly correlated. If a participant was distressed in one condition they would likely be distressed in all three. *b.distress* with *r.distress* ($r(20) = .59, p < .01$), *b.distress* with *u.distress* ($r(20) = .68, p < .001$), and *r.distress* with *u.distress* ($r(20) = .59, p < .01$). The higher correlation between the barren and urban conditions possibly shows that the rural condition was slightly less distressing. There appears to be a positive correlation between all of the distress variables and the RPE (rate of perceived exertion) variables for the related condition. This makes sense, as the distress questions related to things such as physical fatigue, and participants having more difficulty with the physical activity would likely perceive their exertion higher. That distress in the barren condition is correlated with RPE in all three conditions, *b.distress* with *b.rpe* ($r(20) = .44, p < .05$), *b.distress* with *u.rpe* ($r(20) = .53, p < .05$), and *b.distress* with *u.rpe* ($r(20) = .48, p < .05$) is odd, suggesting that participants most aware of their exertion were particularly distressed in the barren condition. It may have been that with little to look at in the environment they found it more distressing. Prior studies [BVRL96, LWE09] have shown a relationship between dissociation and a lowered RPE. This could potentially show itself as a negative correlation between RPE and association, as association and dissociation are inverse measures, but that does not appear in our results, nor is association significantly correlated with anything other than the other association variables. This may be an indicator that the measure of association was not appropriate for our purposes.

The negative correlations show the relationship between distress, pressure and tension on the one hand, and immersion, interest and enjoyment on the other. Similar to the positive correlation of RPE in the urban condition with RPE in the other two conditions, distress in the urban condition was negatively correlated with all three interest and enjoyment variables. If a participant felt distress in the urban condition, they would not be interested in or enjoy any version of the game, perhaps hinting at the urban environment being the least distressing. On the other hand, if a participant was distressed in the rural condition, they could still enjoy the other two. This potentially indicates that the rural environment was the most distressing, as a participant could be interested in and enjoy the other two game conditions with little distress, but find themselves distressed and not enjoying the rural condition. To add to that, immersion in the rural condition was significantly negatively correlated with distress in all three conditions. If a participant was able to be immersed in the rural condition, they would not feel distressed in any of the three; or if they could not be immersed by the rural environment, they would be distressed in all versions of the game. Pressure and tension for the most part was significantly negatively correlated with interest and enjoyment. If a participant felt under pressure and tense in any of the game conditions, they would not enjoy that condition or any of the others. Likewise, if they did not enjoy and were not interested in any particular condition, they would feel under pressure and tense in all three conditions.

There were also significant correlations between association, distress and score. Firstly, the variable for score in the barren condition (*b.score*) is negatively correlated with association in the same condition, with $r(20) = -.44, p < .05$. This shows that a participant who was dissociating, as an inverse of association, was able to achieve a higher score. Perhaps with less cognitive load from a richer environment they were able to concentrate more on scoring points, possibly showing that the rural and urban environments were acting as a distraction from the effects of exercise. Interestingly, a higher score in the barren condition was also negatively correlated with both association and distress in the rural condition. A participant who was more distracted and more relaxed in the rural environment was able to score more points in the barren condition, again, perhaps because this condition was less distracting. Though the score variable for the rural condition (*r.score*) was also negatively correlated with distress in the rural condition (*r.distress*), with $r(20) = -.44, p < .05$. In this case, a participant who was less distressed, or more relaxed, was able to achieve more points.

5.3. Limitations

One of the big limitations of the study was the questionnaires used. They were not intended for exergaming. The AFQ is a traditional measure of attentional focus, concentrating on participants performing exercise. While our exergame certainly has an exercise component, the model of association and dissociation does not entirely fit. As the game includes gameplay features, there is a second level of attentional focus at play, and with virtual reality there is a third. The traditional survey is only one dimensional, while we required a three dimensional investigation. The immersion questionnaire, while perhaps more suited, was not designed for a virtual reality game or an exergame, and it was not sensitive enough to measure the subtle differences that may have been present in the different environments. All of the game conditions were very immersive, including the barren environment, which was used as the control condition.

Some form of competitiveness measure would be useful, as competitive drive has an effect on the way in which a user plays the game. Some players were very focused on achieving a high score, others attempted to avoid every obstacle, while others still were happy just taking in the experience. A competitive sports questionnaire has been used in the past but it was found to be too specific to sports. We require a more general questionnaire, as well as a measure for competitiveness in games.

There were also some potential issues with the length of the questionnaires used, particularly in having three questionnaires follow each game condition, and repeating three times. Participants may have ended up clicking through to get to the end of the experiment quicker.

There may have been a bias introduced by displaying a high score at the end of the game. It is the last thing that a participant would see when completing an experimental condition, and many made comments regarding score when beginning a subsequent condition. While the motivation gained by attempting to achieve a high score is certainly a benefit of our exergame over exercise alone, this desire may have nullified much of the measurable effects of the different visual environments.

6. Conclusions

Our research shows that our exergame is very immersive for users, though with no significant difference between the environments. This suggests that immersion is due from the core elements of gameplay and not the visual richness and complexity of the environment. The barren environment, with almost nothing to look at, was just as immersive as the rural and urban environments. Additionally, there is a strong connection between immersion in the game and users' interest and enjoyment.

A possible explanation for the lack of effect of the virtual environment on immersion, is the research by Taylor, who discerns two types of immersion: diegetic immersion, caused by the act of playing the game, and intra diegetic or situated immersion, which means immersion "in the created virtual space of the game situated through both a character's perspective and an embodied point-of-view" [Tay02]. Since exercises are a physical strenuous activity it seems possible that players are predominantly immersed in the act of playing (and exercising). A different, but closely related, explanation is offered by Diemer et al., who suggest that a major factor of "presence" is arousal [DAP*15], which is increased by intense physical activity [GMH*15].

Our results suggest that exergame developers should focus their attention on designing games that have more interesting and more enjoyable elements of gameplay in order to increase immersion, rather than putting their efforts into the visual environment. Our findings also indicate that distress has a negative effect on users interest, enjoyment, and immersion. While most of the distress is likely to be caused by the exercise, effort should be put into designing games that do not cause any additional distress. It could be that a game with cannon balls hurtling towards the player while they have to avoid sandpits was too overwhelming for some participants. Games that could adapt to the specific needs of an individual might be more effective.

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