Play Therapy Utilizing the Sony EyeToy ®

Anthony Lewis Brooks[1] and Eva Petersson[2],
[1]Associate Professor, [2]Assistant Professor, Aalborg University Esbjerg, Denmark
{tonybrooks@cs.aaue.dk, eva.petersson@cs.aaue.dk}

Abstract

An international collaborative explorative pilot study is detailed between hospitals in Denmark and Sweden involving rehabilitation medical staff and children where the affordable, popular and commercially available Sony Playstation 2 EyeToy® is used to investigate our goal in enquiring to the potentials of games utilizing mirrored user embodiment in therapy. Results highlight the positive aspects of gameplay and the evaluand potential in the field. Conclusions suggest a continuum where presence state is a significant interim mode toward a higher order aesthetic resonance state that we claim inherent to our interpretation of play therapy.

Keywords--- **Flow, Therapy, Training, Play.**

1. Introduction

Our hypothesis is that game playing using embodied user interaction has evaluand potentials in therapy and thus significance in quality of life research for the special needs community. A state of presence is inherent where stimulation of fantasy and imagination involves engagement and subsequent interaction with a virtual environment (VE). Once this engagement is achieved and sustained we propose that a higher order state is achievable through empowered activity toward a zone of optimized motivation (ZOOM) [1]. This is possible by using an interface to the VE that is empowering without the need for any wearable technology that is deemed encumbering or limiting for the participant. The interface data – participant motion - is mapped to control immediate feedback content that has real world physical traits of response and is interesting, enjoyable, and fun for the participant so that experience and engagement is further enhanced.

Subjective presence has predominantly been investigated in respect of optimal user state in virtual environments and has been suggested as being increased when interaction techniques are employed that permit the user to engage in whole-body movement [2].

Our findings to date indicate at the motivational potential from an enhanced state of presence achieved from game environments where the body is used as the interactive unencumbered interface [3, 4, 5, 6, 7].

1. 1. Presence and Aesthetic Resonance: as a 'sense state' continuum

We are interested in observed behaviour aspects of presence where there is evidence of only a limited body of research.

Accordingly the case is made for a continuum beyond presence that satisfies our requirement of a play therapy scenario where, from within what is termed a state of aesthetic resonance, we enquire to the potential from game systems with mirrored user embodiment by using the EyeToy®. As a result of this initial pilot enquiry we intend to reach a point from where to launch a fuller investigation with a more optimized environment, method, and analysis design.

Aesthetic Resonance (AR) is when the response to intent is so immediate and aesthetically pleasing as to make one forget the physical movement (and often effort) involved in the conveying of the intention and is in line with [4, 8].

Within targeted aesthetic resonance our strategy is to approach the same immersive engagement that occurs between a child and a computer video game that is often subject to negativity and reverse the polarity of attitude so that it is positively used to empower activities beyond the usual limits of the special needs participant through encouraging an immersed 'play' mindset rather than a 'therapy' mindset which our prior research has shown as optimal [9].

Within this set up the same information that is used as control data to the interactive feedback content is available for simultaneously performance progress monitoring.

System tailoring as a result of observations of user performance – both physiological and psychological – is opportune with related testing that supplements traditional forms of performance measurement.

This in line with our earlier approach to interaction in virtual environments with acquired brain damage patients [4, 5, 9, 11] and is related to a study concerning brain neuroplasticity and associated locomotor recovery of stroke patients that reports on users interacting with games and perceiving the activity not as exercise or therapy, but as play [10].

1.2. Play

Most play research informs about its relationship to children's cognitive development, and focuses on solitary play [12]. However, this research does not account for the totality of what is going on between children in situations of *interactive* play therapy. Our play therapy approach is activity driven and the targeted aesthetic resonant state of the user we suggest is beyond the often used all encompassing term of presence.

Significantly, others have approached presence as an activity including video games [13] - but conducted in a laboratory which we question due to the situated effect of the environment on the participants. In previous studies [1] we state that activities always are situated, which underline a complex relationship between the individual, the activity, and the environment as mutually constitutive [14]. Thus a relationship to situated presence is implied as we base our enquiry at locales of predicted use with real users. The goal being exploratory is thus implemented in a pilot study so as to define problem areas to achieve preliminary data on potential of video games in therapy.

1.3. Under used resource for therapy

With the advancement in computer vision techniques and camera advancements we claim that systems such as the EyeToy® which focus on the body as the interface are an under resourced opportunity for therapists to include into training as unlike traditional biofeedback systems specific licensing is not required as there are no attachments to the patient. The system also achieves an essential aspect of children's engagement in virtual or real worlds as within our situated interactive therapy space they are 'placed' in the midst of the experience, as in a flow state [15].

We hypothesize that tools such as the EyeToy® have potentials to decrease the physical and cognitive load in a daily physical training regime, and this is central to our concept as the child experiences a proactive multimodal state of presence that encourages an unconscious 'pushing of their limits' that they otherwise would not approach outside of the interactive framework. This supports the statement of iterative human afferent efferent neural loop closure as a result of the motivational feedback and feed-forward interaction. This process is valuable for the child's physical demands in everyday life as the pushing intensifies the child's experience of movements in practice [18].

2. Gameplaying and mastery

The investigation presented in this paper addresses the promotion of motivational feedback within empowered gameplaying activities whilst attempting at understanding motivational mechanisms. This is by analyzing the gameplaying as an action where the child's increased skills in using the video game is viewed as a process of emerged mastery [19] of their 'doings' in a form relating to cycles of action-reaction-interaction. The material of the child's action within this study is the movement as the child masters the computer game by moving the body. In Laban's [18] terminology this is described as an 'effort' and he furthermore underlines the importance of offering the child opportunities to express him- or herself through non-human directed efforts in order to keep and increase the child's immediate spontaneity in the situation (e.g. reactive content that promotes subsequent interaction from the child).

For environments to be supportive in this sense, they must engage the child in challenging ways. Even though environments provide children a sense of challenge, they have to feel that their skills meet the challenges. If there is an imbalance between the challenges and the child's skills the child will become stressed or bored. Play and exploration encourage a sense of flow (immersion in enjoyable activities) that "provides a sense of discovery, a creative feeling of transporting the person into a new reality. It pushed the person to higher levels of performance, and led to previously undreamed-of states of consciousness" [15, p.74]. Optimal experience is also described as "a sense that one's skills are adequate to cope with the challenges at hand, in a goal-directed, rule-bound action system that provides clear clues as to how well one is performing" [15, p.71].

These activities are intrinsically rewarding and the enjoyment derives from the gameplaying activity in itself, which is related to the notion of the Zone of Proximal Development in learning situations [20]. In an explorative manner the child's cycle of movements can be shown to be fluent and intense or segmented without connection.

Laban [18] defines such changes in movements as important as they indicate whether there is a presence or absence of flow from one action and state of mind to another. As such the ZOOM [1] is important in its encouragement of the child's unintentional and/or intentional explorations, without immediate goals as in play, or curious discovery, and as a foundation of evoked interest [21]. This kind of interest indicates that the state of aesthetic resonance facilitates a foundation of creative achievements.

The motivational feedback loop described in this paper is also influenced by Leont'ev's [22] description of the formation of an internal plane. We have chosen to use the term of mastery to describe such processes where emphasis is on how the child's use of the game features leads to development of certain skills rather than on internalization [20], or more generalized abilities.

Thus, gameplaying actions do not need to be conscious, as at a certain level they can be unconscious skills, which, supported by playful aspects of the game, proactively push the child's limits towards new levels of movements.

As a preliminary investigation, we attempt to understand movements according to a semiotic interplay between the child's inner and outer world [23] and relate the understanding to presence, through which spontaneous movement engagement and intensity is assigned [18].

We compare this to Wenger's [24] and Vygotsky's [20] description of emergent development processes. Bigün, Petersson and Dahiya [25] characterize such processes as non-formal, where exploration and curiosity are central conditions, rather than traditional formal training conditions.

The movement cycle of the gameplaying child includes a construal of rhythm. The movement cycle is concentrated on the game's external achievement and by moving the body to achieve the external goal the child relates the inner world to the outer. However, it is not so that every movement unifies the inner and outer worlds, there has to be a "reciprocal stimulation of the inward and outward flow of movement, pervading and animating the whole of the body" [18, p.110] in order to enhance a sense of aesthetic resonance. In this way there is a range of flow through presence, from excitement to stillness, which increases and decreases the child's participation in the gameplaying activity.

This range embraces an orchestration of expanding bodily action in space, or, in terms of Laban [18], includes different trace forms of movements that demands continuity of gestures and it is these gestures that we analyse.

3. Method

In consequence with our interpretation of the referenced theories and to fulfil the goals of the investigation we used a triangulation of qualitative methodologies to qualitatively analyze the combined materials from the two hospitals:

- Video observations of children playing with the Keep Up EyeToy® game;
- Interviews with children and facilitators;
- Questionnaires to the facilitators involved;
- Diaries/field notes from the facilitators involved.

The subjects in the studies were 18 children (10 females and 8 males) between the ages of 5 and 12 years, mean age 7.66 years, in 20 gameplaying sessions. The children were selected by the hospitals and were well functioning. The control group was similar children from the hospitals not in sessions [5, 9, 11]. The facilitators involved at the hospital were two play therapists and three doctors.

3.1. Description of material

In 2003 Sony Computer Entertainment Inc. released the EyeToy® as a new video game series for its market leading PlayStation®2 (PS2) platform which is based upon using the player's body movements as the interface to the game.

This controller is unique in concept as all interactions to the game are through the video window rather than through the more common handheld gamepad or joystick device. The system is thus ideal for our enquiry.

The EyeToy® game chosen for this study was called 'Keep Up' due to its immediate action content, built in scoring, and cross gender qualities. A monitoring system based on multiple cameras supplemented so that post session analysis was available.

3.2. Description of procedure

EyeToy® games have 'tasks' for the participants to accomplish. The task within this game is to keep a virtual football - with animated real-world physical properties - 'up' within a virtual environment.

One game sequence is limited to three balls and three minutes.

After three balls, or alternatively three minutes, the game agent turns up and gives the player negative or positive feedback related to the scores of the game. The player can increase or decrease the scores by hitting monkeys and other animated characters with the ball as the game progresses.

At both hospitals the studied activities took place in rooms that also were used for other purposes, such as staff meetings and parent information. The children were not normally playing in this room and the system had to be set up around positional markers on floor and tables.

Parents were approached about the project, informed of the goals, and were asked to give their permission on behalf of their children beforehand.

Following the parents signing their permission the children were also asked to sign their permission to participate.

The process started with positioning the child in the calibration upper torso outline on the screen and after an introduction the game was started.

The gameplaying activity was observed and video recorded by the play therapists and doctors.

After the ending of the session the children were immediately asked follow up questions concerning their experiences of the gameplaying activity.

After the end of all sessions the play therapists and doctors were asked to fill in a questionnaire concerning their own experiences.

A final interview with the play therapists and doctors was also carried out to conclude the field materials.

3.3. Description of the set up

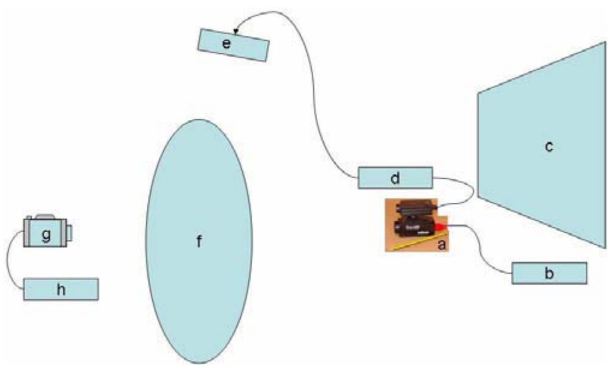

Figure 1 The set up

In previous research on camera capture as game interface [6, 10] standard TV monitors were apparently used. Our approach uses a LSD projector for large image projections approaching a 1:1 size ratio of the child (mirroring). This strategy is built upon our prior research investigations [1, 3, 4, 5, 8, 9, 11, 16] to optimize the experience. A related study is reported in the case of presence and screen size [17]. Traditional use of mirroring is used in therapy training at institutes for people with disabilities and thus our design is 'fit appropriate' to this context. Figure 1 (above) demonstrates the set up of the gameplay. The components included in the set up was: (a) EyeToy® camera plus front monitoring camera to capture face and body expression (b) VHS tape recorder (c) screen (d) PS2 (e) projector (f) the user space (g) rear camera to capture scene and screen (h) VHS tape recorder #2.

3.4. Description of analysis

The video recordings underwent numerous tempospatial analyses [26] where the units of analysis were the qualitatively different expressions of movement. The material attained from the sessions consisted of 36 x 1 (one) hour mini digital videos (rear and front views) – and corresponding additional backup VHS video tapes - of the 240 video games that were played by the children (n = 18) in 20 sessions at the two hospitals. Each video was digitized for the subsequent analysis; similarly, all video interviews, written notes, memos and written interviews were transcribed and transferred onto a computer workstation.

3.4.1. Manual analysis

Annotation was conducted by two coders. An initial series of four manual annotations of the video materials were conducted. These accounted for observed expressive gesture of the children (facial & body) (see Figure 2, and Appendix 4: Table 3).

Figure 2 Fully engrossed in the interaction with attention on content

In addition each video archive game and pause duration was time logged and the first, last, and best performance extracted for later analysis (example charts of three children in Appendix 1: Figure 3). Annotation of parameters of the games and pauses (*between*) before/after best and worst performance were also subject of closer analysis. An extra annotation was carried out on same child multiple sessions (n = 2) including *t* element task scores (ball 1, 2, 3).

The temporal specifics concerns rhythm as a periodic repetition and include dynamic kinetic change as well as structural patterns. Examples of temporal events are the qualities that are in play when the child affects the ball from one spot to another by swinging the body/hands or arms to and fro, which is often a challenge for those with functionality problems. The repetition of a movement develops a sense of enjoyment and engagement of the activity, which, in turn, motivates the child to continue to experience the movement. Laban [18] states that the repetition creates a memory of the experience, which is needed for new inspiration and insight to develop. More specifically the temporal data was classified into discrete units for analysis by applying the specifics of speed, intensity, and fluency of movements [18, and Efron in 26].

The spatial specifics concerns where the body moves through extended movements towards another situation in the spatial environment. Example of spatial events are the qualities that are in play when the child seeks another situation in the spatial environment, e.g. moving like jumping or leaning the body from one side of the screen to the other whereby the central area of the child's body is transported to a new position when keeping the virtual game ball up in the air. The spatial data was classified into discrete units for analysis by applying the specifics of range and intentionality of movements [18, and Efron in 26]. Alongside with these tempospatial qualities children's face expressions and utterances were analyzed.

Thus, a detailed manual multimodal analysis of the videos was realized so that:

- each video was watched twice before the detailed analysis began;
- the analysis of the first eight videos was realised twice each and the following eight videos once each;
- each minute of video was systematically analysed and transcribed into an excel flowchart in relation to the categories described above. The categories analysed represented high or low degrees of the specific movement trait. This flowchart also included analysis of a facial expression, a description of what happened on the screen (Appendix 4: Table 3);
- every category (n = 8) was analysed separately, which means that the first eight videos were watched in total 18 times each, and the remaining being watched 10 times each. Additionally the multi-sessions were annotated further four times.

3.4.2. Computer analysis

Toward a goal to amass indicators of the overall motion attributes of each child an automated low-level movement analysis was computed on the videos utilising software modules from the 'EyesWeb Gesture Processing Library' specific to the quantity and contraction aspects of the movement[1] . The data was then exported to a spread sheet for further analysis.

Our strategy for the automated computer video analysis was to supplement the manual annotations toward our overall goal in development of the methodology by (a) following a background subtraction on the source video to segment the body silhouette a Silhouette Motion Image (SMI) algorithm that is capable of detection of overall quantity, velocity and force of movement is used. Extraction of measures related to the 'temporal dynamics of movement' is computed and a threshold value slider can be adjusted according to each child's functional ability so that he or she is considered to be moving if the area of the motion image is greater than the related (to threshold) percentage of the total area [27]. The adjustment of the threshold value is achieved in real-time annotation of the videos (Appendix 2: Figure 4); (b) a contraction index (CI with range 0-1) algorithm is used with a bounding rectangle that surrounds the 2D silhouette representation of the child within the minimal possible rectangle. The CI is lower if the child has outstretched limbs compared to an image showing the limbs held close to the body where the CI approaches 1 (Appendix 2: Figure 5). Problems were apparent with the child encroaching towards the camera, and background noise. A correcting normalisation algorithm was unsuccessful in correcting the problem and thus refinement is needed [27].

4. Results

Our explorative question concerned the potential of video games in therapy and requirements toward a meaningful and optimized full investigation. Our findings present the facts that: (1) more care in the set up of the room background is needed – some videos had curtains blown with wind and people walking behind the child, (2) attire of children should contrast background – if light background and light shirt, then camera software problems occur with differentiating between child and background, (3) lighting of child/room should be optimised, (4) the system is developed for upper torso single person play but many of the children used all of their bodies, especially in kicking when the ball was lower in the screen (5) facilitators should not talk or be in line of sight. Our instructions were also interpreted differently by each hospital in so much that (1) in Sweden a time limit of 10 minutes was established for each session, (2) a long practise period was included within the Swedish ten minute period, (3) in Denmark one of the doctors also included practice periods for his children, (4) in Sweden multiple sessions were held in the same day whilst in Denmark single session per day.

4.1. Tempospatial movements

In annotating the games Start – Middle - End segmented zones were interpreted in respect of game and pause data. As expected the best performance was achieved in the end segments on an 8:15:17 ratio (even accounting for extended play boredom through no level change). The

[1] www.bris.ac.uk/carehere & www.eyesweb.org

shortest game ratio was 18:13:9; the longest pause ratio 16:12:12; and the shortest pause ratio 8:14.18.

These figures indicate that the virtual environment interaction with the EyeToy® met with predicted balance of performance and learning curve. Of interest within the figures was the fact that in most cases the best performance was preceded by the child's shortest pause and that following the best game it was often the case that the next two games declined in performance drastically. This matches the manual annotation where the activity (play) peaks and in most cases the emotional expression from face and body gesture before and after relates.

A general result was the faces of the children giving a defined statement of their presence (and aesthetic resonance) in the interaction with the content of the game, which was mostly pleasing and a challenge for their skills.

The detailed analysis showed a connection between tempospatial movements and aesthetic resonance through a correlation between the categories of intensity and intentionality. When there was a high, medium, or low degree of movement intensity, the same degree was always appearing in the category of intentionality of movements. Furthermore, there was a higher degrees of aesthetic resonance related to spatial movements than to temporal as the categories of range, intentionality, and shifts had high or medium degree of movements. The categories of speed and fluency, on the other hand, had low or medium degrees of movements, while the degree of intensity in temporal movements was high (Appendix 3, table 2). The computed data analysis supported the manual analysis so as to indicate higher or lower degrees of quantity of movements (QOM) and through the threshold of motion and non motion segmentation (Appendix 2: Figure 4).

Our findings in the multi-sessions were limited to two children. The standard deviation in scores between the sessions is significantly reduced with the girl [duration] 46% [between] 30% [1st ball duration] 79% [2nd ball duration] 1% [3rd ball duration] 49% - the boy, who notably in the first session had an intravenous attachment, showed insignificant change in total. Overall, consistent to our single sessions were reduced 'between' times for both the girl (12%) and the boy (9%) which we claim as a possible indicator of motivation, which we relate to the enjoyment and fun in playing the game. This involves emergent learning of navigation modes and is an attribute to aesthetic resonance through its inherent presence factor. In the multi-sessions we conducted a preliminary computer analysis for duration of last pause and motion phases (Appendix 2: Figure 4). Our findings were that both the girl and the boy had increased standard deviation and average of duration of last pause phase combined with a reduced duration of motion phase from the first to second session. This may indicate that over a number of sessions less motion is required to achieve similar tasks, thus more effective movement is learnt as the child gets acquainted with the game. Further investigation in relating such findings to presence would seem in order.

To sum up, aesthetic resonance was indicated partly through the high degree of intensity and intentionality in movements. Intensity and intentionality was shown through the children's concentration and also through their force and passion when playing the game. Aesthetic resonance was indicated by the degree of movements of range and shifts in the children's movements. The categories of speed and fluency did not have any influence on aesthetic resonance as they did not influence the intensity, intentionality, range, or shifts in movements.

4.2. Interface and activities

In interviews with children concerning their positive and negative experiences of the EyeToy® game the main part of the children expressed positive experiences. 61.1% (n = 11) of the children thought the EyeToy® game was fun, while 22.2% (n = 4) said that they liked it. One (1) child said that the EyeToy® game was difficult, but he also said that the gameplaying was fun. Concerning positive and negative specifics of the gameplay 38.8% (n = 7) of the children answered on the interface attributes and 61.1% (n = 11) on the activity attributes of the game (Table 1). The children's negative experiences of the game only concerned activity attributes regards the content of the game. Two children answered that they enjoyed the whole EyeToy® game. Six children referred to movements – using the body and to move – when they were asked about the positive attributes of the game. Four children said that the ball-play attribute was the best, while seven children stated that the ball-play attribute was the most difficult. These facts indicate that the ball-play attribute in itself was a challenging activity, as three of the children also confirmed.

Table 1 Attributes

Positive?			
Interface	Children	Activity	Children
Body used	22.2% (4)	Ball-play	22.2% (4)
To move	11.1% (2)	Monkeys	16.6% (3)
Mirroring	5.5% (1)	Challenge	16.6% (3)
		Scoring	5.5% (1)
SUM	38.8% (7)	SUM	61.1% (11)
Negative?		Difficult?	
Activity	Children	Activity	Children
Monkeys	5.5% (1)	Ball-play	38.3% (7)
Repetition	5.5% (1)		
Pauses	5.5% (1)		
SUM	16.6% (3)	SUM	38.3% (7)

The game agents were the main attributes when the children referred to negative aspects of the EyeToy® game experiences as it repeatedly gave negative feedback to the children. The monkeys were stated as difficult by one child, but were also considered as fun by three of the children.

In summary, the children's experiences of the EyeToy® game indicated that the interface supported the gameplaying activity in a challenging way and aesthetic resonance was achieved through this challenge

4.2. Resource for therapy

In interviews and the field notes from the play therapists and the doctors positive, negative, and practical aspects of the children's gameplay with the EyeToy® game was started. They also gave indications on potential with the EyeToy® game in therapy.

***Positive aspects*:**
The EyeToy® game was great fun for the children who were concentrated on the tasks in the game.

***Negative aspects*:**
The children quickly became bored as it was either too hard or too easy to play; three balls were too few; the game ended quickly limiting the challenge; the game agent mostly gave negative feedback, which many of the children commented upon.

***Practical aspects*:**
A room allocated for the test is necessary for future research; the camera set-up was too complicated to handle; the camera set-up limited some of the children's movements; both hospitals wish to continue with future EyeToy® research.

***Potentials with EyeToy® in therapy*:**
The game activity is fun and the training aspect simultaneously involved, becomes fun as well; the game activity brings in movements to the therapy, which make sense and benefits the children's rehabilitation; playing the EyeToy® game becomes physiotherapy; if there was more of challenge and action in the games, the potentials for therapy would increase as the fun and motivation for moving probably would increase.

To sum up, the results from field notes and interviews with the play therapists and doctors underlined the potential with the EyeToy® system in therapy emphasizing flow and fun aspects of the gameplaying as beneficial for the therapy training.

5. Discussion

The purpose of the study was to qualify the initial use of the system for children in rehabilitation in a hospital scenario with a consideration of the inherent logistics and practicalities. We restricted our unit of analysis to different expressions of tempospatial movements in process as indicators of a possible presence state related to behaviour and situation within play therapy. Through our exploratory investigation our findings indicate that aesthetic resonance through intensity and intentionality is related to flow and conscious reactions when a child interacts with the EyeToy® game. Furthermore, presence enhanced aesthetic resonance through range and shift related to movement increments. As far as we can ascertain, the limited computed data supports the manual annotations and our claim where observation of activity mediated within a human afferent efferent neural loop closure as a result of interaction to content of a virtual environment. The field-experiments we consider as a start toward understanding the mechanisms of motivation promoted by multimodal immersion, and the triangulations of actions becoming reactions resulting in interaction in play activities.

Conclusions

Our approach relates to the heuristic evaluation strategy of Nielsen [28] where natural engagement and interaction to a virtual environment having 'real-world' physical traits and being compatible with user's task and domain is such that expression of natural action and representation to effect responsive artefacts of interesting content feedback encourages a sense of presence. Beyond presence we seek a *sense state* continuum that stimulates intrinsic motivated activity, and from prior research we have termed this aesthetic resonance. To engage an actor in aesthetic resonance we implement a strategy toward creating enjoyment and fun as the user perceived level of interaction where emotional expression of body is the control data of the feedback. In this way an afferent efferent neural feedback loop is established. The data that is controlling the feedback content is available for therapeutic analysis where progression can be monitored and system design adapted to specifics of the task centred training. The user experience however is targeted at being solely play based.

In this document we report on our pilot study which is the first phase of an extended full scale research investigation based on our hypothesis that the positive attributes in utilizing digital interactive games that embody the actor in VE therapy will relegate the negativity tagged to video games and offer new opportunities to supplement traditional therapy training and testing. Our prior research informs that intrinsic motivation is a potential strength of game interaction where the user becomes aware only of the task and in an autotelic manner extends otherwise limiting physical attributes beyond what may otherwise be possible to achieve, and this supports our hypothesis. This study discovered that problems to overcome are the video recording system, the interpretation of instruction, and the room availability. A new single button system for optimizing the video recording system has been designed and budget planned to improve the next phase of the project. Similarly, the hospitals promise a designated space in future. The children's quantity, dynamic, and range of movements when immersed in the gameplaying activity were over and above their usual range of movements. Their facial expression and emotional outbursts further substantiated our claim that an initial state of presence was achieved.

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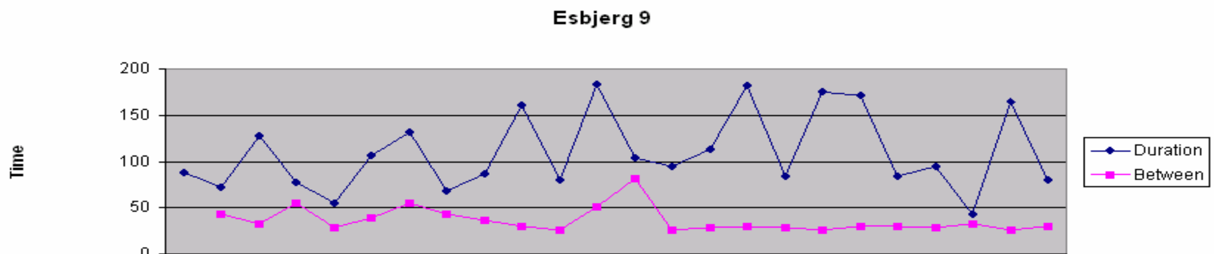
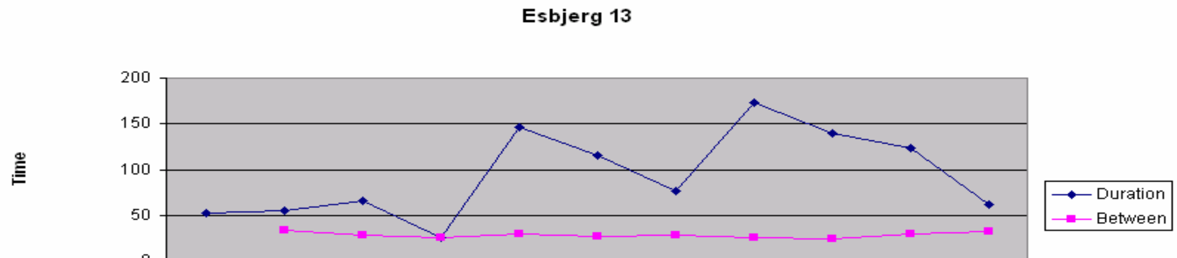
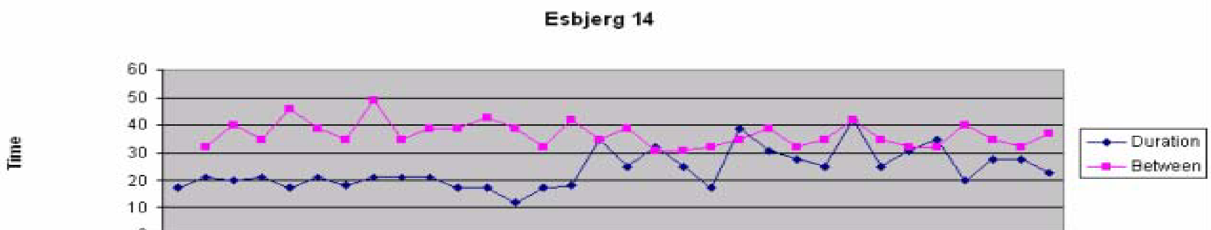
Appendix 1



Games	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Duration	88	73	127	77	55	106	132	69	87	160	80	183	104	95	113	182	84	175	171	84	95	43	164	80
Between		44	33	55	29	40	55	44	37	30	26	51	82	26	29	30	29	26	30	30	29	33	26	30



Games	1	2	3	4	5	6	7	8	9	10	11
Duration	53	55	66	26	146	115	76	173	139	123	62
Between		34	28	26	29	27	28	26	24	30	32



Games	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Duration	17	21	20	21	17	21	18	21	21	21	17	17	12	17	18	35	25	32	25	17	39	31	28	25	42	25	31	35	20	28	28	23
Between		32	40	35	46	39	35	49	35	39	39	43	39	32	42	35	39	31	31	32	35	39	32	35	42	35	32	32	40	35	32	37

Figure 3 Three examples showing game play results: (top graph) Esbjerg 9 (male 7 years of age) where successes are inconsistent and possibly due to unstable presence. Game 13 is where a higher level was attempted shown by his 'between time' high. Esbjerg 13 (girl of 8 years of age –middle graph) achieved completion of the full game (8th game) resulting in an affirmative comment from the game agent. Esbjerg 14 (female 10 years of age – low graph) had most problems (game duration average 24/56.6) this reflective of her functional condition (brain tumor), however she achieved the most number of games (32) whilst continuously pushing her limitations and at conclusion interview described the "great fun" despite her difficulties.

Appendix 2

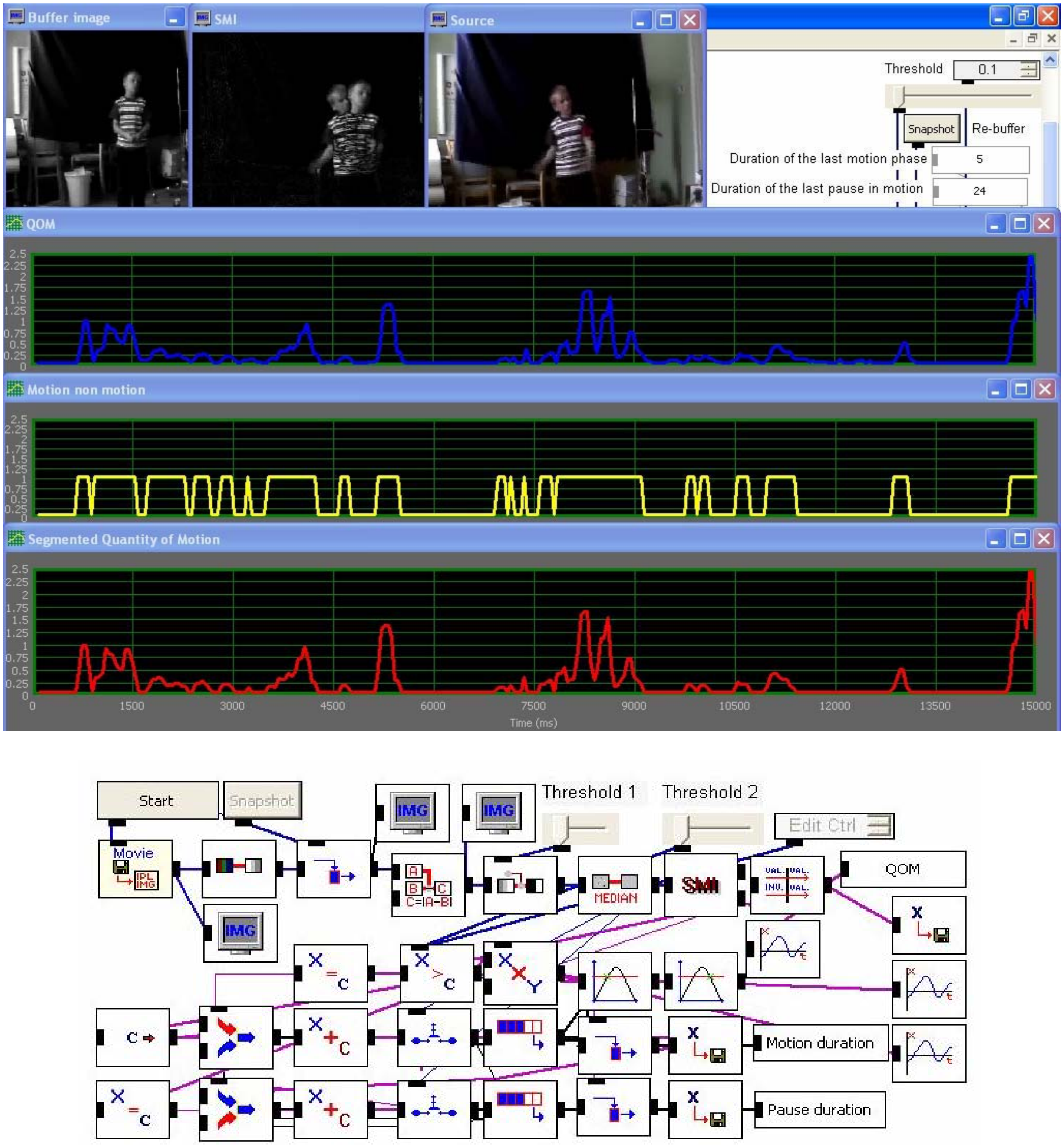


Figure 4 Quantity and segmentation of movement. Threshold/buffer/motion phase indicators (upper right). Buffer image, SMI & source windows (upper left), Halmstad hospital, Sweden. Algorithm for QOM, pause and motion phase duration available from authors.

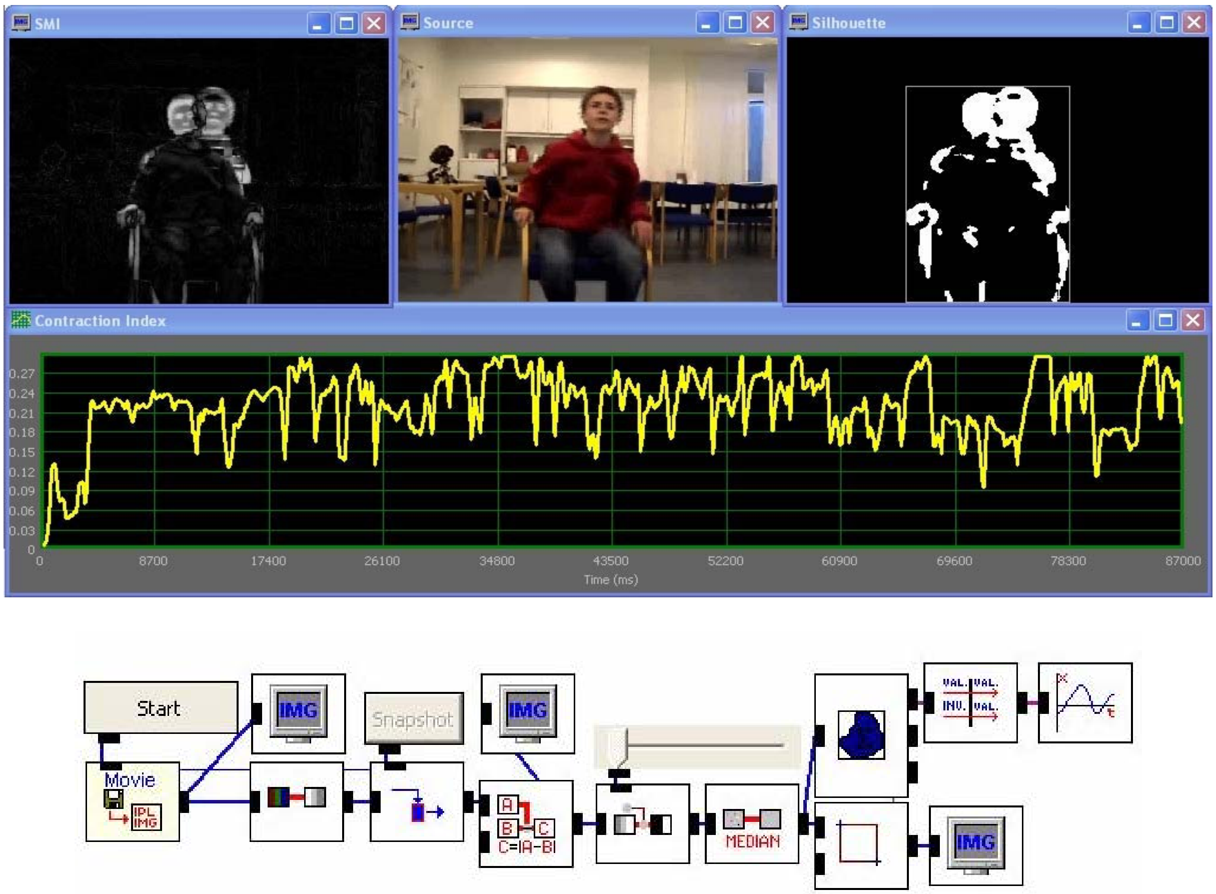


Figure 5 Contraction Index (CI) analysis. Upper right shows silhouette bounding rectangle initially set on buffer image, Esbjerg hospital, Denmark. Algorithm is made available from the authors.

Appendix 3

Table 2: Session overview: Upper = Sessions/Games (g)/Pauses (p). Lower = Movement analysis

Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total games	16	15	28	10	6	7	13	5	24	14	5	5	11	32	14	8	5	6	8	8
Longest g #	7	13	25	9	4	7	5	5	12	7	3	2	8	25	11	2	1	1	3	5
Shortest g #	1	15	7	4	2	3	9	1	22	1	4	3	4	13	3	1	2	3	7	2
Longest p #	16	8	6	2	5	2	5	2	13	2	3	4	2	8	2	3	5	4	8	6
Shortest p #	4	14	9	9	3	6	8	4	14	13	4	2	9	18	8	4	4	6	5	2

Category of movement trait	High degree (%)	Medium degree (%)	Low degree (%)
Speed	33.4	22.2	44.4
Intensity	61.1	16.6	22.3
Fluency	16.6	55.5	27.9
Range	72.2	16.6	11.2
Intentionality	55.5	22.2	22.3
Shifts	66.6	16.6	16.8

Appendix 4.

Table 3: Tempospatial Analysis: An example of one annotated session video file.

Time min.	Temporal						Spatial						Screen
	Speed		Intensity		Fluency		Range		Intentionality		Shift		
	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	
1		1		1		1		1		1		1	Start screen/Character
2		1		1		1		1		1		1	Wave/Ball/Game Over
3		1	1		1			1	1			1	Character/Wave/Ball/Game Over
4	1		1			1		1	1			1	Ball/Monkeys/Game Over/Character/Wave
5	1		1			1	1			1		1	Wave/Ball/Monkeys
6		1	1			1		1	1			1	Monkeys/Game Over/Character/Wave/Ball
7		1	1			1	1		1			1	Ball/Monkeys/Game Over/Character/Wave
8	1		1			1	1		1			1	Wave/Ball/Monkeys/Game Over
9	1		1			1		1	1		1		Character/Wave/Ball/Monkeys
10	1		1			1	1		1		1		Monkeys/Game Over/Character/Wave
11	1		1			1	1		1		1		Ball/Monkeys
12	1		1			1	1		1		1		Ball/Monkeys/Game Over
13	1		1			1	1		1		1		Character/Wave/Ball/Game Over
14	1		1			1	1		1		1		Character/Wave/Ball/Monkeys (shortly)
15		1	1			1		1	1		1		Monkeys/Game Over/Character/Wave
16	1		1			1	1		1		1		Ball/Monkeys/Game Over/Character/Wave
17	1		1		1		1		1		1		Wave/Ball/Monkeys
18		1	1			1		1	1			1	Monkeys/Game Over/Character/Wave/Ball
19	1			1		1		1		1		1	Ball/Monkeys/Game Over/Character/Wave
20		1	1			1	1		1		1		Wave/Ball/Monkeys/Game Over
21	1			1	1			1		1		1	Character/Wave/Ball/Monkeys
22		1		1		1		1		1		1	Game Over/Character/Wave
23		1		1		1		1		1		1	Ball/Monkeys/Game Over/Character
24		1		1		1		1		1		1	Wave
25		1		1		1	1			1		1	Ball/Monkeys/Game Over
SUM	13	12	17	8	3	22	12	13	16	9	10	15	