Gameplay as a Source of Intrinsic Motivation for Individuals in Need of Ankle Training or Rehabilitation

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Abstract

Injuries to the ankle may be a source of great discomfort and the long-term effects can negatively influence the future health of the individual who has suffered the injury. Wobble boards represent a relatively inexpensive type of equipment that may be used to train one's ankles preventively or as part of the rehabilitation process once the damage has been done. However, individuals in need of such training frequently lack the motivation necessary in order to successfully complete the training or rehabilitation process. This paper details the design and implementation of a prototype intended to alleviate this problem by leveraging games' potential as a source of intrinsic motivation. More specifically, the prototype enables users to control a game by means of a wobble board, thus allowing them to perform the necessary exercises while playing. An expert on ankle rehabilitation assessed the efficacy of the training facilitated by the prototype, and 40 individuals partook in a quantitative test performed in order to determine whether the prototype could potentially provide the needed motivation. Based on the findings from the two tests, it is concluded that the prototype does ensure correct ankle training and the act of playing was experienced as intrinsically motivating by the majority of the test participants.

1 Introduction

Every year more than a million people succumb to ankle injuries in the United States alone. It has been estimated that this type of injury amounts to 1.6 million physician office visits and in excess of 8,000 hospitalizations each year. The long-term effects of ankle injuries include, but are not limited to, an increased likelihood of suffering repeated injuries, a decrease in physical activity, and early development of osteoarthritis (McKeon & Mattacola, 2008). This does in turn imply that ankle injuries not only represent a source of discomfort and an obstacle to the health of individuals, but also constitute a substantial health care cost—estimated around several millions of dollars each year (McGuine & Keene, 2006). However, it is both possible to perform preventive training and to rehabilitate the ankle once the injury has occurred. Both preventive training and rehabilitation may be achieved by means of relatively inexpensive equipment, such as the wobble board, which has proved to significantly reduce both the risk of future ankle sprains and the residual symptoms of such

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Figure 1. *A conventional wobble board.*

sprains (e.g., McGuine & Keene; Wester, Jespersen, Nielsen, & Neumann, 1996). A wobble board consists of a circular disk placed upon a half sphere (see Figure 1).

Training with the wobble board is relatively simple and requires the user to stand on the board while performing a series of exercises. These exercises include balancing on the board while keeping it as steady as possible, tilting the board steadily from side to side or back and forth, and performing circular clockwise or counterclockwise movements (see Figure 2). While performing these exercises, one should strive to avoid the edges of the board coming into prolonged contact with the ground, since this serves as an aid, and thus reduces the efficacy of the exercises (Asp et al., 2007).

Even though regular use of a wobble board is a relatively efficient and low-cost measure against ankle injuries, one obstacle seems to prevent some users from getting the full benefit of the training. To be precise, the problem is that individuals fail to successfully complete the training or rehabilitation process because they lack the motivation necessary in order to do so. This is not a concern exclusive to ankle training and rehabilitation. For example, in a review of the concept of patient motivation, Maclean and Pound (2000) describe how motivation has been considered in relation to rehabilitation associated with strokes, fractures, rheumatic disease, aging, and cardiac and neurological issues. The limited motivation on the part of some individuals may, at least in part, be ascribed to the tedious nature of the ankle exercises and the inability to monitor one's improvement throughout the course of the training process (Asp et al., 2007). To elaborate, it would seem that the individual's personal need to perform the exercises does not serve as a sufficient source of extrinsic motivation. Within this context, extrinsic motivation refers to the form of motivation that pushes an individual to perform a particular activity on account of factors that are external to the activity itself, such as punishments and rewards (Guillaume & Jouvelot, 2005). In other words, it would seem that neither the reward of a better physique nor the potential punishment of future injuries provides the necessary extrinsic motivation. Contrary to extrinsic motivation, intrinsic motivation incites individuals to perform an activity for no other reason than the act of performing the activity itself (Guillaume & Jouvelot). Considering the tedious nature of exercising with a conventional wobble board, it seems doubtful that many will find this activity intrinsically motivating. Intrinsically motivated activities include, but are not limited to, acts of play in general as well as instances of play, taking games as their starting point (Nakamura & Csikszentmihalyi, 2005). That is to say that individuals frequently play games for no other reason than the act of playing itself. Notably, the act of playing games frequently includes rewards and punishments. These are, however, intrinsic to the activity and carry little or no value externally. Hence, the activity may be intrinsically motivating despite the presence of rewards and punishments. Nevertheless, it is possible for an individual to be extrinsically motivated to play. Sources of extrinsic motivation include monetary rewards and prestige (Nakamura & Csikszentmihalyi). Further, instances of play involving competition between players may consequently be extrinsically motivated (Holbrook, Chestnut, Oliva, & Greenleaf, 1984). Considering the motivational potential of games, it seems likely that the inclusion of games as part of the training and rehabilitation process might alleviate the problem of patients lacking the necessary motivation. However, this is by no means a novel insight. For example, Alankus, Lazar, May, and Kelleher (2010) describe a system that allows stroke patients to perform therapeutically useful upper body movements while controlling different games with gestures captured by means of a web camera or Wii remotes; Munih et al. (2011) have created a multimodal system that combines cognitive challenges with repeated, robot aided physical actions in a game-like scenario, which similarly is intended to motivate stroke patients to exercise; and Deutsch, Latonio, Burdea, and Boian (2001) describe an application developed for the Rutgers Ankle rehabilitation interface (Girone, Burdea, & Bouzit, 1999), which allows users to control the move-

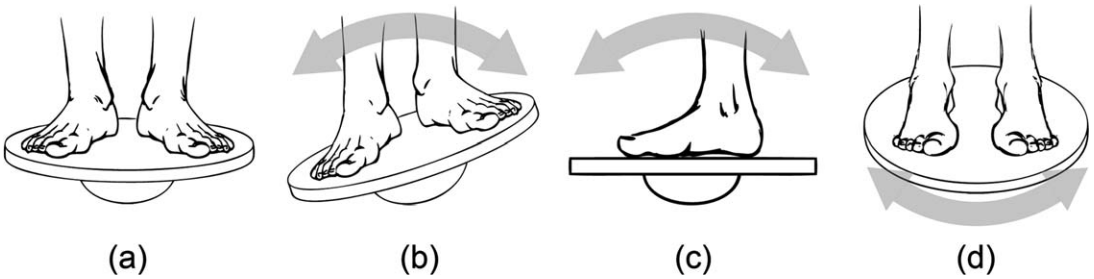

Figure 2. *The four common wobble board exercises recommended by physiotherapist Anders Heckmann (Asp et al., 2007). (a) Balance while keeping as steady as possible. (b) Move the board back and forth. (c) Move the board from side to side. (d) Clockwise and counterclockwise circular movement.*

ment of an airplane with their feet and thereby train their ankles while playing.

The present paper details the development and evaluation of a prototype intended to incite otherwise unmotivated individuals to perform ankle exercises by leveraging games' potential as a source of intrinsic motivation. This was essentially done by allowing users to control a game by means of a wobble board, thus combining ankle training with the autotelic activity of playing. Since the work presented here can be considered as the second iteration in the design of a previously produced prototype (Asp et al., 2007), the first section of the paper will introduce the original prototype in Section 2. Subsequently, parts of Järvinen's conceptualization of video games as emotional experiences (Järvinen, 2008) will be outlined in Section 3 since this theory informed the design. After the design has been introduced in Section 4, the two tests performed in order to evaluate whether the prototype facilitated correct ankle training while serving as a source of intrinsic motivation will be described in Section 5.

2 The Original Prototype

The original prototype was dubbed the WobbleActive (Asp et al., 2007) and was largely developed to serve the same purpose as the current one. The WobbleActive allowed users to interact with two simple games by means of a traditional wobble board. Four One-Directional Flex Sensors (Images SI Inc., 2010), attached within hinges, distributed evenly underneath the board, registered its movement and thus facilitated the interaction. The supplied input was used to control the user's avatar and to navigate a menu system. Both of the two games had three difficulty levels and allowed the user to control the movement of a flying saucer displayed on a screen positioned in front the user (see Figure 3). The first game was designed to facilitate the previously mentioned balancing exercise (see Figure 2[a]) and required the user to keep the flying saucer hovering within a predefined region at the center of the screen. The second game was designed with the intention of making the user tilt the board from side to side and back and forth. This was achieved by making the user navigate the flying saucer through a maze. It should, however, be noted that the design of the two games first and foremost was informed by the recommended exercises, thus implying that little explicit effort was made to foster intrinsic motivation on behalf of the potential users. One crucial question was in other words largely not addressed, namely, what is it about the act of playing games that incites individuals to play for no other reason than the act itself?

3 The Feeling of Intrinsic Motivation

In his contribution to *The Video Game Theory Reader 2*, Järvinen (2008) presents a description of players' emotions that seemingly provides some clues as to why games in and of themselves incite players to play. Järvinen presents the argument that the act of playing games should be considered as a fundamentally human

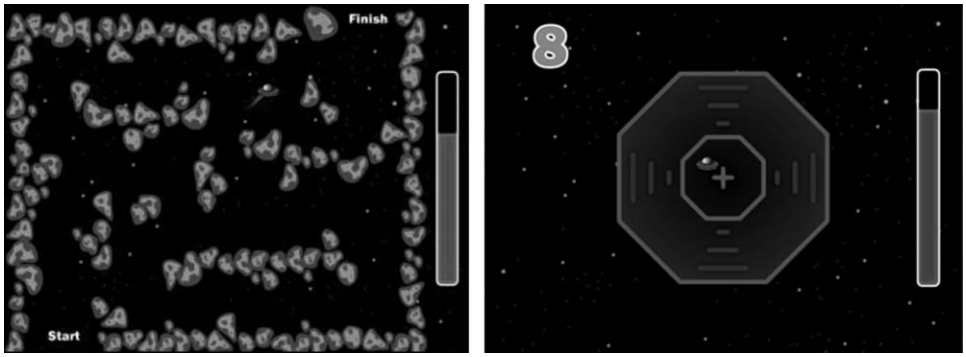

Figure 3. *Left: Screen shot of the maze game. Right: Screen shot of the balancing game (Asp et al., 2007).*

activity, thus implying that emotions should be considered central to the experience brought about by playing games. The goals that games impose on players are central to Järvinen's description of the player experience, since by and large it is the player's aspiration to achieve these goals that makes it possible for the game to elicit emotional responses. However, it is not the goals themselves that elicit the emotions, but rather the events experienced while striving to achieve the goals (Järvinen). Even though the aspiration of reaching the goals may motivate the player to continue playing, it would seem that it is the emotions experienced that ultimately determine whether the player finds the experience pleasurable and thus continues to play. This necessarily brings about the question of what pleasures gameplay may give rise to.

Järvinen (2008) introduces a conceptualization of the pleasures brought about by games and other forms of entertainment that provides a potential answer to this question. The conceptualization was adopted from experimental psychologist Kubovy (1999), who proposed that it is possible to identify at least five pleasures of the mind. A pleasure of the mind may in general terms be described as a temporally distributed sequence of emotions. A feature of these pleasures, which makes their connection to the experience of intrinsic motivation more readily apparent, is that they are sought out voluntarily (Järvinen). In other words, players strive to experience these pleasures of the mind and use games as vehicles to do so. While Järvinen does not explicitly describe whether players are mindful of their pursuit for pleasure, it would seem that this pursuit, and the pleasures it leads to, can help explain why the act of playing games may be intrinsically motivated. That is to say that the conscious or unconscious prospect of experiencing one or more of these pleasures of the mind serves as an intrinsic goal, while the actual experience constitutes an intrinsic reward. The five types of pleasures of the mind outlined by Järvinen are curiosity, virtuosity, nurturing, sociality, and suffering.

3.0.1 Curiosity. The pleasure of the mind curiosity comprises pleasures derived from the process of satisfying one's epistemic hunger, that is, the process of acquiring knowledge pertaining to something previously unknown. This does, in turn, imply that the associated emotions by and large are leveled at the unknown and related to the inferences made about the outcome of current and future events (Järvinen, 2008).

3.0.2 Virtuosity. This category of pleasure accompanies the experience of being proficient, implying that the underlying emotions are leveled at the individual's own actions and level of proficiency (Järvinen, 2008).

3.0.3 Nurture. Nurturing as a pleasure of the mind relates to the pleasures experienced when one is taking care of living things. The emotions forming the

basis for these pleasures may therefore be leveled at the objects of the nurturing or the act of nurturing itself (Järvinen, 2008). However, it is worth noting that the objects of the nurturing can just as well be simulated living beings, such as virtual pets (Järvinen).

3.0.4 Sociality. As the name implies, this category of pleasures relates to the pleasure of being a member of a social group, which, in turn, suggests that the emotions forming the basis for these pleasures are leveled at the remaining members of a social group. The pleasure of sociality is also closely tied to the joy of cooperating and receiving praise from one's peers (Järvinen, 2008).

3.0.5 Suffering. The fifth and final category of pleasures does quite paradoxically have its roots in the experience of negatively valenced emotions. According to Järvinen, suffering involves "... negative pleasures of the mind from 'mundane' psychological pains, such as shame and guilt, or from 'existential' pains, such as fears of death or related concerns, which consequently function as the object of emotions" (Järvinen).

Even though the experience of negatively valenced emotions may be pleasurable, it seems doubtful that these types of emotions always will yield a pleasurable experience. On the contrary, it would appear that negatively valenced emotions help make the experience intrinsically motivating only if they fall within a tolerable range. That is to say that the emotions do not exceed the player's internal threshold for tolerating negative affect. Consequently, it would seem that emotions in many regards are analogous to a filter, which ultimately determines whether the player derives pleasure from playing and thus determines whether the player continues to find the game intrinsically motivating.

4 Prototype Design and Implementation

The prototype described in this paper was designed based on principles of iterative player-centered design (e.g., Salen & Zimmerman, 2004; Gulliksen et al., 2003). In other words, the design was not just informed by the reviewed theory but also based on user feedback obtained from four qualitative tests. This ongoing evaluation was intended to provide information about the usability and playability of the prototype. In general terms, the playability of a game may be described as the degree to which the game is experienced as enjoyable and entertaining (Sánchez, Iranzo, & Vela, 2011). Considering that small scale tests usually are sufficient when identifying usability issues (Nielsen, 2000), no more than five participants took part in each test. Since individuals of nearly all ages and backgrounds may succumb to ankle injuries, the potential user group is very diverse. Consequently, the intended user group was delimited as follows. Firstly, it was decided to concentrate on designing a game accommodating the needs of first-time users in need of rehabilitation or preventive training who did not suffer from any other disabilities. Secondly, a decision was made to focus on developing a game for individuals who had prior experience with playing video games. This does in turn imply that elderly people and small children were excluded from the target population, as it predominantly consists of teenagers and young adults without any severe physical disabilities. All participants in the ongoing evaluation were undergraduate or graduate students at Medialogy, Aalborg University Copenhagen, and lived up to the specified criteria.

This necessarily had some implications for how the theory could be applied. The act of balancing on a traditional wobble board already poses a considerable challenge to novice users. It therefore seemed natural to expand upon this element of challenge and try to facilitate the pleasure of virtuosity. Moreover, it was the belief that the challenge of balancing would leave novice users incapable of simultaneously engaging with the challenges requiring high levels of cognitive capacity and mental acuity. Saariluoma (2005) more specifically described that our limited attentional capacity normally is restricted to one item at a time. However, we do possess mechanisms such as automatization that enable us to circumvent this limitation. Automatization refers to how repeated execution of a particular task under similar conditions may result in increased speed and efficiency. Once a task is fully automated, its demands on cognition diminish and performance becomes effortless and possibly even unconscious, thus enabling it to be performed

Figure 4. *Left: The Phidgets accelerometer used to measure the tilt angle of the wobble board. Middle: The accelerometer attached at the center of the board. Right: Since the placement of the accelerometer dictates the heading of the tilt, it was necessary to add an icon that indicated how users should position themselves on the board.*

alongside a more controlled main task. Considering that the task of balancing has yet to become automated in the case of novice users, it was decided to omit complex intellectual challenges, as these would be less likely to lead to an experience of virtuosity. The pleasure of curiosity might also incite players to continue playing. However, since the users might not possess the attentional surplus necessary in order to comprehend continuously presented narrative cues, it was decided to omit an elaborate storyline. However, this does not mean that the pleasure of curiosity was disregarded altogether. Contrarily, this pleasure might be facilitated by spurring a sense of uncertainty about the outcome of ongoing events since curiosity largely is the product of emotions leveled at the unknown, such as suspense. Finally, it should be noted that it was decided to focus on ankle training as a solitary activity, and the facilitation of sociality and nurture was therefore not assigned great importance.

4.1 Gameplay at a Glance

When playing the game, the player uses the wobble board to control a flying saucer and takes on the role of a caricatured alien on a reconnaissance mission to Earth. The mission involves three objectives, which define the goals of each of the game's three consecutive levels: (1) maneuvering the flying saucer through an asteroid field to reach Earth; (2) within a limited period of time, locate and abduct as many Earth specimens (cows) as possible; and (3) return the collected specimens to the mothership by shooting these through an opening on the ship's side. Once a level has been completed, the objective of the following one is revealed to the player. This particular theme was essentially chosen for three reasons. Firstly, the similar appearance of the wobble board and the flying saucer should make the interaction more intuitive. Secondly, the simple narrative was intended to impose meaningful, yet bizarre, goals on the part of the player. It is worth noting that the decision of employing a humorous theme was a conscious choice since the narrative was not intended to give rise to any intense negatively valenced emotions. In the previous discussion of emotions and intrinsic motivation, it was described that negatively valenced emotions may be pleasurable in their own right. However, such emotions only help make an experience intrinsically motivating if they fall within a tolerable range. Since individuals' thresholds for tolerating negative effect may differ greatly, it was decided not to aim for a narrative eliciting negative affect. Finally, it is worth noting that the flying saucer theme had a relatively wide appeal when used for the first iteration of the prototype (Asp et al., 2007).

4.2 Physical Interface Design

The movements of the wobble board are translated into their virtual correlates by means of an accelerometer mounted at the center of the hollow spherical base of the board (see Figure 4, middle). A Phidgets accelerometer (Phidgets Inc., 2010) was used, since the associated

API (application programming interface) provides out-of-the-box USB support and does not require any additional software processing before the data can be read by Unity 3D—the multiplatform game development tool of choice.

Using the unit circle as a representation of the gravitational acceleration of 1 *g*, a simple trigonometric calculation is performed in order to derive the tilting angle from the acceleration. To elaborate, the angular tilt (θ) on the two axes, *x* and *y*, is calculated from the acceleration (o) using the gravitational acceleration (h) by means of the formula $\theta = arcsin(o/h)$. Since the fixed axes on the accelerometer are mapped to particular movements in the game, it is important that the user is facing in the right direction when standing on the board. Consequently, a set of iconic footprints were added to the surface of the board in order to indicate how one should position oneself on the board (see Figure 4, right).

4.3 Navigating While Exercising

The choice of control schemes was informed by the prescribed exercises (see Figure 2) as well as the ongoing evaluation of the prototypes' usability. In addition to resolving various minor usability issues, these tests revealed that different control schemes were suitable for different tasks. In one test, the participants were asked to compare two different controls schemes for controlling the sideward movement of the UFO. With the first control scheme, the UFO would rotate around its vertical axis when the user tilted the board to either the right or the left, and in the second control scheme, this movement would result in rightward and leftward movement (see Figure 5). The qualitative feedback provided by the participants revealed that the former was suitable when the user was traveling long distances, while the latter scheme was preferable when a higher level of precision was necessary. Another test was performed in order to determine how to map the movement of the user to the forward and backward movement. With one control scheme, the angle of the forward and backward tilt of the board determined the speed of the UFO, while these movements resulted in acceleration in either of the two directions with the second control scheme. This

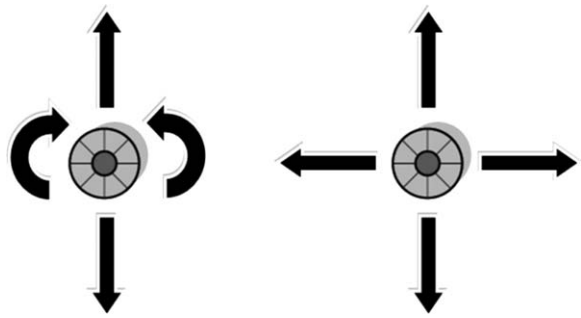

Figure 5. *The two interaction schemes for sideward movement. Left: Tilting the board left and right causes the UFO to rotate around itself toward the tilted side. Right: Tilting the wobble board left and right causes the UFO to move in a leftward and rightward direction.*

implies that tilting the board in the opposite direction from the one which the UFO is moving will cause it to decelerate. The feedback from the participants suggested that the acceleration scheme was preferable when traveling from one point to another while avoiding obstacles, but it was less suitable when trying to make the UFO steadily hover over a particular point.

In order to reduce monotony and ensure that the game facilitates the appropriate ankle exercises, the player is faced with a set of unique challenges in each of the game's three levels.

When navigating through the asteroid field in the first level, the player is able to make the flying saucer move in all three dimensions. The speed of the spacecraft is constant, and the player therefore only has to control the pitch and roll by means of the board. Hence, the mapping resembles that used in a flight simulator controlled with a joystick. None of the informal usability tests suggested that the participants found this control scheme unintuitive. In order to successfully complete the level, the spaceship has to fly around, over, and under asteroids, thus ensuring that the player both tilts the board from side to side and back and forth. Moreover, it is worth noting that evasive maneuvers frequently are achieved by performing semicircular movements of the board, thus affecting both the horizontal and vertical direction of flight.

When faced with the challenge of locating and collecting cows in the second level, the player's movement is restricted to two dimensions, that is, sideward and forward

and backward motion. In this level, the player controls the flying saucer by means of an adaptive control scheme which was based on findings from the ongoing evaluations. To be more exact, the control scheme changes depending on the challenge currently faced, that is, either locating or abducting cows. When navigating the level in search of cows, the player controls the acceleration and deceleration of the flying saucer with forward and backward movement of the board while altering the direction of flight by rotating the spacecraft around its vertical axis. This rotation is controlled by either tilting the board to the right or to the left. This control scheme forces the player to perform tilts of the board from side to side and back and forth as was the case in the first level. When attempting to abduct a cow, the control scheme changes and the tilting of the board is now mapped to the lateral, forward, and backward movement of the spaceship. The change in control scheme takes place when the ship enters a circular area with the cow at its center. When the player either exits this area or successfully abducts the cow, the control scheme is changed once again. Whereas maneuvering around the level requires repeated changes to the bearing, this challenge forces the player to balance steadily on the board, since the spaceship has to hover over the cow while slowly lifting it off the ground. In order to indicate to the player that the control scheme has changed and that it is possible to abduct the cow, a tractor beam is emitted from the saucer. Moreover, the point of view changes so as to make it easier for the player to determine whether the space ship is directly over a cow. Recall that in order to perform the exercises properly, one should avoid the edges of the board coming into prolonged contact with the ground. In order to minimize such actions, a simple penalty mechanism was implemented. Prolonged contact with the ground will cause the saucer to swirl around and end up hovering upside down for a brief period of time. This leaves the player unable to control the saucer and valuable time is lost. If the player has abducted a cow, prolonged contact with the ground will result in the cow being released, thus forcing the player to locate and collect another cow.

The challenges faced in the third level differ from the ones of the previous two since the user no longer is tasked with navigating a virtual environment, but instead has to return the cows to the mothership by shooting them through a gate on the mothership's side. In this level, the player controls the movement of crosshairs that move in accordance with the tilting angle of the wobble board; that is, the more the board is tilting to one side, the faster the crosshairs will move in that direction on the screen. Since the board is a buttonless interface, the player is unable to determine when to fire, and an alternative way of performing a shot had to be implemented. When the player moves the crosshair within the vicinity of the target—the mothership's gate—a launch sequence is initiated and after a 3 s countdown, a cow is fired. This in turn implies that the player has to balance steadily on the board in order to maintain the aim of the crosshairs and ensure that the cow will not miss its target.

4.4 Level Design

Since the prototype is designed for novice users, the first level of the game is intended to introduce players to the challenge of balancing on the board while using it to control the game. Challenges exceeding the players' capacity for action may elicit negatively valenced emotions leveled at the players themselves rather than the pleasure of virtuosity. The difficulty of the first level was consequently adjusted so as to make it suitable for individuals with little or no experience with balancing on a wobble board. This was achieved by altering the size and density of the asteroid field based on the information obtained from the ongoing evaluation. Moreover, the visuals of this level are designed so as to make the challenge seem far more daunting than it actually is. When the player first sees the asteroid field, it appears far denser than it actually is (see Figure 6). This initial impression may lead to feelings of suspense or worry, both emotions leveled at the unknown, which may be related to the pleasure of curiosity. In addition to evoking such pleasures, it seems plausible that the intimidating appearance of the asteroid field might intensify the pleasure of virtuosity experienced upon successful completion of the level.

While playing the second level, the player is repeatedly confronted with a sequence of three challenges. The

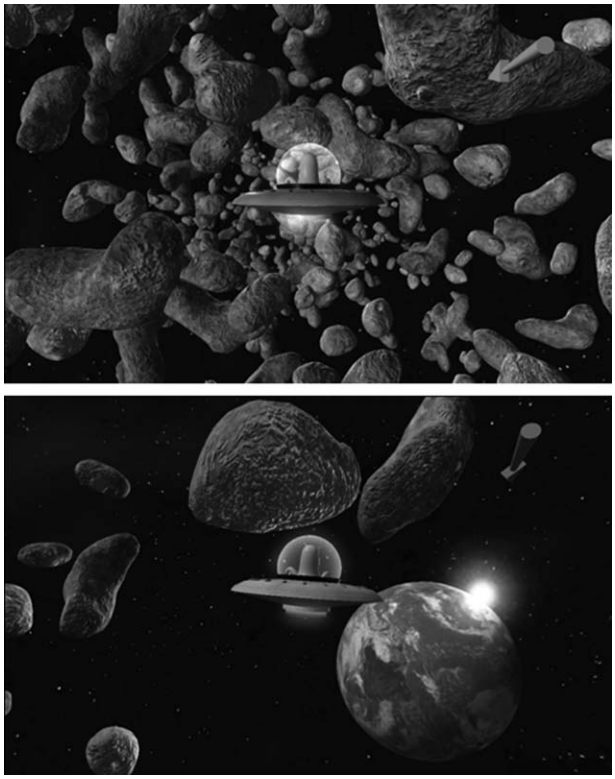

Figure 6. *Top: Screen shot of the first level in the game, illustrating the appearance of the asteroid field at the beginning of the level. Bottom: Screen shot of the final part of the first level.*

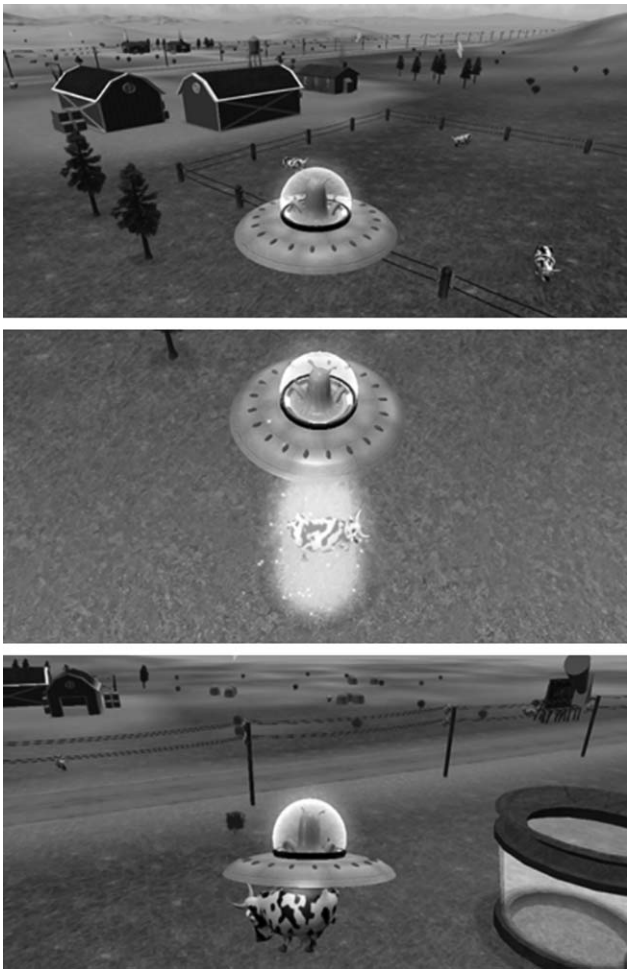

Figure 7. *Top: Screen shot of a player in search of cows. Middle: Screen shot of a player in the process of abducting a cow. Bottom: A player attempting to send a cow to the container in the bottom right corner of the screen shot.*

player has to locate a cow, abduct it, and finally return it to a container at the center of the map (see Figure 7). Once the cow has been returned, the three challenges are repeated. The player is simply told to collect as many cows as possible within a period of 4 min, and no other criteria for success are specified. In order to reduce the risk of novice players experiencing a sense of failure at this stage of the game, no minimum number of cows is specified. The time limit of 4 min was based on the ongoing evaluation which indicated that this was a sufficient time for novice players to fully experience the level without experiencing fatigue. It should be stressed that since the ongoing evaluation was performed on undergraduate and graduate students, the time limit need not be suitable for all users. However, this was not believed to pose a considerable problem, as a similar group of participants would take part in the summative evaluation. The player's ability to balance is crucial for success in this level. Therefore, the level was designed so as to enable the player to experience a gradual sense of improvement, while repeatedly facing the three challenges. The potential sense of achievement accompanying the ongoing increase in proficiency might lead to an experience of virtuosity. Despite the belief that players generally would not possess the attentional surplus necessary in order to engage intellectually demanding challenges, it was decided to implicitly encourage players to employ some level of strategic thinking. This was done by enabling players to pick up two types of power-ups, which might be beneficial at certain points in time. One power-up

Figure 8. *Screen shot of a player positioning the crosshairs before the launch sequence is initiated.*

increased the speed of the flying saucer for a limited period of time and the other revealed the shortest distance to the nearest cow by displaying an arrow in the corner of the screen. The hope was that the successful use of these power-ups would lead to experiences of virtuosity. Please note that the size of the level, the distribution of cows and power-ups, and the design of the icons representing these power-ups, were informed by the ongoing evaluation.

The objective of the third level is, as mentioned, to return the collected cows by shooting these into a hatch on the side of the mothership hovering in the distance (see Figure 8). In order to achieve this objective, the player has to determine where to aim given the current wind conditions and then balance steadily in order to maintain the position of the crosshairs until the cow is fired. The risk of failure is most readily apparent during this level, since the player only has the cows previously collected at his or her disposal. The belief was that the player's knowledge of this fact might give rise to feelings of anticipation or suspense associated with the pleasure of the mind curiosity. As was the case with the previous levels, it was hoped that players might experience virtuosity upon successful completion of the level.

5 Prototype Evaluation

Considering the objective of the prototype, the objective of the evaluation of the prototype was twofold: (1) to determine whether the prototype facilitated correct ankle training; and (2) to assert whether the participants found the act of playing the game intrinsically motivating.

5.1 Training Efficacy

In order to evaluate efficacy of the afforded ankle training, an expert on the topic was consulted, namely Anders Laun, who at the time was finishing his degree as a physiotherapist at the University College Metropol in Copenhagen. Although Laun had yet to become a fully certified physiotherapist, he was considered sufficiently knowledgeable, as he was specialized within the field of proprioceptive ankle training. The expert consultation was divided into two sessions, an expert test and expert observation. The expert test involved Laun's evaluation of the training, after and while he was playing the game. As part of the expert observation, Laun was asked to observe the ankle movement of an individual playing the game, and based on his observations, he evaluated the efficacy of the performed training.

5.2 Intrinsic Motivation

In order to assert whether the act of playing the game would be experienced as intrinsically motivating, a quantitative test was performed. The participants were asked to fill out a questionnaire about their experience of playing the game, after doing so. In addition to assessing whether the participants generally experienced a continued commitment to the act of playing, the questionnaire was also designed to determine whether they had experienced one or more of the described pleasures of the mind. Finally, the questionnaire was also intended to evaluate the prototype's usability, as usability deficits have been shown to negatively influence the experience of engagement, that is, the "... the degree of voluntary use of a system along a wide period of time" (Febretti & Garzotto, 2009, p. 4063.). The reason why an ad hoc questionnaire was used instead of an existing motivation questionnaire, such as the Intrinsic Motivation Inventory (Ryan, Mims, & Koestner, 1983), was that we wanted to it to be specific to the type of experience the game was designed to elicit. Alternately, an existing questionnaire

could have been used as a supplement. However, since lengthy questionnaires may negatively influence the data quality (Kasunic, 2005) this option was discarded. The final questionnaire was composed of a total of 19 items, which were intended to answer the following questions:

1. How was the usability of the prototype? The questionnaire items pertaining to usability related to the participants' experience of the controls, the information presented on the heads-up display, and how clear the goals of the game were.
2. Did the experience of the game give rise to the pleasure of the mind virtuosity? The items pertaining to virtuosity first and foremost related to whether the participants had been satisfied with their own performance and how they experienced the difficulty level of the game.
3. Did the gameplay give rise to the pleasure of the mind curiosity? Curiosity is as described closely tied to uncertainty leveled at the outcome of future and current events. The associated items inquired into whether the participants had experienced a sense of worry while playing the first and third level, which were intended to elicit such emotions.
4. Did the sound and visuals contribute positively to the participants' experience of the game and did they employ any form of strategy while playing? Although novice users presumably would be unable to focus on much beyond the challenge of balancing, an item was included with the intention of determining whether they did employ strategic thinking while playing the second level. The attentional limitations would presumably also make the participants less likely to attend to the sounds and visuals and, as a consequence, experience curiosity in the form of a desire to explore the virtual environment. Despite these limitations, an item pertaining to the experience of the audiovisual stimuli was included, as these stimuli might positively influence whether the participants wished to continue playing or not.
5. Did the participants experience a continued commitment to the act of playing? The final three items related to whether the participants had adopted the goals of the game, whether they wanted to continue playing once the game was over, and whether they experienced fatigue as a result of playing the game.

It should be noted that the items featured in the questionnaire were not presented in this order. All of the questionnaire items were answered by means of Likert scales. The questionnaire items associated with the level of difficulty experienced required the participants to rate whether the level was too low, low, moderate, high, or too high. The remaining items required the participants to rate their level of agreement with different statements on a six-point scale (where 1 signified strong disagreement and 6 indicated strong agreement). While no formal procedure for gathering qualitative data was employed, the individuals conducting the test did note any relevant comments made by the participants during and after exposure to the game.

The test was conducted on the campus of Aalborg University Copenhagen and 40 adult volunteers (average age 28 years; 30 males and 10 females) took part in the test. All were students at either Medialogy Aalborg University Copenhagen or Copenhagen University College of Engineering, or guests invited particularly for the purpose of the test. In order to avoid any unwanted positive bias, the participants were led to believe that they were to evaluate one out of a series of possible prototype designs. All participants played the game on an identical setup and were placed approximately 2 m from the 50-in plasma monitor (Samsung PPM50H3Q) used to display the visuals. The auditory display employed was a set of stereo speakers (Creative SBS 250). In order to ensure the safety and comfort of the participants, a chair was placed in front of the board during play. Once done playing, the participants answered the questionnaire, signed a consent form permitting the use of the data gathered, and were offered a beverage for participating.

6 Results

The results of the two performed tests will be presented in turn, starting with the qualitative data obtained from the expert consultation.

Table 1. *Results Pertaining to the Six-Point Likert Scale Items*

Questionnaire item	Mean rating ± *SD*
Items pertaining to usability	
1. The movement of the UFO corresponded with the movement of the wobble board	5.3 ± 0.8
2. It was easy to understand the text and symbols displayed throughout the game	5.2 ± 0.9
3. At some point I felt annoyed by the text and the symbols displayed throughout the game	1.6 ± 0.9
4. I was never in doubt of what I was supposed to do in the game	5.0 ± 1.9
Items pertaining to virtuosity	
5. Once I made it through the asteroid field I felt a sense of achievement	4.7 ± 1.0
6. I was satisfied with the number of cows I collected	3.0 ± 1.4
7. I was satisfied with the number of cows I returned to the mothership	2.8 ± 1.6
8. I felt that I gradually became better at playing the game	4.6 ± 1.0
Items pertaining to curiosity	
9. I was worried about whether I would make it through the asteroid field	3.5 ± 1.6
10. I was worried about whether I would be able to hit the mothership's gate with my cows	3.8 ± 1.5
Items pertaining to the use of strategy and stimuli	
11. I devised a strategy for collecting the cows and returning them to the container	3.1 ± 1.6
12. The sound and visuals made me like the game more	5.3 ± 0.7
Items pertaining to the general commitment to playing	
13. It mattered to me how many cows I managed to collect and return to the mothership	4.8 ± 1.1
14. I would have liked to continue playing once the game was over	4.8 ± 1.2
15. I was too tired to continue playing once the game was over	2.9 ± 1.5

Based on his observations and his own experiences with the prototype, Laun believed it to comply with the necessary demands, as it afforded both controlled proactive and reactive movements. (Proactive balance is the ability to employ sensory and motor skills in response to expected postural demands, and reactive balance refers to the ability to regain balance after an unexpected disruptive action.) On a similar note, Laun mentioned that the prototype, unlike traditional wobble board exercises, affords reactive training, since the player continuously has to compensate in response to the events of the game. Moreover, Laun added that the prototype prompts a lot of static tension involving constant activation of the ankles. He did not regard this as a particularly negative feature, but added that it may make the training more physically straining than the one performed with a normal board where the user can rest momentarily each time the board is tilted from one side to another. Finally, he noted that since the gameplay prompts reactive balancing, it would be irresponsible to recommend the prototype to people immediately after they had suffered from an ankle sprain. Instead it would be more useful during the later stages of the rehabilitation process. Please note that Laun has read and approved the initial summary of the interview.

Table 2. *Frequency of Responses to the Items Pertaining to the Perceived Difficulty of the Levels*

	Too low	Low	Moderate	High	Too high
Level 1	1	9	21	9	0
Level 2	1	1	12	26	0
Level 3	0	5	16	18	1

The results of the quantitative test are presented in Tables 1 and 2. All the data obtained from the six-point Likert scales (see Table 1) were treated as interval data.

Central tendencies are presented as the mean rating of each item, and variability is presented as the standard deviation. The data obtained from the items relating to the perceived difficulty of the three levels were treated as ordinal data and the central tendency is summarized by the mode associated with each item (see Table 2). It is important to stress that, since convenience sampling was employed, the results do not reflect the experience of some greater population, but solely experience of the participant taking part in the test.

7 Discussion

Considering that the prototype according to the expert affords both controlled proactive and reactive training, we feel reasonably confident that it does ensure correct ankle training, albeit with some reservations. The fact that the training afforded by the prototype is physically harder than traditional wobble board exercises, along with the knowledge that it facilitates reactive training, leads us to conclude that it is less suitable during the earlier stages of a rehabilitation process. This seemingly has two possible implications for the future development of the prototype. Either the game should be redesigned so that it would become less physically strenuous and thus suitable for novice users; or else the game should be altered with the increased capacity of more proficient users in mind. This does not mean to say that first-time users will not need an introduction to the act of using the board as a controller. Instead, it would seem that it might be possible to design games based on the premise that the players are familiar with balancing on the board, and therefore are able to assign greater attention to events occurring in the game while playing.

On the topic of the quantitative test, the four questionnaire items pertaining to the usability of the prototype suggested that the participants generally found it usable. That is to say, the participants generally thought the movement of the board and spaceship corresponded well; the text and symbols were easy to understand and not regarded as an intrusion; and the participants were generally not in doubt about what to do next. These results were necessarily regarded as positive indications since usability generally is a prerequisite for a positive experience.

The obtained average and standard deviation pertaining to the sense of achievement experienced during the first of the three levels suggests that the successful completion of the first level led to a more or less intense sense of achievement on the part of a number of the participants. This in turn implies that these participants may have experienced virtuosity, albeit in different intensities. The results obtained from the two questions pertaining to the participants' satisfaction with the number of collected and returned cows did, however, paint a somewhat different picture. That is to say that the relatively low mean values suggest that it is unlikely that the experience of virtuosity was the norm. This does not necessarily imply that the participants actually performed better during the first level, but simply that they were more satisfied with their own performance. One possible explanation is that the only criterion for success in the first level was to make it to Earth, while the two subsequent levels provided the participants with more explicit information about their performance, that is, the number of cows collected and delivered to the mothership. The item pertaining to the experience of gradual improvement suggests that a number of the participants did gradually experience becoming better as the game progressed. However, since this question involves references to the particular feeling state of the participants, it remains uncertain whether this meant that they experienced positively valenced emotions leveled at themselves. Notably, a comparison of the data pertaining to the experience of improvement and the general willingness to continue playing indicated that the participants, who had experienced a sense of progressive improvement, on average also provided higher ratings when asked if they would have liked to continue playing (Pearson $r = 0.47$). Moreover, each level only received one rating reflecting a negative experience of the difficulty level, that is, the difficulty level was rated as too low or too high. Assuming that the majority of participants refrained from making these ratings because the challenges were neither too trivial nor exceeded their capacity for action, this may be viewed as a positive indication.

The results obtained from the two questionnaire items related to the participants' experience of worry while

playing the first and third level did not yield remotely conclusive results. In both cases, the means and standard deviations indicated little or no agreement among the participants. So it would seem that some participants may have experienced some level of suspense or worry, but this was by no means the norm. In other words, it seems unlikely that the participants experienced the pleasure of curiosity based on an experience of these negatively valenced prospect-based emotions. The average rating related to the question of whether the participants had devised strategies while playing indicated that they to some extent had done so. However, these ratings do not provide any information about what the participants consider to be a strategy, whether they managed to execute it, or whether the successful execution led to an experience of virtuosity. The average ratings associated with the question of whether the sound and visuals contributed positively to the participants' experience indicated that this was indeed the case, which in turn suggests that the sound and visuals were generally well received.

The results related to the question of whether it mattered to the participants how many cows they managed to collect and return to the mothership indicates that it did in some capacity matter to most of the participants how well they performed. Moreover, it is worth mentioning that some participants wanted to know what the record number of collected and returned cows was, and several participants expressed that they would like to try the game once more to get a better score. This may be seen as an indication that the game successfully imposed goals on at least some of the participants. The data pertaining to the participants' desire to continue playing suggested that many of the participants to some extent wanted to continue once the game was over. Finally, the results related to the question of fatigue suggested that it varied greatly from participant to participant how tired they were after playing the game.

8 Conclusions and Future Perspectives

In this paper, we have described the design and evaluation of a prototype intended to fulfill two purposes, namely, to facilitate correct ankle training by means of a wobble board while leveraging games' potential as a source of intrinsic motivation. The expert consultation confirmed that the prototype did ensure correct ankle training even though it was not ideal during the early stages of a rehabilitation process.

Although the quantitative test results did not unequivocally prove that all of the participants found the act of playing the game intrinsically motivating, it did indicate that this was the case for a number of the participants. We conclude that several of the participants did experience some level of virtuosity and that the prospect of becoming proficient at playing brought about a wish to continue playing in many cases. Despite participants' reporting that they did devise strategies, it remains unclear whether strategies were successfully executed and whether this execution led to experiences of virtuosity. We conclude that the audiovisual representation of the game contributed positively to the participants' experience since they generally seemed to agree that the sound and visuals made them like the game more. Finally, the game appears to have successfully imposed goals on a number of the participants and we conclude that the participants generally wanted to continue playing once the game was over. With this being said, it is worth recalling that this version of the prototype was designed for and tested on first-time users who had prior experience with playing video games. Thus, we are at present unable to conclude whether this specific game would appeal to other users, such as elderly people. It does in fact seem likely that future games should be tailored for the particular segment of potential users. This notwithstanding, we can with cautious optimism conclude that the prototype may serve as a source of intrinsic motivation for this particular group of users. However, further assessment by means of well-established measures of intrinsic motivation is necessary in order to further substantiate this conclusion. More evaluations of the efficacy of the training facilitated by the prototype are similarly needed in order to determine how the training compares to the one achieved with conventional wobble boards.

The need for reactive balancing by the player did, as suggested, make the game less suitable during the early stages of a rehabilitation process. This knowledge has led

us to believe that the game may be more suitable for individuals in need of preventive training. However, in order for the game to continue serving as a source of motivation for individuals in need of such training, the gameplay will need to be modified so that it remains challenging for an extended period of time. That is to say, in order for the game to continue eliciting a feeling of virtuosity, the difficulty of the challenges will have to become progressively higher as the individual becomes more proficient. At present, we are considering two approaches to dealing with this issue, namely, the addition of more levels, and the inclusion of adaptive gameplay. By including additional levels, where the player faces increasingly difficult challenges, it should be possible to ensure a continued experience of virtuosity. This solution is, however, not particularly cost-effective, since players inevitably will reach a level of proficiency that enables them to complete all levels with relative ease. The second approach, adaptive gameplay, may provide a viable solution. By adaptive gameplay, we mean gameplay where the difficulty of the challenges changes dynamically in response to the player's current skill level. The difficulty level could be changed by dynamically varying the sensitivity of the controls or altering the game environment, for example, by changing the density of the asteroids and cows or the sensitivity of the controls. It should be stressed that in order for adaptive gameplay to elicit virtuosity rather than frustration, the player has to be aware that the difficulty has increased in response to his or her increase in proficiency. Notably, the inclusion of adaptive gameplay does not preclude the option of adding more levels.

Presently, we are working on producing games that do not prompt reactive balancing and thus may be suitable for individuals in need of ankle rehabilitation rather than preventive training. To be more exact, we have started designing and implementing a series of minigames based on the described theory of video games as emotional experiences. Each game will be designed to facilitate one or more of the prescribed ankle exercises (Figure 2) by integrating these into the gameplay. For example, one game was developed with the intention of making the user balance steadily on the board for as long as possible. When playing this game, the player controls

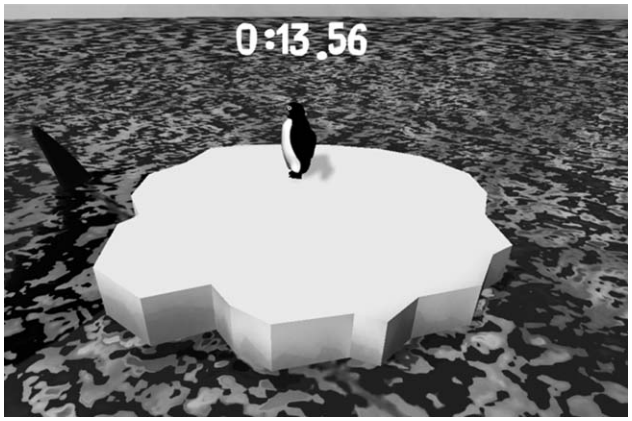

Figure 9. *Screen shot of a simple game designed with the intention of facilitating ankle training without the need for reactive balancing.*

the movement of an ice floe by means of the wobble board. The tilting angle of the board is directly mapped to the tilt of the ice floe. On the flat surface of the ice floe, the player sees a penguin slowly walking in a circle. The objective of the game is to simply prevent the penguin from falling off the ice floe and thus falling prey to the killer whale circling in the water (see Figure 9).

This game is first and foremost designed with the intention of eliciting a feeling of virtuosity, and since the player does not have to respond to unexpected obstacles, it is believed that there is no need for reactive balancing on the part of the player. Our initial tests of the gameplay indicate that players find the game enjoyable and simultaneously highlight the need for gameplay mechanics that penalize the player when performing undesired actions such as letting the edges of the board come into prolonged contact with the ground. In response to this need, we have redesigned the game so that pieces of the ice floe fall off when the player performs such actions. In conclusion, we feel reasonably confident that the continued iterative development of the prototype will amount to a hardware and software solution which can provide individuals with the motivation necessary in order to successfully complete ankle rehabilitation processes.

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