Exploring Spatial Experiences of Children and Young Adolescents While Playing the Dual Flow-based Fitness Game "Plunder Planet"

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Keywords: Exergame Fitness Training, Dual Flow, Spatial Experience, Exergame Spaces, Children.

Abstract: With the trend towards movement-based exergames and the gamification of sport, new body-centered controller technologies have moved into the living rooms and the gyms. The highly complex, multi-modal and multi-sensory interactions with these systems create new ways of perception and interaction, the exploration and experience of which completely captivate the users. Based on related work we analyzed interactions and interdependencies between these new perceptual and interactive spaces at the levels of "body space", "controller space" and "in-game space". This extensive theoretical framework is then used to illustrate possible applications of these theories, using the example of our fitness game environment "Plunder Planet" for children and young adolescents. Subsequently, we present a user study specifically focusing on the qualitative analysis of space-related gameplay experiences and play strategies of users playing "Plunder Planet". We introduce and analyze sketches drawn by children and young adolescents after playing the psychophysiologically adaptive exergame with two different controller devices. The additional qualitative evaluation showed positive effects of all three design categories (body, controller and in-game scenario) on the player's space-related gameplay experiences. Finally, we identify possible departure points for future research-based developments of holistic, user-centered exergame settings which have maximum attractiveness and effectiveness for the player.

1 INTRODUCTION

Movement based games, targeted gamification of fitness training, and fully equipped game gyms are today more popular than ever. In incorporating the whole body into the gameplay, and by controlling the game through special full-body motion controllers, these applications present not only an effective alternative to traditional training, but also offer the player holistic flowing, immersive experiences. These new, multi-modal and multi-sensory interactions offer the player unknown perceptive and interactive spaces, which in their turn offer a point of departure for innovative and holistic exergame developments. In order to fully exploit this potential, these arising exergame spaces need to be explored and analyzed both as single dimensions as well as a construct of mutually interdependent and influencing dimensions on the levels of "body", "controller" and "in-game scenario".

Currently, various studies provide insights into the effects of specific body movements (e.g. Pasch et al. 2009), controller technologies (e.g. Shafer, Carbonara and Popova, 2014) as well as game mechanics and other aspects of design (e.g. Cardona et al., 2016) on the player's gameplay experience (e.g. flow, immersion or engagement), and propose specific frameworks (e.g. Martin and Wiemeyer, 2012) or design guidelines (e.g. Mueller et al. 2011). However, these approaches rather focus on single or dual dimensions than on the combination and interplay of all three exergame space dimensions. Consequently, insights from these studies remain limited although they hold important indicators for designers of future exergame developments.

Furthermore, mainly quantitative research methods were applied for the evaluation of exergame spaces. Regarding the target group of children and young adolescents in particular, qualitative methods hold additional benefits and could provide extremely informative insights, which might be missed with the exclusive application of quantitative methods. Children and young adolescents often struggle to explain their feelings and experiences with words. Thus, qualitative methods like drawings should be applied more often in order to obtain a more comprehensive evaluation.

Finally, the majority of existing exergame studies

Martin-Niedecken A.
Exploring Spatial Experiences of Children and Young Adolescents While Playing the Dual Flow-based Fitness Game âĂIJPlunder PlanetâĂİ.
DOI: 10.5220/0006587702180229
In *Proceedings of the International Conference on Computer-Human Interaction Research and Applications (CHIRA 2017)*, pages 218-229
ISBN: 978-989-758-267-7

is conducted using commercially available exergames (e.g. Wii® Fit or Dance Central) and input devices (e.g. Nintendo Wii® or Microsoft Kinect®), which are neither user-centered nor research-based designed, or may be developed based on single theories and dimensions only. Game designers should exploit the full potential of all dimensions in the research-based development of exergame environments, including the design of synchronized virtual game scenarios and full-body-motion controllers as well as the specification of associated body movements. Thus, they target the most attractive and effective gameplay experience for the player and simultaneously allow researchers to investigate promising aspects and effects of game-based perception processes, usability and human computer interaction in the fields of physical activity and health.

In order to approach the topics mentioned above and to bridge the existing gaps, we conducted both, theoretical and applied research and development work, which will be presented in this paper.

We begin the paper by giving an outline of existing frameworks and findings from related work and studies. We introduce space-related gameplay experience concepts and theories, which are specified and discussed in the context of exergaming. As a next step, and in order to determine a theoretical design and evaluation framework for our research and development work, we assign the existing approaches to the categories of "body space", "controller space" and "in-game space".

Based on this theoretical foundation, we then present our research-based designed, dual flow-based fitness game environment "Plunder Planet" for children and young adolescents, which was developed in an user-centered and iterative design process. We show how we translated and implemented the existing interdiciplinary know-how into the design of an attractive and effective exergame setting.

Finally, we present relevant and inspriring extracts from a user study, mainly focusing on the introduction of children's drawings as an additional explorative method for the qualitative evaluation of spatial and gameplay experiences of children and young adolescets after playing "Plunder Planet" with two different controller devices. The sketches were analyzed following the approach of a qualitative analysis (similar to Mayring's (2010) qualitative content analysis) employing the main categories of our theoretical framework, which is established on the dimensions of "body space", "controller space" and "in-game space".

To conclude, we identify potential points of departure for future exergame environments and provide an outlook on promising future R&D work.

2 RELATED WORK & THEORETICAL FRAMEWORK

2.1 Gameplay Experiences

There are now numerous concepts that concern themselves with the analysis of many different dimensions of user experience in digital gameplay. The most commonly identified are immersion, fun, presence, involvement, engagement, and flow (Brown and Crains, 2004; Ijsselsteijn et al., 2007; Nakatsu, Rautberg and Vorderer, 2005; Sweetser and Wyeth, 2005). The majority of these, however, cannot be understood as single, independent dimensions, but only in combination and interrelation with each other. One generally speaks of a multi-dimensional user experience in gameplay, as well as of so-called gameplay experiences (Takatalo, Häkkinen and Nyman, 2015).

In general, gameplay experiences can be described as a kind of hallmark of the quality of a game. If a game succeeds in eliciting particular experiences for the player, it will leave a lasting impression. Game experiences that are repeatedly brought up in relation to body-centered innovation in exergames and controller-technologies are the closely related, and spatial-concept based experiences of immersion and presence, as well as flow experiences.

2.1.1 Immersion and Presence

Ermi and Mäyrä (2005) identify three equal types of immersion:

- Sensory immersion – refers to the multi-sensory properties (e.g. game mechanics, audiovisual representation, etc.) of a game.
- Challenge-based immersion – refers to the immersion in the cognitive and motoric aspect that results from a challenge-skill balance (flow) while playing a game.
- Imaginative immersion – refers to the immersion within the imaginary world created through the game.

Brown and Cairns (2004) introduce a concept of graded immersion and define three levels of immersion that build upon each other: Engagement, Engrossment and Total Immersion (Brown and Crains, 2004). Whether, and if yes, how a player can dive into the lowest immersion level – “engagement” – depends on fundamental, individual preferences, game control and the willingness to invest time, effort and attention during gameplay, as well as on the feedback from the game. If players have the feeling that they understand the controlling mechanisms, and like the game genre, they rapidly attain the level of “engagement”. Conversely, any antipathy to any of the components mentioned makes it difficult to experience “engagement”.

Access to the next highest state of “engrossment” depends greatly on the game structure and construction. If this is found wanting, for example, in the area of game tasks or audiovisual representation, the player will not attain “engrossment”. At this level the player is already emotionally involved in the game, which is what spurs them to continue playing.

The highest level, which can be equated with “presence experience”, is “total immersion”. In this state, players forget everything around them and are “cut off” from the real world. They find themselves in a world in which only the game matters. Barriers to experiencing total immersion include a lack of empathy with the avatar or insufficient game atmospherics.

According to Weibel and Wissmath, the immersion experience is directly related to flow and presence. While presence refers to the sensation of being physically located in the mediated world (Weibel and Wissmath, 2011) flow refers to the sensation of being involved in the gaming action at a high level of enjoyment and fulfillment (Csikszentmihalyi, 1990).

2.1.2 Flow Variations

Sweester and Wyeth (2005) take classic Flow Theory and apply it to games. In their “GameFlow Model”, they describe the core elements of “Enjoyment”: Concentration, Challenge, Player Skills, Control, Clear Goals, Feedback, Immersion and in the case of multiplayer games, Social Interaction.

In contrast to classical computer games, movement based games are played with the whole body. The body movements are tracked by a motion-based controller and mediated into the virtual game scenario. Exergames challenge the player holistically with regard to both coordination and to cognition.

In response to the classic flow concept, Sinclair et al. (2007) have extended this concept to the components of the body, calling it “Dual Flow”. According to this concept, the optimal flow experience during exergame play requires a balance between the game-related challenge and player skills, and the intensity of the required movement input and the player’s fitness level. In the ideal exergame, the player is never physically or mentally over- or under-challenged. Only in this way can players attain their individualized, perfect training/game mode.

Concepts derived primarily from game research draw from the theoretical concepts described above and extend them into practical application for exergames, in the form of so-called “dynamic game balancing” mechanisms (DGB) or “dynamic game adjustment” mechanisms (DDA) (e.g. Altimira et al., 2016).

This makes it possible, for example, for players with different levels of skill to play an exergame with or against each other, still allowing each player to have a dual flow experience (e.g. Gerling et al. 2014). Balancing mechanisms range from different movement inputs (easier for less-skilled players vs. harder for better-skilled players), to the use of different controllers (e.g. one-button for less-skilled players vs. gesture-based devices for better-skilled players), all the way to different credit systems (e.g. more points for the less-skilled player vs. fewer points for the better skilled player for completion of the same challenges).

Other examples are directed towards the individual dual flow experience, even though these are transferable to multiplayer DGBs. This includes, in particular, psychophysiological measurements of the affective and effective state in game design (e.g. Cardona et al., 2016; Mueller et al., 2012). The focus is on the individual tailoring of game mechanics (e.g. game difficulty) to the sensitivities and/or the heart rate. In that context, sensor technologies which measure these psychophysio-logical states come into play in this setting, and are often directly coupled with the game or the game engine.

Game balancing can therefore occur on several levels in both single- and multiplayer modes: on the “real level” in the area of the game controller and the body movements, and on the “virtual level” via game scenario, game mechanics and audiovisual representation.

2.2 Exergame Spaces

A consideration of all of these exergaming theories and concepts gives a new significance to the notions of space and spatial perception in this highly complex, multi-sensoric and multi-modal interaction of the player on the various levels of an exergame (body, controller, game scenario).

Nitsche (2008), for example, speaks, in relation to the interaction with classical computer games, of an interplay of five spaces:

- "Rule-based space" as defined by the mathematical rules that determine e.g. physics, sound, AI, and game-level architecture.
- "Mediated space" as defined by the presentation, which is the space of the imagery and the use of this image including the cinematic form of presentation.
- "Fictional space" that lives in the imagination, in other words, the space "imagined" by players from their comprehension of available images.
- "Play space", meaning space of the play, which includes the player and the video game hardware.
- "Social space" as defined by interaction with others, meaning the game space of other players affected (e.g. in a multiplayer game).

If this spatial model is transferred to body-centered exergames, two crucial components are found to be missing, especially on the level of "play space". In contrast to classical PC games, exergame play incorporates the whole body in a sportive manner. The body in turn interacts through movements, which is made possible by special body-centered controller technologies.

2.2.1 "Body Space"

An indication of the degree of complexity created by the extension of the game system through the use of the body can be found in the model of the "Four Lenses of Exertion Interaction" (Mueller et al., 2011). Mueller et al. (2011) suggested looking at the moving and interacting body from a four-lenses perspective. They identified the "responding body", the "moving body", the "sensing body" and the "relating body", working from the inside of the body to the outside:

- The "responding body" describes how the body responds to physical activity and sport, both immediately after the exercise and after some time has elapsed. Short-term effects of physical activity include sweating and increased heart rate, whereas in the long term such effects as increased lung volume and a better trained cardiovascular system can be the result of physical activity. As previously described, these effects are also used to dynamically adapt an exergame to the individual sensitivities of the player.
- The "moving body" describes the movement of the body and individual body parts in space/time relation to each other. The "moving body" also comprises an individual's natural awareness of the location in space of the body parts during a particular movement. This is particularly important in the context of the often complex movement inputs with special exergame controllers.
- The "sensing body" describes how the body reacts to and experiences the world. In the area of sport, this includes sporting equipment. At the same time, it incorporates the external environment (spectators etc.). If this concept is transferred to exergames, the world to be experienced doubles: the player experiences both the real and the virtual world and interacts with them through the special controller devices.
- The "relating body" deals with the player's own body in relation to other bodies, in physical interactions that lead to other kinds of interaction, such as social interaction. This concept of body is relevant in multiplayer exergames, for example.

Numerous game research studies have explored further the fundamental meaning and effect of the body as the central element of an exergame. In general, the inclusion of holistic physical activity into the gameplay is found to be a positive predictor for the feeling of immersion and engagement (Pasch et al., 2009), and to be an important variable in the emotional experience of games (Vara et al., 2016).

Bianchi-Berthouze (2013) investigated how body-movement can be exploited to modulate the quality of the playing experience and identified five classes of movement:

- Task-control movements: These movements are defined by the game controller. They are necessary to play the game and to score points.
- Task-facilitating movements: These movements are not defined by the game controller (the controller does not react to them).
- Role-related movements: These movements are typical of the role adopted by the player in the game scenario.
- Affective expression: This class of gestures expresses the player's affective state during game play. They are spontaneously expressed or acted and generally not recognized by the current game interface. They are a window to the player's experience.

- Expression of social behavior: Expressions of social behavior are expressions that facilitate and support interaction between players. They are spontaneously expressed and are not recognized by the controller.

The choice of movement strategy depends on personal skills and on the motivation of the player while playing the game. Pasch et al. (2009) distinguished between the motivation "to achieve" (to win the game) and "to relax" (to enjoy the game). If the players' motivation is "to achieve" they will challenge themselves ("hard fun") and optimize their strategy to gain as many points as possible (e.g. by using the minimum movements required). If the players' motivation is "to relax", they will look for mental relaxation ("easy fun") and tend to recreate movements from the actual sport.

2.2.2 "Controller Space"

Beside the body movement strategies ("playing styles") and the player's motivation while playing a game, the type of controller interface has a great influence on the player's gameplay experiences.

During exergame play, the intermediary controller technology ideally assumes the role of mediator between the "real" and the "virtual" game worlds (Martin and Wiemeyer, 2012). However, the decisive factor is always how well an input device integrates itself into the body patterns of the moving player. Kim et al. found that an embodied interface improves user experience, energy expenditure, and intention to repeat the experience within the exergame (Kim et al., 2014).

The precision of movement recognition (Nijhar, Bianchi-Berthouze and Boguslawski, 2011), as well as the natural integration of this recognition into the game scenario and the related movement feedback are decisive indicators for the "incorporation" of the game controller, and for the immersion into the game world (Pasch et al., 2009).

If, for example, a controller vibrates unexpectedly, or reacts to the player's movement inputs only sporadically or with delays, the controller will interrupt the flow developed up until that point, or make it impossible for a flow to develop at all. The controller will then not be understood as a part, or an extension of the integral game movement apparatus.

If, on the other hand, a controller supports the spatial orientation of the player in their immediate sphere of movement through well-balanced design, and in doing so enables the most natural body movements appropriate to the game scenario, then a symbiosis results between the controller and the player's body (e.g. Shafer, Carbonara and Popova, 2014). Beside the natural feeling of control, Pasch et al. identified that a "mimicry of movements" (if the exergame-controller provides an accurate mapping of the player's movements and the representation on the screen) positively influences immersion in movement-based interaction (Pasch et al., 2009).

As exergames stimulate physical activity, it is extremely important that, in addition to the simplest possible integration of the controller into the player's body patterns, elements are included that result in high activity. Taking Nintendo Wii-tennis as an example, it is immediately apparent how easily the Wii remote control can be tricked if a player wants to hit a backhand: a simple flick of the wrist is all that is required to hit a virtual clean shot.

Concepts from the so-called exergame fitness training sector try to counter this. In this field, training equipment is often retooled into game controllers and extended with game scenarios (e.g. the Exerbike by Motion Fitness), but completely new exergame fitness game environments have also been created. This includes not only the development of new games, but also of matching full-body motion controllers (e.g. the Makoto Arena by MakotoNow).

2.2.3 "In-Game Space"

At the level of "in-game spaces", design aspects in particular direct the (spatial) perceptions and gameplay experiences of the player and should be embedded as convincingly as possible within the complete system of the exergame. At the audiovisual-, spatial-, game mechanics- and narrative levels, the game designer therefore should create an experience which is as multi-sensory as possible for the player.

Perceptual psychology, in particular, provides designers with a range of spatial concepts and principles as anchors or points of departure for their work. These include Gestalt theory and Gestalt principles (e.g. Wertheimer, 1985), ecological perception theory (Gibson, 1978), and information processing theory (e.g. Shiffrin and Schneider, 1977).

With regard to immersion, presence and flow, various game research studies have investigated the impact of creative elements of games on the spatial experiences of the player. For example, in a first-person perspective, the player virtually turns into the game character as he/she feels like he/she is acting directly in the virtual game world. In addition to the first-person perspective, the consequence and meaning of player action within the environment and its impact on gameplay greatly add to the feeling of immersion (McMahan, 2003). Simultaneously, seeing the avatar from a third-person perspective positively influences the player's identification and emotional attachments towards his/her virtual image (Blinka, 2008).

Furthermore, games provide so-called narrative spaces (Jenkins, 2004). Narrative spaces allow players to interact with each other, other characters, the environment, and aspects of the game. These narrative spaces are mapped throughout an environment, and the narrative is constructed by the relationships between space and events Dickey, 2005).

3 "PLUNDER PLANET"

Based upon the variety of concepts and theories related to "body space", "controller space" and "in game space", we created "Plunder Planet" (Martin-Niedecken and Götz, 2016), a dual flow-based, psychophysiologically adaptive fitness game environment for children and young adolescents (Figure 1, 2 and 3).

Below, we describe all components of the exergame, which were developed within an iterative and user-centered design process with a specific focus on the previously introduced theoretical framework of "body space", "controller space" and "in-game space".

Figure 1: In-game screenshot of "Plunder Planet".

3.1 Dual Flow-based Design

During gameplay, the player wears a Polar H7 sensor, with which his or her heart rate is measured and forwarded to the game engine using a specially developed app. In addition, the in-game performance allows inferences about the emotional state of the player.

"Plunder Planet" is based on adaptive game mechanics. Depending on the psychophysiological state of the player during a "Plunder Planet" workout, a Trainer-GUI can be used to gradually adjust the difficulty and complexity of the game. This ensures that the player is optimally challenged at all times, and finds him- or herself in the dual flow-mode.

3.2 Plunder Planet: Controller

Beside the development of an adaptive game scenario, we focused in particular on the exploratory development of a specific Full-Body-Motion Controller (FBMC). This was intended to further support the dual flow and immersion experience of the player, and also to enable cognitive and coordination training. To achieve this, we experimented with a variety of input variants and put these through repeated user tests.

"Plunder Planet" can currently be played with two controller variants (Figure 2): the specially developed FBMC challenges the player's cognitive and coordinative skills, and offers haptic feedback through the use of buttons. The gesture-based Kinect® sensor allows more freedom of movement and in principle allows more natural or intuitive movements.

With regard to design, in both the development of the FBMC and of the game concept, an effort was made to cover all the categories mentioned in the literature that were found to lead to positive gameplay experiences, and especially to immersion, presence and (dual) flow.

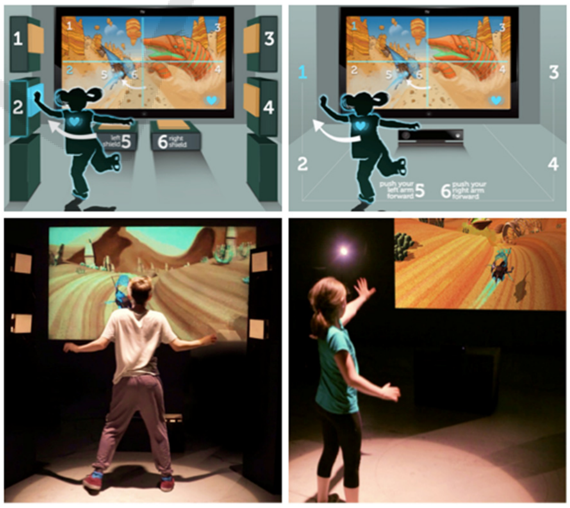

Figure 2: "Plunder Planet" FBMC- and Kinect-setting.

3.3 Plunder Planet: Narrative Frame

The narrative of "Plunder Planet" draws the player into the world of a young pirate, searching for buried treasures on an abandoned desert planet, with his or her flying pirate ship. The decision to use this scenario resulted from several user tests, in which we included the target group in the design process of the game.

3.4 Plunder Planet: In-Game Design

As the perspective, we chose an immersive point-of-view, which allows the player's avatar – a flying pirate ship – a slightly raised third-person view of a desert planet from the air.

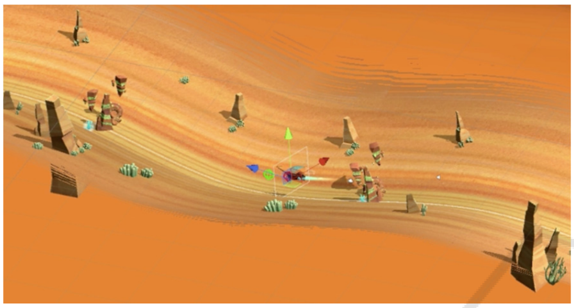

Figure 3: In-engine screenshot of the procedural generated race course.

We generated additional immersive moments using dynamic elements, such as sand blowing around the ship when it touches the ground, a change of direction of the ship's flag waving when the wind changes, ruts leading towards a bright horizon, as well as a procedural generated race course (Figure 3). These visual elements and moments are intensified by the strategic use of sound.

3.5 Plunder Planet: Body Movements

We also took care to ensure that the input movements fit each scenario presented (so that they feel as natural as possible), both with the use of the FBMC and the Kinect®, and that these movements are comparable despite the differences in the controls of the two devices.

The FBMC is controlled by pushing six buttons in the direct vicinity of the player's body and/or exercise space. The buttons are located at three heights (high, middle and low) to the left and right of the player. The player has to jump quite dynamically between the buttons in order to press these at the right moments. The height and distance of the buttons can be adjusted to the size of the player. In order to avoid virtual obstacles, the player must hit the middle and upper buttons on the right or the left, while the two lower buttons (one on each side) serve to activate force fields to protect the player from giant sandworms.

The Kinect® sensor is also steered through six movements on three levels. To avoid obstacles, the player must either jump or duck to the left or the right as the situation requires. The force fields are activated by extending the left or the right arm to the front.

4 EXPLORATIVE USER STUDY

In order to validate the adaptive exergame design of "Plunder Planet", we conducted a feasibility study (Martin-Niedecken and Götz, 2016). So far, we have only reported preliminary, quantitative results (see section 4.2). Based on these findings and our theoretical framework, we collected further qualitative data in the form of drawings within the same setting, which has not been evaluated and interpreted yet.

Since our R&D work targets children and young adolescents, we hypothesized that these sketches would provide us with additional insights into the spatial effects and gameplay experiences of "Plunder Planet" on players, and thus give us potential points of departure for future exergame developments.

4.1 Participants and Procedure

We recruited 16 children and young adolescents (13 males and 3 females) with and without experience with playing games (8 GX and 8 nGX), and with or without athletic or sport experience (8 A and 8 nA). The age of the participants ranged from 10 to 14 years (M = 12.1 years; SD = 1.29). Participants were divided into four equal groups (GX/A; nGX/A; GX/nA; nGX/nA). To balance sequence effects, eight participants started the exergame session with the FBMC, while eight participants started using the Kinect® sensor. Each exergame setup was played twice, every session took 10 minutes.

Before starting the sessions, participants were briefly introduced to "Plunder Planet" and asked questions about their personal preferences in gaming and sports. After two completed runs with one controller, participants were asked to fill in two questionnaires; the "KidsGEQ" (Poels, Ijsselsteijn and de Kort 2008) for their gameplay experiences, and the "SPES" (Hartmann et al., 2015), concerning their spatial presence experience. Additionally, participants were asked to answer questions about dual flow, enjoyment and motivation.

4.2 Preliminary Quantitative Results

So far, the feasibility study (Martin-Niedecken and Götz, 2016) has helped us to quantitatively examine and confirm the design of Plunder Planet. We compared the effects of both controller variants on the extent of gameplay experiences and the spatial presence experience, which, as can be seen from the literature, can both influence (dual) flow.

In summary, we found that participants with former game experience (GX/A and GX/nA) generally felt more spatially present in the game while playing "Plunder Planet". If they had additional athletic experience (GX/A and nGX/A), they also reported a slightly better feeling of spatial presence when playing with the Kinect®. Participants with former game experience (GX/A and GX/nA) tended to rank most items of the KidsGEQ better than participants without previous game experience. All subjects reported better feelings of immersion and competence playing with the FBMC. Flow was ranked slightly better with the Kinect®. All participants who experienced a great feeling of flow and immersion also reported a greater feeling of spatial presence. A narrow majority of subjects experienced a better dual flow and enjoyment with the FBMC while motivation was higher playing with the Kinect.

Generally, all components of "Plunder Planet" (the virtual adaptive game scenario, both controller versions and the related body movements) were valued very positively.

4.3 Qualitative Data Collection

In addition to the questionnaires on the player's game and spatial presence experience, we asked participants to sketch their most memorable perspectives from the "Plunder Planet" gameplay with the FBMC and with the Kinect®. All test subjects played both controller versions, and created a simple illustration for each experience immediately after each game session and before filling in the questionnaires.

The approach of using children's drawings for qualitative evaluation and for gaining additional insights into their world of feelings has been used successfully in various social research studies (e.g. Scheid, 2013). Drawings enable children to express more than they could say with words.

4.4 Qualitative Results

The sketches were analyzed following the approach of a qualitative analysis (similar to Mayring's (2010) qualitative content analysis) according to the three categories of our theoretical framework: "body space", "controller space" and "in-game space". The sketches were analyzed independently by two researchers (1 male and 1 female) with the aid of the specifically developed system of categories described above. The individual surveys were compared and in case of a deviation they were discussed to reach a common consensus. We were especially interested in the degree of immersion and spatial presence experience as a result of the use of the two controller variants, and how, and towards what, the players oriented themselves and their relating moving bodies during play.

4.4.1 Most Memorable Spatial Perspective

In total, four players in the FBMC version felt themselves wholly absorbed by the game scenario – that is, in the "in-game space" – (Figure 4a) while only one player felt the same in the Kinect® version (Figure 4b). By "wholly absorbed" we mean that the player takes the first-person perspective and looks through the eyes of the avatar. According to Brown and Crains (2004), this can be described as "total immersion". The majority of these players had previous gaming experience.

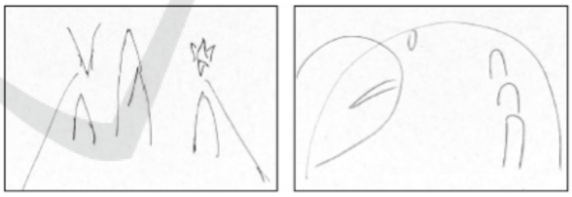

Figure 4a (left), 4b (right): Exemplary FBMC- and Kinect-sketches.

Seven test subjects in the FBMC version (Figure 5a), and eight in the Kinect® version (Figure 5b) sketched their most memorable perspectives from the real exercise space – that is, in the "body-controller space". This is comparable with Brown and Crains' "engagement level" and describes a very external point of view on the exergame setting. The majority of these subjects had previous gaming experience (GX/A and GX/nA).

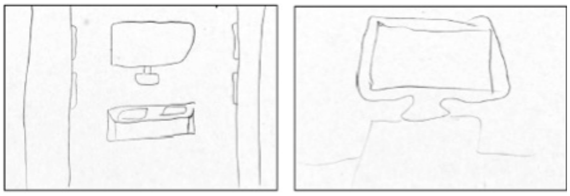

Figure 5a (left), 5b (right): Exemplary FBMC- and Kinect-sketches.

Five FBMC- (Figure 6a), and seven Kinect®-players (Figure 6b) sketched their most memorable perspectives as a mixture of in-game, body and controller space.

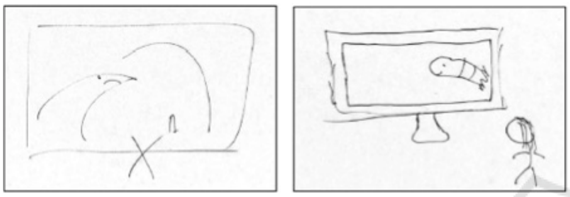

Figure 6a (left), 6b (right): Exemplary FBMC- and Kinect-sketches.

Participants drew their own body or position of their body as well as elements and sequences from inside the game (e.g. sandworms). At the same time, they clearly differentiated between the real or physical space and the virtual in-game space. This experience is equivalent to the intermediary level between "engagement" and "total immersion", i.e. "engrossment". The test subjects had all either sport or gaming experience (GX/A, GX/nA and nGX/A).

In summary, it appears that all players felt "engaged", the majority even "engrossed" or "totally immersed". With regard to "engagement" and "engrossment" the assessments of both controller variants were largely balanced and positive.

These results correspond to the results from the analysis of the quantitative data. These also showed largely positive results for both controllers with respect to spatial experiences. On average, test subjects with gaming experience (GX/A and GX/nA) judged the FBMC to be slightly better than the Kinect®, while those with athletic experience (GX/A and nGx/A) found the Kinect® slightly more immersive.

The only somewhat surprising result was that of "total immersion" or "presence". Here, many more test subjects in the FBMC version were found to be in the "in-game space" than in the Kinect® version. The qualitative data would have suggested the opposite tendency.

4.4.2 Spatial Orientation Strategies: Body, Controller & In-Game Elements

We deepened our qualitative analysis of the 32 sketches by looking at the marked location of the body, the controller and in-game elements, in order to make some inferences about possible orientation strategies of individual player/sports types.

Body. Four FBMC players (Figure 7a) and five Kinect® players (Figure 7b) sketched their own bodies in the real exercise space.

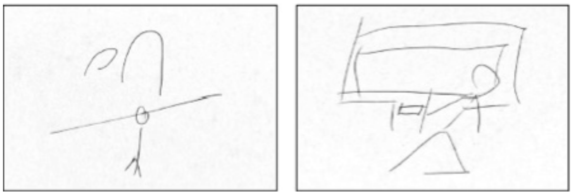

Figure 7a (left), 7b (right): Exemplary FBMC- and Kinect-sketches.

Four test subjects in the Kinect® version sketched the virtual image of their own body, which was only visible during the movement tutorial at the very beginning of the game session and in the intermediate tutorials (Figure 8a), whereas none of the subjects in the FBMC version considered this a memorable orientation point. In the Kinect® version (Figure 8b) one test subject drew a mixture of the representations of his/her body in virtual space and his/her body in the real exercise space. Thus, according to the sketches, the Kinect® version tends to provide the more body-centered experience while playing "Plunder Planet".

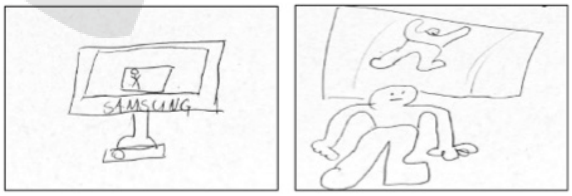

Figure 8a (left), 8b (right): Exemplary FBMC- and Kinect-sketches.

Controller. Nine participants sketched the controller in the real exercise space in the FBMC (Figure 9a), and six participants in the Kinect® version (Figure 9b). Consequently, the FBMC seems to provide more spatial and bodily guidance compared to the Kinect®. This result is confirmed by the quantitative findings.

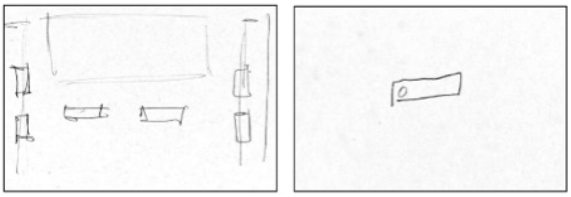

Figure 9a (left), 9b (right): Exemplary FBMC- and Kinect-sketches.

In addition, two test subjects in the FBMC version (Figure 10a) and three in the Kinect® version (Figure 10b) produced illustrations of not just real but also virtual steering information.

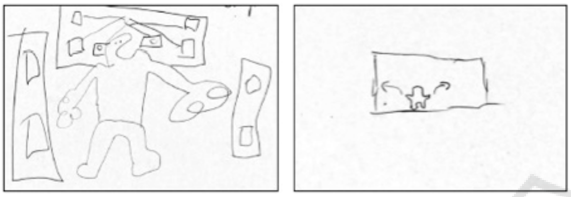

Figure 10a (left), 10b (right): Exemplary FBMC- and Kinect-sketches.

In-game Elements. Nine subjects sketched in-game elements like obstacles and sandworms or steering information in the FBMC version (Figure 11a), while the majority of seven participants in the Kinect® version drew the virtual image of their own body which was only visible during the tutorial sequences (Figure 11b). Thus, the FBMC seems to allow for a better involvement of the player into the narrative space of "Plun-der Planet", whereas the Kinect® version tends to facilitate the bodily focus.

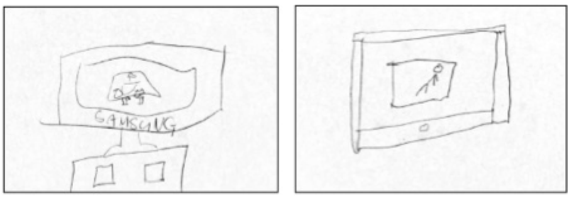

Figure 11a (left), 11b (right): Exemplary FBMC- and Kinect-sketches.

Generally, it is striking that the majority of test subjects with gaming experience tended to spatially orient themselves with elements in virtual space and using the controller, while those with sporting experience tended towards orienting themselves using their own bodies and the controller. This may be due to the subjects' specific experiences: athletes generally have well-developed body perception and, depending on the type of sport, are also used to the interaction between the body and some sporting equipment. Classical gamers on the other hand are more accustomed to orienting themselves to virtual objects and to interacting with the accompanying controller devices.

It is also interesting that despite the third-person perspective, none of the participants sketched the external view of the ship. This suggests that all players who felt themselves partially or wholly integrated into the "in-game space" identified strongly with the avatar, and therefore apparently assumed a first-person perspective. This thesis is supported by the sketching of in-game obstacles and sandworms from the first-person perspective as well as statements of the participants regarding their experience of being in the driver's cab of the pirate ship.

5 DISCUSSION

The additional qualitative evaluation of "Plunder Planet" showed positive effects of all three design parameters ("body space", "controller space" and "in-game space") on the player's space-related gameplay experiences (especially on the three levels of immersion). All design levels targeted specific experiences and play strategies among the players depending on their previous experience in gaming and sports. Specific design elements like the sandworms and the obstacles were very appealing to players with previous gaming experience while athletic players additionally strongly focused on their body and body movements. In terms of future work, this provides interesting departure points for specific exergame developments for different player/sport types. To deepen the holistic design approach it would be revealing to evaluate the three design levels in more detail (e.g. by experimenting with different body movements triggering the same in-game task).

Furthermore, applying the qualitative method within further user studies (with larger samples), in combination with further qualitative methods (e.g. guideline-based interviews and participatory observation) and in closer relation to the analysis of the quantitative data will help to fix and solidify it as evaluation tool.

6 CONCLUSION AND OUTLOOK

The explorative analysis of the sketches, against both the theoretical approaches laid out in the first part of this paper, and the scientifically based development of “Plunder Planet”, allows additional, and confirmatory insights into the (space-)perceptual processes and levels in the gameplay of “Plunder Planet”. The lessons learnt should be deepened and developed further in future, and can contribute significantly to the next stages of research and development.

Figure 12: The new FBMC-setup allows for individual adjustments of height, distance and position of the but-tons.

Based on the results of all the partial examinations, the three relevant areas “body space”, “controller space” and “in-game space” should in future be further experimented with using various, holistic design approaches and concepts. We are particularly interested in the application and exploration of targeted DGB mechanisms on all three levels, and their impact on the (space-) perceptual processes and experiences of players.
In the meantime, our FBMC-prototype has been successfully developed further (Figure 12) and now offers multiple topics for further exploration in the area of spatial interaction and experience (e.g. (i) dynamical adjustment of the position of the buttons depending on the player’s heart rate and in-game performance or (ii) predetermination of body movements the player is allowed to perform in order to control the game, depending on the player’s skill level).

ACKNOWLEDGEMENTS

We thank Koboldgames GmbH for the excellent cooperation in the realization of the “Plunder Planet” game scenario. We also thank Roman Jurt for the expert further development of our FBMC as well as Prof. Ulrich Götz and René Bauer for their generous and expert support.

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