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ORIGINAL RESEARCH

Tactile Radar: experimenting a computer game with visually disabled

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ABSTRACT

Background: Visually disabled people increasingly use computers in everyday life, thanks to novel assistive technologies better tailored to their cognitive functioning. Like sighted people, many are interested in computer games – videogames and audio-games. Tactile-games are beginning to emerge. The Tactile Radar is a device through which a visually disabled person is able to detect distal obstacles. In this study, it is connected to a computer running a tactile-game. The game consists in finding and collecting randomly arranged coins in a virtual room.
Methods: The study was conducted with nine congenital blind people including both sexes, aged 20–64 years old. Complementary methods of first and third person were used: the debriefing interview and the quasi-experimental design.
Results: The results indicate that the Tactile Radar is suitable for the creation of computer games specifically tailored for visually disabled people.
Conclusions: Furthermore, the device seems capable of eliciting a powerful immersive experience. Methodologically speaking, this research contributes to the consolidation and development of first and third person complementary methods, particularly useful in disabled people research field, including the evaluation by users of the Tactile Radar effectiveness in a virtual reality context.

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Tactile Radar; tactile-games; visual disability; assistive technology; virtual reality

➤ IMPLICATIONS FOR REHABILITATION

- Despite the growing interest in virtual games for visually disabled people, they still find barriers to access such games.
- Through the development of assistive technologies such as the Tactile Radar, applied in virtual games, we can create new opportunities for leisure, socialization and education for visually disabled people.
- The results of our study indicate that the Tactile Radar is adapted to the creation of video games for visually disabled people, providing a playful interaction with the players.

Introduction

Assistive technologies for the visually disabled have significantly improved in the last decades. These people have increased access to computers during their formative years, at work and in everyday life, thanks to novel assistive technologies and software better suited to their particular cognitive functioning. Like sighted people, especially the young, many are interested in computer games. Some of them developed the habit of playing with sighted relatives and friends, using mnemonic strategies and the game's auditory features.

Computer games, in addition to providing entertainment and leisure, can also be used in education, health and rehabilitation [1]. Despite the growing interest in this type of application, visually disabled people suffer from the lack of an appropriate interface (indeed, by and large, today computer games are *video* games). Most virtual games are designed using primarily *visual* stimuli, i.e., the necessary stimuli for proper understanding and interaction with the game are visual. Secondary stimuli may be auditory or haptic, but these are only supplementary since their absence does not prevent the user from interacting and understanding the game [2].

Among the games accessible to visually disabled people, we can highlight audio games [3]. In these, the primary stimulus is auditory. Different techniques can be used, such as binaural sound and spatialized soundscapes to enhanced spatial awareness, or musical cues such as rhythms and tones. There is an extensive list of audio games available on the web with different themes and features, such as car racing games, shooting, role-playing game, strategy, platform, puzzle and also educational games [3].

Recently, games using haptic stimuli – mostly for musical training and sports games – are been developed [2]. Tactile stimuli may be provided by a specialized interface such as the haptic glove [4], or by fitting vibration actuators onto commercial game controllers (Wii Remote) [5]. They can also be associated with a gesture detection device via camera as Kinect, working as a sensory substitution solution in real time [2]. Although these games are not targeted for the visually disabled, they involve accessible strategies such as haptic clues to the player's response which can vary in duration, pattern and frequency. The haptification, in other words, "modulation of a continuous representation of a haptic clue (frequency, intensity or a pattern) can be used to indicate spatial information such as the distance to or the location of an object in front of the player" [2, *p* .19]. The combination of

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auditory and haptic stimuli is also used, improving performance and reducing errors [6].

Through the development of assistive technologies such as the Tactile Radar, applied in virtual games, we can create new opportunities for leisure, socialization and education for visually disabled people. The present study aims to contribute to the technological improvement of the Tactile Radar applied to tactile-games.

From a practical point of view, the greatest impact of the lack of vision is locomotion, due to the difficulty or impossibility of anticipating the characteristics of the environmental space [7,8]. Although the long cane offers some anticipation to the blind, this anticipation is, according to Foulke [9], very restricted when compared to the anticipation provided by the visual sensory system to the sighted pedestrian.

Despite all technological commitment in finding solutions for autonomous and risk-free locomotion, the spatial displacement of blind and low vision individuals remains problematic. Although the cane represents a very useful resource, it presents some serious limitations, especially because it is not able to give the desired protection to one of the most important parts of the human body: the head. This problem becomes particularly acute in cases when the blind needs to move around alone in cities, crammed of objects such as signposts, public telephones, advertisements, etc. [10–12].

Several tactile-vision sensory substitution devices have been developed. One of the most famous is the tactile vision sensory substitution. This device, invented by Bach y Rita [13–15] and his team in the early 1960s, allows to transform the visual images captured by a miniature video camera into tactile images transmitted to an array of mini piston vibrators placed in contact with the skin of the back [13–15]. However, since the transmitted information by this device is quite complex, the blind person must undergo training to learn how to interpret the multiple information from the natural environment during the locomotion. Moreover, the high cost of this device makes it sometimes inaccessible.

In order to overcome these limitations, researchers at the University of Tokyo have recently developed a less ambitious and less expensive device than Tactile Vision Sensory Substitution, but through which the visually disabled person is able to easily detect the presence of distal obstacles without interfering with the sense of hearing or in the interpretation of a complex information: The Tactile Radar [16]. Emitters and receivers which can be fixed in different regions of the body transmit, in a discrete and effective way, by tactile stimulation, the most varied information about the surrounding space. According to preliminary studies [16,17], and functional demonstrations presented during the 11th edition of the scientific show "Laval Virtual" in France in 2009 [18], this promising device is not only suitable to guide blind individuals in their movements in space, as well as to better protect their bodies, especially their heads. Consisting in relatively simple modules, it enables easy use with acceptable aesthetics (sensors/stimulators can be easily hidden under a hat or cap) and low manufacturing cost.

Blind people who use Tactile Radar perceive and react by avoiding obstacles, in the same way insects detect, through their antennae and mammals through their specialized hairs or fibrils, the stimuli located in space. Whenever an object enters the Tactile Radar user's space field, he receives a vibratory stimulation that allows him to intuitively interpret the angle of its approach. As a consequence, he tries to get rid of stimulation automatically, moving his body away from the position and trajectory of the external object. This same principle of operation allows subjects to detect stimuli not only to avoid them, but also to locate and interact with them. This feature is particularly useful for discovering the stimuli present in the surrounding environment and act towards them.

A subsequent study by Cassinelli et al. [19] assessed the impact of Tactile Radar in the degree of anxiety that autonomous locomotion usually trigger on people who are blind. A hairband-like prototype was created consisting of five modules containing an infrared distance sensor and a vibratory motor each, placed in the frontal and temporal regions of the head. The obstacle detection radius forms a sort of invisible protective umbrella around the peri- and extrapersonal space. With a maximum detection radius of approximately 1 m, this device assists in detecting obstacles in the region of the user's head and shoulders, covering an area neglected by the cane commonly used by the blind. This previous study, published in 2014 was performed with 42 visually disabled people, 20 of them were congenital or early blind and 22 were late blind. The experiment consisted in crossing two consecutive corridors, one empty and the other with seven light and flexible obstacles at the height of the head, following a straight line and avoiding collisions. The results indicate a significant decrease in anxiety, when the values of the two groups are compared, before and after the experiment. This seems to be due to the protection in the region of the head and shoulders by the use of the device.

The present study is about a different version of the Tactile Radar, which functions as a virtual interface device.

Materials and methods

Objective

The aim of this study was to analyse the use of Tactile Radar in a computer game whose purpose is locate and collect coins in a room inside a virtual reality environment. The study was conducted with congenital blind people and sought to identify the playful characteristics of this experience and immersion capability in the virtual world, as well as to examine possible links between mobility in the real world and the virtual world, regarding the detection of targets and avoidance of obstacles.

Virtual Tactile Radar

This prototype has six vibration modules around the head (one in the anterior region, two in each lateral region and one in the posterior region), a compact inertial measurement sensor, comprising an electronic compass, accelerometer and gyroscope placed on the top of the head, an analogic joystick and a module with a rechargeable battery and an radio frequency transmitter/receiver for communication with the computer (Figure 1).

The goal of the game is to capture 10 coins scattered randomly in a rectangular virtual space. The avatar (player's virtual representation) has a (controllable) radius of detection so the user can perceive coins and walls before a virtual collision takes place. Vibratory stimulation from one or more modules allows the user to intuitively interpret the angle of approach and the proximity of the obstacle (roughly proportional to the intensity of the stimulus) [19]. The subject receives two distinct types of stimulus: one related to the wall, which is a continuous vibration; and the other to the coin, which is an intermittent vibration. When the subject touches the coin, the computer speakers emit an audio clue, similar to the drop of a coin in a can. An additional sonic stimulus represents the collision with the rectangular space walls, which is presented as an acute and continuous beep emitted by the Tactile Radar itself.

The software allows experimenters to observe participant performance by displaying the avatar, coins, and walls of the virtual environment. The avatar's trajectory is seen as a blue line (Figure 2). The trajectory, timing and performance metrics (mean distance to walls, etc.) are logged and saved in a file at the end of each experiment.

Participants

The group of participants consisted of nine people, seven males and two females (students, faculty, and staff of the Benjamin Constant Institute of Rio de Janeiro) with congenital or precocious blindness (born blind or lost vision by the age of 3) and were therefore deprived of visual memory [20]. Ages range between 20 and 64 years. The participants are identified with the letter P and a number (P1, P2, … P9) when referenced in the interviews and in their plots in Figure 3.

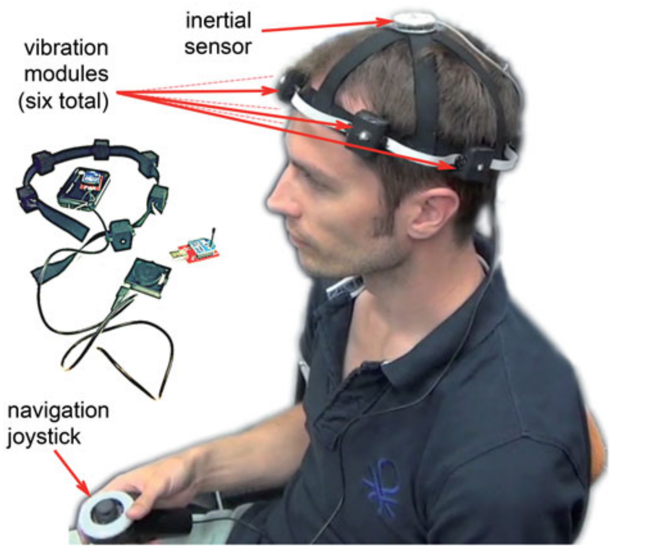

Figure 1. The virtual Tactile Radar system comprises an inertial sensor, six motor vibrators, a beeper, a joystick, a radio frequency transceiver and a wearable battery pack.

This study articulates third-person and first-person methodologies [21,22], which are particularly useful in researches involving visually disabled people [23,24]. The third person methods analyse a performance, with emphasis in the behavioural and quantitative aspects, as is the case of the classic experimental method. In turn, first person studies seek to describe the experience itself by the participants of the research. Recent studies [21,22] gathered papers about well-defined strategies for access to lived experience. These strategies, such as the debriefing interview, go beyond mere self-observation and involve a second person who guides access to experience. In the field of visual disability, the use of complementary methods of first and third person [23] has enabled the production of distinctive data with complementary value.

The experiment

The quasi-experimental within-subjects design was used in the production and analysis of third-person data on virtual locomotion performance. The experiment was conducted with one participant at a time and the presence of at least two experimenters. A notebook, the Virtual Tactile Radar, a swivel chair for the participant and a screen projector were used in the experiment. A camera was installed in the room to record the sessions, focusing on the participant and projecting the computer screen onto a screen located behind the subject.

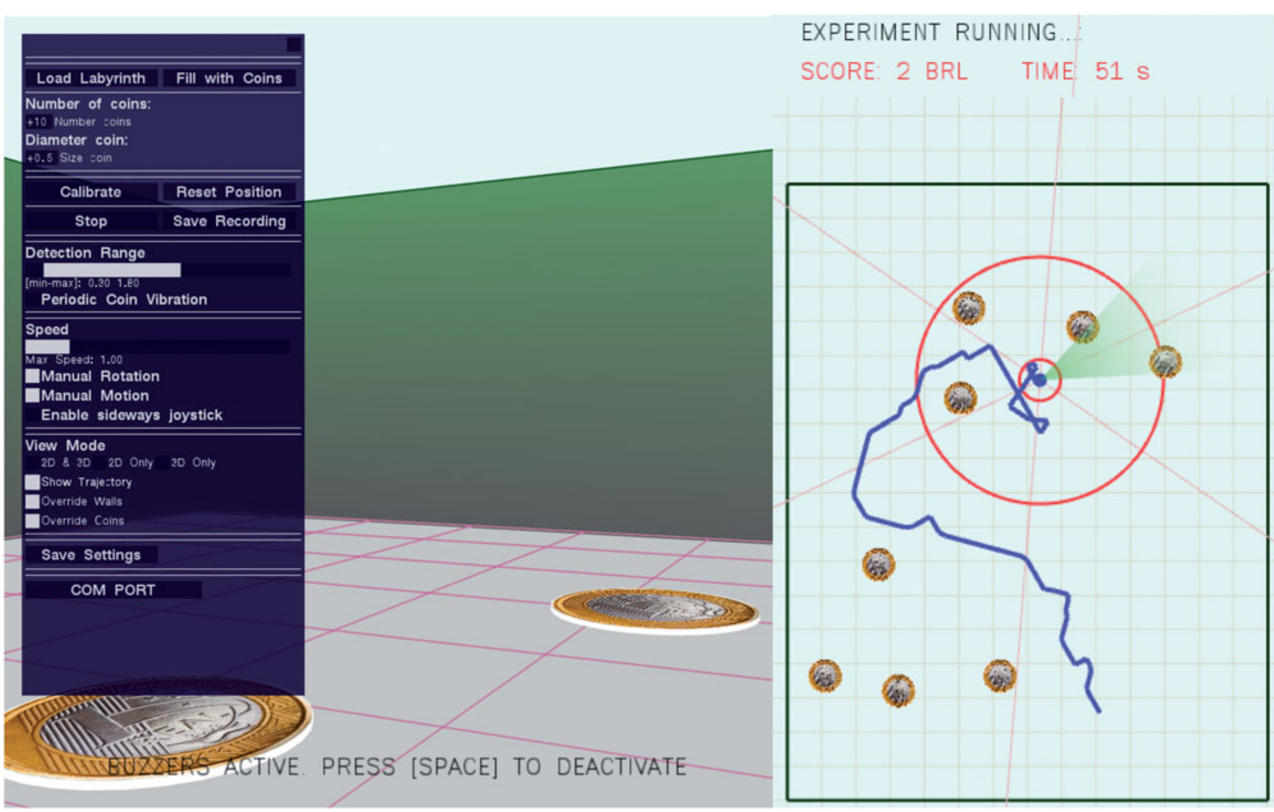

Figure 2. Video output of the experiment. Left: 3D view of the virtual space and dashboard to set game parameters. Right: 2D "bird view" of participant's trajectory in virtual space.

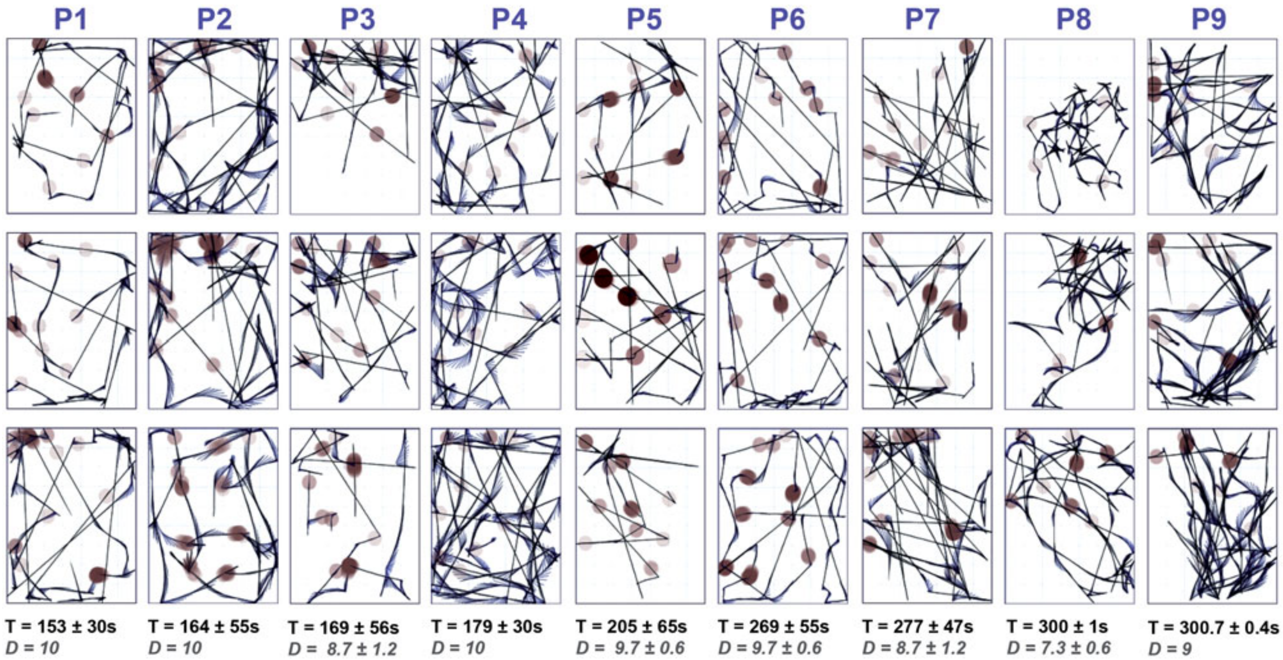

Figure 3. Recorded trajectories for the nine subjects identified from P1 to P9, arranged in the horizontal direction, from left to right in order of increasing completion time (T). The three trials of each subject are placed in the vertical direction, from top to bottom. It is visually clear that the subjects use different search strategies as described in the text. The trajectory fractal dimension D – as calculated in [25] – did not correlate with completion time though ($r^2 = 0.0018$).

The participant seated in a swivel chair, moves in the virtual environment using the joystick. He can push the lever forward or backward, moving straight and at a constant speed, calibrated by the computer. He can change the moving direction by rotating around the chair's axis. The heading is continuously logged by the electronic compass, after initial calibration.

When the game starts, the participant finds himself in the centre of a rectangular walled space, facing one of the smaller walls of the game – which corresponds to the "back of a room". Physically, he is in front of the experimenters' table, who help him with the game. A metronome gives audio cues and assists the subject locating the reference point (the back of the virtual room). Ten coins are randomly distributed in this space; they must be captured in 5 min.

Each volunteer had participated in a single session of approximately 1 h, consisting of instructions, anamnesis interview, Tactile Radar use training and three final tests of 5 min each. The sessions were recorded on video with participants' permission.

In the anamnesis interview information on schooling, daily activities, type of visual disability, computer use, and self-evaluation on the level of motion autonomy, scores from 0 to 10 were obtained. After anamnesis, the participant sits in the swivel chair facing the table where the computer is located and is invited to experience the device with his hands, freely exploring its components and receiving explanations about them. After this initial recognition, one of the experimenters adjusts the device on the participant's head and the transmitter module and battery are placed in a small bag hanging from his neck. He is asked if he is feeling comfortable and further adjustments are done. He should be seated in the chair facing the desk, with the device set and holding the joystick for the training to continue.

At the beginning of the training, the avatar is placed facing a virtual wall at a maximum detection distance and the Tactile Radar is turned on. The participant thus receives a weak stimulation and is asked if he is feeling the vibration. The experimenters gradually approach the avatar to the wall and observe the subject reactions, asking about the intensity and the direction of the stimulus. They explain the vibration stimulus is a wall. Then, they change the position of the avatar, triggering the side and rear vibration modules, experimenting and asking him to recognize the direction of the stimuli. After recognition of the wall's stimulus, they proceed to the coin's stimulus. The avatar is placed next to the coin and the participant is asked if he had noticed any difference. The recognition of both stimuli is tested, presenting the coin or the wall alternatively.

After the participant learns to distinguish both stimuli, the software is calibrated for the test situation. The participant sits facing the table and the avatar is positioned in the centre of the virtual room and the metronome beacon is turned on. Ten coins appear randomly distributed and the game can start. The participant thus experiences the game as many times as he wants with the experimenters' help, learning to move inside the virtual space using the joystick and rotating the chair. At this point, he is assisted in capturing coins, receives instructions and is reinforced in successes. The coin-catching sound and the colliding-wall beep are perceived and acknowledged by the participant. In the end, one more training is done in the same conditions, but without help of the experimenters and with a 5 min time limit.

After training, each participant plays three games (in each, 10 coins should be captured within 5 min). Each test was considered concluded after the capture of all coins or after timeout. While one of the experimenters calibrates and monitors the game's operation, the other registers (in seconds) the capture time of each coin in a table. At the end of each test, a file containing all logged data is saved in the computer (coin capture time, trajectory, speed and heading).

Data analysis methodology

To verify if the Tactile Radar is suitable, from the point of view of the control exercised by the participants, to a virtual environment of a computer game, the videos were analysed in order to classify coin capture into two categories: intentional capture and accidental or random capture. Two observers were recruited to evaluate independently all the tests performed, classifying each catch in one of the two categories.

When there were indications that the subject was moving intentionally to the coin, perceived by the vibration, the case was classified as "intentional capture." These clues were the targeting of the avatar to the coin upon its detection, repeated movements around the target before reaching it, and movements apparently aimed at the target.

When there were indications that the catch was accidental, that is, when they accidentally collided with the coin during the exploration of the virtual environment, the case should be classified as "random capture." These indications were: capture of the coin after a steady course in one direction without interruption, the verbal expression of the player, who spontaneously admitted capturing at random and movements apparently not aimed at the target but which resulted in its capture.

After the observers' evaluation, an interobserver agreement analysis was performed, using the Kappa coefficient to measure the degree of agreement beyond what would be expected by chance alone. Furthermore, comparison of strategies and single trajectory were analysed visually and using fractal index [25].

Participants were also divided into two groups: the most experienced and familiar with games (Gamers = 5) and the lay or little experienced (Non-gamers = 4). A Pearson chi-square test was performed to verify if there was a significant difference in the performance of these groups in relation to the intentional capture strategy. Participants' progress was assessed by the number of intentional catches and the duration of each test using the repeated-measures ANOVA test.

The interviews

First-person data were obtained through interviews with participants. The debriefing interview technique [26] was used to obtain a first-person description of the experience of using Tactile Radar. The interviews sought to identify the potential playfulness of the experience, the possible experience of immersion and the possible links between locomotion in the real world and in the virtual world. Interviews were conducted with all participants, which were recorded, transcribed and analysed.

Results

The interviews revealed that seven out of nine participants liked the game and had pleasure, as well as enough engagement to reach the end and the goal of the game. In the group, the young boys had already previous experience with electronic games, which was not verified with the older and female participants. These data are similar to the sighted players' universe, where video games reach more strongly young male, being a hallmark of a generation. Several participants in our study are audio-games users (car racing, war games), available free on the internet, having the habit of playing at least a few hours on weekends. However, there was no significant difference in the scores of gamers ($N = 5$) and non-gamers ($N = 4$), verified by Pearson's chi-square test, χ^2 $(1) = 1.03$, ($p > .05$). These results could suggest that the Tactile Radar showed a similar difficulty level for both groups and that previous experience with other game types did not give significant advantage to the group of young gamers over non-gamers. Nonetheless, the low number of subjects does not provide enough statistical power to support this conclusion. Further studies can clarify this issue.

Performance and control

Participants showed a progression between the first and last sessions (T1, T2, T3, respectively), both in terms of correctness (mean/standard deviation: T1 = 6.55, SD = 1.59, T2 = 7.11, SD = 1.61, T3 = 7.22, SD = 1.20) and duration (mean/standard deviation: T1 = 245.55 s, SD = 68.16 s, T2 = 227.33 s, SD = 69.96 s, T3 = 211.56 s, SD = 73,28 s), indicating a learning process. However, the repeated measures ANOVA indicates that this difference is not statistically significant neither for the correctness ($F2,16 = 0.56$, $p = .58$) nor for the duration ($F2,16 = 1.11$, $p = .35$).

Regarding the randomness margin and the game control, the first-person data analysis indicated that some participants considered the game very random and they wanted to have greater player control, avoiding errors and undesirable repetitions. The observers' analysis, relating to the capture strategies used by the subjects, showed a substantial degree of interobserver agreement [27], Kappa =0.618 ($p < .000001$). The results points to a significantly higher difference in the intentional capture strategy (188 of 220 cases, 85.5%), revealing the subjects' concern to maintain a game control, as can be seen in the trajectory analysis, and in the interviews below.

Trajectories

Comparison of strategies

From the visual analysis of the trajectories it is clear that different people have different "strategies" while exploring the terrain. Some seem to prefer to move fast and cover a wide area; others seem to pay more attention to the tactile cues or the presence of walls; and when capturing a coin, some seem to re-start the exploration somehow forgetting about the mental map (see below).

Something that would be great is to find some measure explaining the differences of completion time from the geometry of the curve – how good the person "fills" the space. We tried to rate the strategy using a space-filling measure (fractal index [25]), but the results were not significant (no correlation between the completion time and the fractal index).

Single trajectory analysis

It follows from the visual analysis of the trajectories (Figure 4), that subjects barely rotate *while* advancing (minimum speed correlates with maximum angular speed), perhaps indicating that the swivel chair coupled with the forward button is not an ideal setup. Also, the orientation of the head is in general not aligned with the eyes' pointing direction. In some cases, the user even moves backwards as he continues exploring the space (perhaps the head orientation and the forward direction are less correlated in blind people).

Interviews

Some participants (P2, P9) linked the space exploration in the game with activities in real life. For example, the sweep of space with the action of sweeping a room. One of them said that when he sweeps, he feels with the soles of his feet where he already cleaned and does not go there again. Although in the game, there are no indications if a part of the room has already been explored.

Three participants (P2, P5, P7, see Figure 3) stated that during the game, they sought to create mental maps of the room using daily life strategies and the Tactile Radar resources. In this regard, P7 pointed out that he usually likes to have a fixed reference

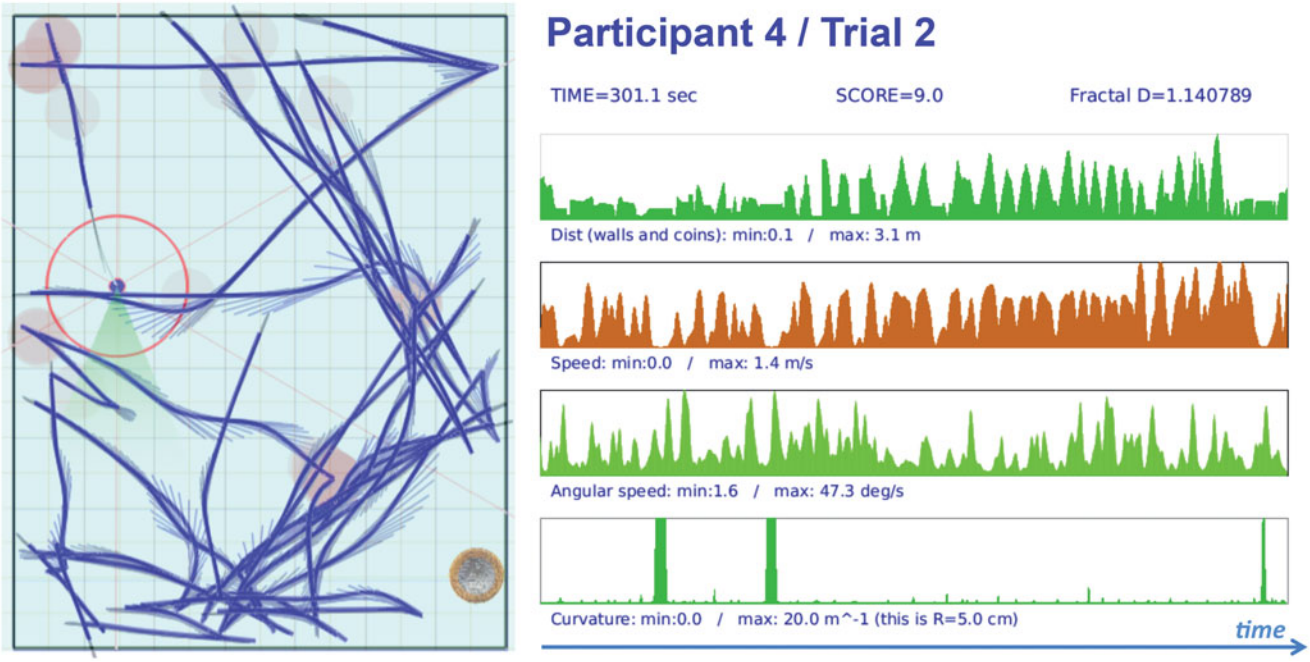

Figure 4. Analysis of a single trajectory (mean distance to walls, mean speed, rotation and curvature). We tried to rate the strategy using a space-filling measure (fractal index as in [25]), but the results were not significant.

point and emphasized the importance of the metronome. P5 reported that his cognitive map of the room did not include the coins.

P7 said that he tried to know if hitting the wall of the virtual room took points in the game. After a negative answer, he decided to move forward as fast as he could to save time, even at the risk of colliding with the wall.

P2 used the vibration on the forehead to circumvent the room, thus performing a systematic exploration. He said: "I was trying to keep the same lateral vibrating intensity, so that I judged it was a reasonable distance from the wall." His strategy was to first circumvent the room and then explore the inner part, as he usually does in everyday life. To trace the outline of the room, he started from the right and counted the four corners, believing it to be a square. He said that "all the time I was remembering it (the room) so that I could have a reasonable notion of where I had already been."

P5 did not want to scan the room completely, as the fun of it would "begin to wane". As the game involves spatial displacement and location, and logical reasoning does not account for it, he did not want to use logical strategies and mathematical calculations. However, he sought to construct a mind map.

Regarding the immersion experience, the subjects spontaneously used terms such as P2: "I was walking", "I was pacing back and forth", "and I imagined myself walking on the chair". "I felt in the game. The fact that you move around, makes you feel in a kind of real situation, which forces you to create a strategy. It is a kind of stopped motion. (…) It is very confusing for you to be moving and standing still. So I had to virtualize the space, as if I were walking in it. I imagined myself walking, so much that I really moved. The feet sometimes moved so much … but I knew I was sitting. (…) Maybe if I were standing up I would move. Maybe I would walk around the room, but as I was sitting, the body just intended to move. I had never thought of or been through it, I had never imagined that. It was very different for me. It was surprising." P7 said: "my chair running like this – Vruuum".

When asked if that feeling happened while playing the automobile racing audio games, P2 said no. "I did not feel like I was inside the car. (…) It was the control of something that you just turned left, right, the arrows, brake… You feel the noise of the car next door, but I did not feel inside the car properly because I was not moving. It was a surprise in relation to what I used to play." In the game with the Tactile Radar "You are inside the space, you feel to be the avatar. You are not guiding a doll. You are the doll! The tactile game brings you to reality. (…) Unlike the audio games. Here, I really felt inside that square, as if I were walking there in that space."

P7 also had the feeling he was moving. "I thought I was going too fast [laughing]. I imagined it forward and backward as well. I imagined my chair running like this – 'Vruuum'. I always imagined myself walking on the chair. The chair swung there. Then I would turn around quickly. As if I was driving it. I turned with it as if it were a cart [laughing]… I *lived* that thing there!"

P1 said that he felt "the experience of being there in the room looking for an object that was lost".

When they were asked to talk about a remarkable experience during the game, participants mentioned the surprise of finding the coin, the sound of the coin catching: "Plim!" The sound that marks the end of the game and, finally, the unexpected immersion experience.

It is worth saying that the success in the game proved to be independent of immersion experience. One of the subjects (P4) with best performance seemed not to experience immersion.

The participants listed a number of suggestions to improve the game in future versions. Aiming for greater autonomy, it was suggested that the game had its instructions in audio. It was also suggested to include a greater number of auditory resources, which in the current version are restricted to the sound of the wall and the capture of the coin.

Some of the participants suggested that coin capture should be inserted into a context or even part of a story, as in the latest video games, thus increasing the level of "adrenaline" in the game. It was mentioned the interest that the game had increasing levels of difficulty and steps to be overcome. Still regarding to adapted games more similar to the games currently developed for sighted people, it was suggested to create a kind of clothing with tactile devices. In this case, the game would involve the whole body of the player, not only the head.

The participants suggested that the game could not only be aimed for blind people, but also for sighted people. Some of the participants claimed to have a habit of playing games aimed for sighted people, in the company of siblings and friends who are sighted. It was observed that this was easier in games of previous generations, since nowadays the games increasingly use eminently visual resources, making the participation of players with different visual conditions more difficult. One of the participants said that he would like to play a game that would be more difficult for the sighted, as the game with tactile resources, to "get his own back".

Participants' comments and suggestions about the immersion experience are consistent with Boullier's [28] study of attention regimes. The immersion system combines fidelity systems (which are based on duration) and the alert system (which is based on intensity) and has privileged media in video games. Its predecessors are flight simulators, where engagement in the fictitious world is favoured by the fact that the spectator/player is effectively an actor, constituting with the device a close coupling. The actor is summoned to participate directly in the production of events and reaches a sensory-motor coupling as described by Varela et al. [29] in his enaction approach. The game makes a world emerge, or rather, we make a world emerge as we play.

Immersion is the ability to stay connected to the game for a long time and it is independent of special helmets use. During tests performed to evaluate the quality of games during its design, it was found that the attractive character of the game is an important criterion for lasting attention anchoring of the player. The presence of a plot and the quality of the sound environment were also highlighted to create the conditions for a deep immersion experience. The positive character of rewards was also emphasized, that is to say, to regularly obtain satisfaction for progress made. The observations collected by Boullier [28] with sighted players go in the same direction as those presented to us by blind players for the development and improvement of the Tactile Radar game.

Conclusions

Based on the third and first person data, it can be concluded that the Tactile Radar may be successfully used in tactile-games, which is an important step in the computer games accessibility to blind people. It was found that the desire to play exists, especially in young boys, part of the electronic games generation, but no significant difference was found between the group of more experienced players (Gamers) and the lay (Non-gamers) in regard to catch strategies. Regarding to the control exercised by participants in the coins' capture, the third and first person data are congruent. However, the interviews revealed a desire for even greater control over future versions of the game. In the future, it would be interesting to use this kind of simulation as a tool to adjust the range of detection of the real Tactile Radar as a function of the walking speed and the mean distance to obstacles in the real world. This could be done for instance by measuring the time it takes to find the exit of a (straight or curved) corridor or a labyrinth of different width, while varying the range of detection which was fixed in the present experiment.

Two different relations were established between the experience of the game and the learning of everyday life. In a first relation, strategies employed in daily life are employed to play. In a second relation, the game is perceived as being able to be used for training the necessary abilities to daily life, such as the displacement and space exploration directed towards specific goals. One of the participants stated that the game can increase self-confidence to explore the space of a real room. It could serve to develop skills in location and spatial displacement (serious games) [1]. Future versions of the game could more easily provide the experience of immersion, which can contribute to the use of the game in training techniques and cognitive strategies of daily life. It was also noted that the radar would be quite useful in practical life.

The results indicate that the Tactile Radar is adapted to the creation of video games for visually disabled people, providing a playful interaction with the players. There are indications that the immersive character is present, and can be increased. Some elements have proved to be important in the emergence of the immersion experience, which seems to be directly related to the active manipulation of the joystick and the tactile experience. Sitting in a swivel chair also seems to be an important element. In addition, this research contributed to the consolidation and development of the articulation of first and third person complementary methodologies, particularly useful in the disabled people research field, including the evaluation by users of the Tactile Radar effectiveness in the virtual reality context.

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