

# Evaluation of Three Accessible Interfaces for Educational Point-and-Click Computer Games

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## Abstract

Despite the increasing importance of digital games, game accessibility has not yet received enough attention. As a consequence it is unclear how to design games that are engaging and usable also for people with disabilities. This work analyses perceived usability, entertainment and overall experience provided by three interfaces for blind people with different gaming habits: (1) a keyboard navigation system, (2) a sonar and (3) a conversational interface. Data collected from a preliminary experience suggests that the three interfaces could be used for games, although (3) seems a better choice for occasional gamers and novice users and (2) for regular and frequent gamers or users seeking new challenges.

## Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – *auditory (non-speech) feedback, graphical user interfaces (GUI), natural language, screen design;*

K.3.1 [Computers and Education]: Computer uses in education – *distance learning, computer-managed instruction;*

K.8.0 [Personal Computing]: General – *games.*

D.1.7 [Programming Techniques]: Visual programming;

## General Terms

Design, Economics, Human Factors.

## Keywords

Accessibility, audio 3D, eAdventure, point-and-click interaction, eyes-free games, e-learning, distance learning, game authoring tools, game-based learning, online learning, videogames.

## 1. Introduction

Playing digital games has become one of the most popular leisure activities for people of all ages, genders and backgrounds. Moreover digital games are increasingly being adopted in education as a way to engage students and improve academic performance (Johnson, Adams, & Cummins, 2012). But at the same time digital games remain almost inaccessible for people with disabilities, as the number of games that are accessible in the

market is still very limited (Westin, Bierre, Gramenos, & Hinn, 2011). Given their importance in modern society, this means a significant potential source of digital divide (Abrahams, 2010; Yuan, Folmer, & Harris, 2011).

Research to improve the accessibility of the games has been conducted in the last years. Nonetheless, the state-of-the-art in game accessibility is years behind other fields. Broad guidelines have been built from successful case studies by influential organizations like the International Game Developers Association (Bierre et al., 2004) and also by enthusiastic advocates (Game Accessibility Guidelines, 2012; Yuan et al., 2011). But these recommendations are far from being as stable, as used and as widely accepted as other guidelines like the WAI, which even have the status of standard (W3C, 2006). This is partially because games are very complex pieces of software that deliver a unique user experience (J. L. G. Sánchez, Vela, Simarro, & Padilla-Zea, 2012) and thus approaches that have helped to improve accessibility of other Information Systems are not fully applicable. Accessible game interfaces should be usable, allowing user-friendly and pleasant interaction but preserving elements that are central to entertainment, like immersion, challenge and engagement regardless of the player's abilities or previous experience. For example, if an accessible interface alters substantially the level of challenge of the game, enjoyment would be diminished, as there is a clear relation between an appropriate level of challenge and players' engagement (Chen, 2007).

Game play experience is influenced by a number of personal and contextual factors that makes the 'one-size-fits-all' approach unlikely to suit all players. Studies like (Yee, 2006) reveal how players differ from one another, showing that the motivations that drive players to play a game and their mental goals are variable. In education, there are additional personal parameters to consider, like the different backgrounds, gaming habits and preferences of the students, which result in having a very diverse population. Dealing with player diversity, which is something that many good games do naturally, is very important to avoid exclusion and maximize the positive effects of Game-Based Learning (GBL). For example, literature has shown that gender affects student performance and perspectives on GBL (Hwang, Hong, Cheng, Peng, & Wu, 2013).

Game accessibility research usually ignores the effects of personal characteristics on the game play experience. This paper aims to contribute to bridge this gap. As previously discussed, diversity is determined by a wide number of factors. In this study we focus on gaming habits as a single player diversity parameter. We investigate accessible interfaces that can deliver an optimum game experience to blind people with different gaming habits. To narrow the scope of the project we have focused on *point-and-click* adventure games, a genre that is suitable not only for entertaining but also for education and other serious applications (Amory, Naicker, Vincent, & Adams, 1999; Dickey, 2006). Usability and entertainment provided by three non-visual interfaces for blind users are analyzed: (1) a keyboard navigation system that makes playing similar to web browsing, (2) a sonar that allows play by using the mouse; and (3) a conversational interface that interprets short commands in natural language.

This paper is structured as follows: section 2 summarizes the state-of-the-art in designing games that are accessible for blind users. Section 3 analyses the point-and-click adventure genre we are focusing on. Section 4 introduces the eAdventure gaming platform, which has been used as a base to implement the interfaces proposed, which are described in section 5. Section 6 describes the preliminary evaluation conducted and section 7 elaborates conclusions and future lines of work.

## 2. Related Work: Non-Visual Games

Blind people are among the communities of people with a disability that find more barriers in mainstream titles. However, they also constitute one of the target groups that have attracted more research (Westin et al., 2011). They are also supported by influential communities of advocates and gamers like AudioGames.net (Audio-Games, 2013), or the International Game Developers Association (IGDA) special interest group on accessibility (Bierre et al., 2004), which are actively engaged in the development of guidelines and recommendations that are considered the state-of-the-art in game accessibility. These communities have also contributed in pointing out barriers present in mainstream video games (Bierre et al., 2005).

Reviewing the literature on non-visual games, a common approach is to substitute all visual stimuli by auditory feedback, finding many variants and examples (Friberg & Gärdenfors, 2004; Röber & Masuch, 2005). Atkinson et al. used "earcons", structured sounds that are designed to alert the user to an object or event (Atkinson, Gucukoglu, Machin, & Lawrence, 2006). Directional audio (Grammenos, Savidis, Georgalis, & Stephanidis, 2006; Savidis, Stamou, & Stephanidis, 2007) and 3D sound systems have been used to orient

users and help them locate static or moving elements in the game universe (J. Sánchez & Espinoza, 2011; J. Sánchez, Sáenz, & Ripoll, 2009). The project "The Sound of Football" also combined mobile devices with a sonar-like interface to help users playing football without using sight (Pepsico, 2011).

In an effort to create more appealing experiences for blind gamers, other developments have explored stimulation of multiple senses, especially the use of touch combined with supplementary audio. One of the first examples is the use of the PHANTOM™ device that was able to convey 3D haptic feedback (Sjöström & Rassmus-Gröhn, 1999). More recently this kind of technique has been applied, through different devices, to games like a 2D pong (Savidis et al., 2007) or a Sudoku (Gutschmidt, Schiewe, Zinke, & Jürgensen, 2010). This kind of feedback proved successful not only in computers but also in mobile devices (Kim & Ricaurte, 2011).

Game accessibility has also been addressed conceptually by proposing general design methodologies or frameworks that may be applicable to a broad number of games. For example, Grammenos et al introduced a unified design method that guides developers in producing more accessible games (Grammenos, Savidis, & Stephanidis, 2007). It uses the concept of abstract tasks to make the games independent from the device and technology used, and therefore they can be more easily adapted to the needs of different users. In some cases, these initiatives are supported by demonstration prototypes (Grammenos et al., 2006; Grammenos, Savidis, & Stephanidis, 2005). However, they often lack of reference implementations or support tools that facilitate their application for developing new games. As a consequence most of these approaches are difficult to scale. In this regard, focus is usually placed on specific titles, like Quake (Atkinson et al., 2006), "Dance Dance Revolution" (Miller, Parecki, & Douglas, 2007), Rockband (Allman, Dhillon, Landau, & Kurniawan, 2009) or Guitar Hero (Yuan & Folmer, 2008), with few game development packages catering for accessibility more generally. One example is the work of Roden and Parberry who propose a game engine for creating interactive audio-only games (Roden & Parberry, 2005).

### **3. Point-and-click Adventure Games**

In this section we describe the *point-and-click* adventure game genre, which we have focused on in this study. The importance of these games for serious applications is discussed, and interaction is described as a means to understand the challenge of introducing accessibility in these games.

#### **3.1 The Genre**

*Point-and-click* adventure games were very popular in the 90's, when titles like the *Monkey Island™*, *Indiana Jones™*, *Myst™* or *Day of the Tentacle™* sagas were easily found at the very top of the best selling games rankings. The genre lost traction in the 2000's, at least among mainstream titles, but it still has a place in the indie market (e.g. *Machinarium* or *Tomorrow*) and attracts an active user community. Besides, the *point-and-click* adventure genre gathered interest from the academia because of its potential for serious and educational applications, which is partly attributed to its strong narrative underpinnings (Amory, 2001; Dickey, 2006), an aspect that is well aligned with learning (Garris, Ahlers, & Driskell, 2002).

From a Human-Computer Interaction perspective, these games are excellent representatives of *point-and-click* interfaces and the barriers they pose, which are present in many modern games and applications. In classical adventure games the user moves the mouse cursor around to find elements in the game universe to interact with. When hovering over an interactive element visual feedback is provided, hinting to the user that clicking on it will trigger a reaction of the game universe (e.g. a character starts talking or a menu with additional actions being displayed). The problem that makes these games inaccessible for blind players is the need of using the sight to explore the game world, which is also a common problem in other game types (Archambault, Ossmann, Gaudy, & Miesenberger, 2007). But in general *point-and-click* adventure games are more accessible than other genres as they lack many typical barriers, like a very fast pace, absence of configuration features or the use of time pressure to provide challenge (Bierre et al., 2004).

#### **3.2 Exploration in Point-and-Click Adventure Games is Key to Achieve Fun**

Providing well balanced challenges for the player throughout the whole game play is a key success factor of any good game (Chen, 2007; Gee, 2003). Challenge helps the player to reach a flow experience where engagement, feeling of personal fulfillment and enjoyment are maximum according to Csikszentmihalyi's theory of flow (Csikszentmihalyi, 1991). The difficulty of the game is usually designed to challenge the

player's abilities without surpassing them to the extent of becoming unbeatable to prevent frustration. Since players' skills are expected to grow as they play, the challenge posed by the game needs to increase as well, to avoid ending up with a boring experience. There are different strategies to provide challenge (e.g. time pressure, problem-solving or lateral thinking puzzles), and most of the games use a different combination of these.

In *point-and-click* adventure games, observation and exploration are key aspects to reach engagement. The player is challenged with puzzles that require designing a problem-solving strategy. For that purpose the player applies information provided by the game and also previous meanings and patterns learned from previous puzzles in the game (Egenfeldt-Nielsen, 2003). To gather information the player carefully explores and scrutinizes the game world searching for hidden clues and resources for solving the problem. Although the game subtly and non-intrusively guides the player to facilitate discovery of information, this process must be neither immediate nor trivial or obvious. Should the exploration system be unbalanced, it may have a deep impact on the overall game experience. Any adaptation of the interaction aiming to improve accessibility must preserve the exploration process to avoid breaking the game experience.

### 3.3 The Importance of the Story

*Point-and-click* adventure games use an attractive story to engage players, as opposed to other kind of games that use other elements to stimulate the player like striking visual effects and images (Dickey, 2006). From an accessibility perspective, game interfaces must allow every user to experience how the story unfolds in a comfortable way to have a pleasant experience.

Strong narrative underpinnings are usually present in *point-and-click* adventure games. An appealing plot is unveiled while the player progresses in the game, solving different puzzles and riddles that are integrated within the game plot. This strategy keeps the player immersed and engaged. The story is a technology-independent element that appeals to different players with different abilities, including blind and sighted players. Any action taken to improve accessibility must preserve the narrative experience of the game.

## 4. The eAdventure Platform

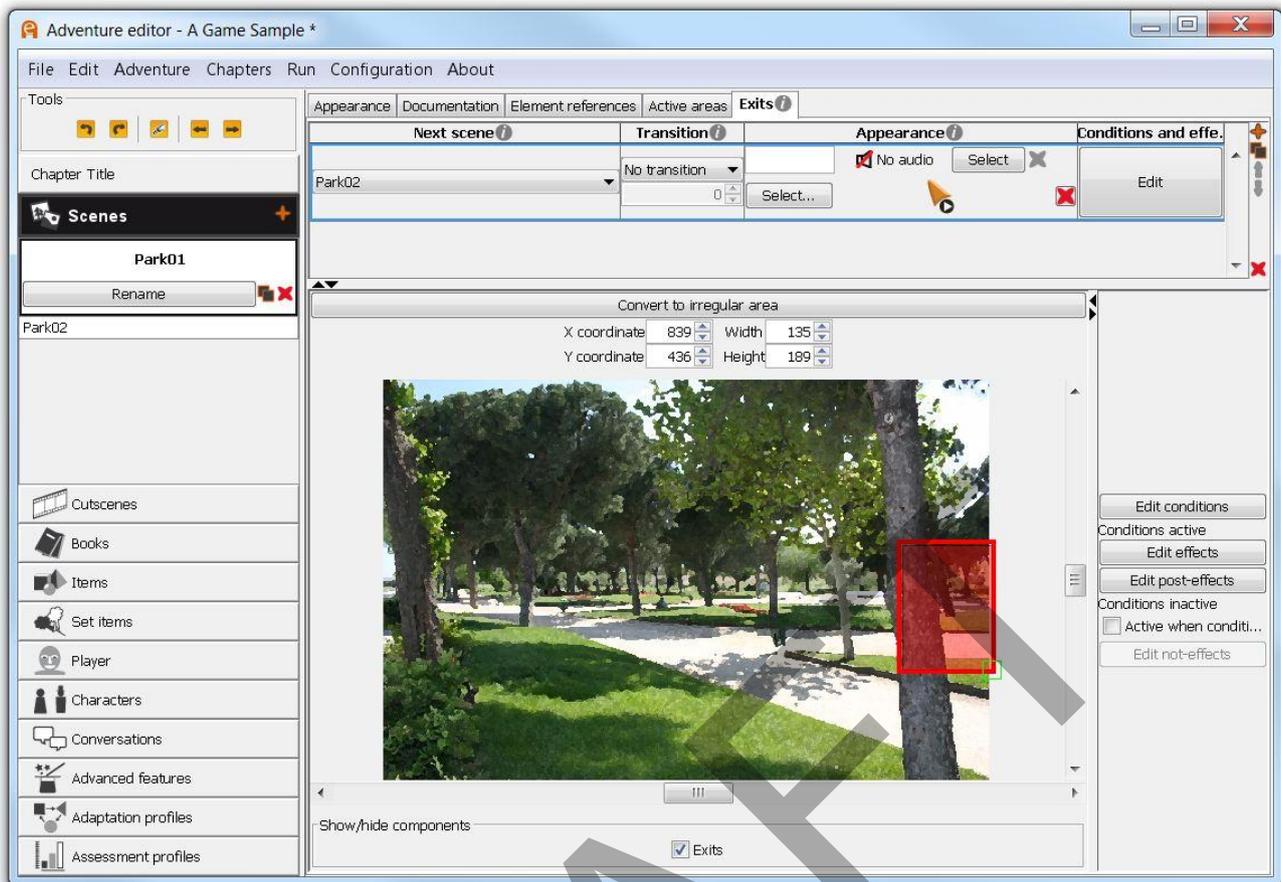
The eAdventure platform is a game authoring tool that allows for the development of 2D educational games, with special focus in *point-and-click* adventures (Moreno-Ger, Burgos, Sierra, & Fernández-Manjón, 2008; Torrente, Del Blanco, Marchiori, Moreno-Ger, & Fernández-Manjón, 2010). It was designed to facilitate the development of educational games by people with little technical background (e.g. educators). It is composed by a What-You-See-Is-What-You-Get (WYSIWYG) game editor used to create the games (see Figure 1), and a game engine that can be distributed following the Learning Object Model to deliver the games to the students (Torrente, Moreno-Ger, Martínez-Ortiz, & Fernández-Manjón, 2009).

The three interfaces evaluated in this work were implemented with the eAdventure platform, which has already been used as a testbed for educational accessible game research (Torrente, Del Blanco, Moreno-Ger, Martínez-Ortiz, & Fernández-Manjón, 2009). The long-term goal is to integrate these accessible interface prototypes in eAdventure so they could be easily configured by game creators. Both author and player would benefit from having alternative interfaces available. The author (e.g. educator) could include several interfaces in a game, and decide which users would use each one depending on the design, special needs of the users, previous experience, etc. The author could also leave this decision to the user, who could choose the interface that she/he prefers. Or it could be the game itself that sets up an easy interface initially and suggests other interfaces as the user progresses and gains expertise and skills (Torrente, Del Blanco, et al., 2009).

The game universe in eAdventure is defined by a number of 2D game scenarios that are interconnected using "exits"; that is, regions of the scene that can be clicked and that transport the player to a different scene (see Figure 1). Exits, along with objects and characters are the basic interactive elements supported by eAdventure. In addition, objects and characters support several types of action verbs (e.g. grab, talk to, use, etc.). Those are the resources the game can supply for puzzle solving.

## 5. Three Non-Visual Interfaces For Point-And-Click Games

Each non-visual interface prototype developed provides a different experience for game world exploration. For the purpose of this paper, exploration is defined as the process from which the player obtains information



**Figure 1. Screenshot of the eAdventure game editor, version 1.5. The red rectangle marks an exit defined on a game scene.**

about what are the available interactions on the scene and speculate about the consequences these will have in the game world.

All the interfaces use the same system for providing auditory feedback. Each time the game universe changes an audio message is reproduced using the *eSpeak* free text-to-speech software. This includes changes in the game scenario or any interaction with objects or characters defined in the game. The system is flexible, allowing the game author to define alternative messages and audio clues for each specific interaction depending on the users' performance and progress.

The flexibility of the audio feedback system helps to provide fine-tuned guidance to explore each game scene, keeps the user immersed in the story and contributes to create drama and tension. In these games audio was used to provide a message describing the scene a user is in after every change. The descriptions of these scenes change in each subsequent visit to avoid repeating information provided.

## 5.1 Cyclical navigation system

With this interface interaction is similar to browsing the web using a screen reader. Available interactions in the scene are structured in a two-level focus cycle that allows moving the cursor between the elements with the arrow keys (see Figure 2). The first level is composed by the interactive elements on the scene (characters, objects, exits, etc.). The second level contains available actions for each element. To access the second level, the user hits the action key (enter). To return to the first level, the user hits the go-back key (escape).

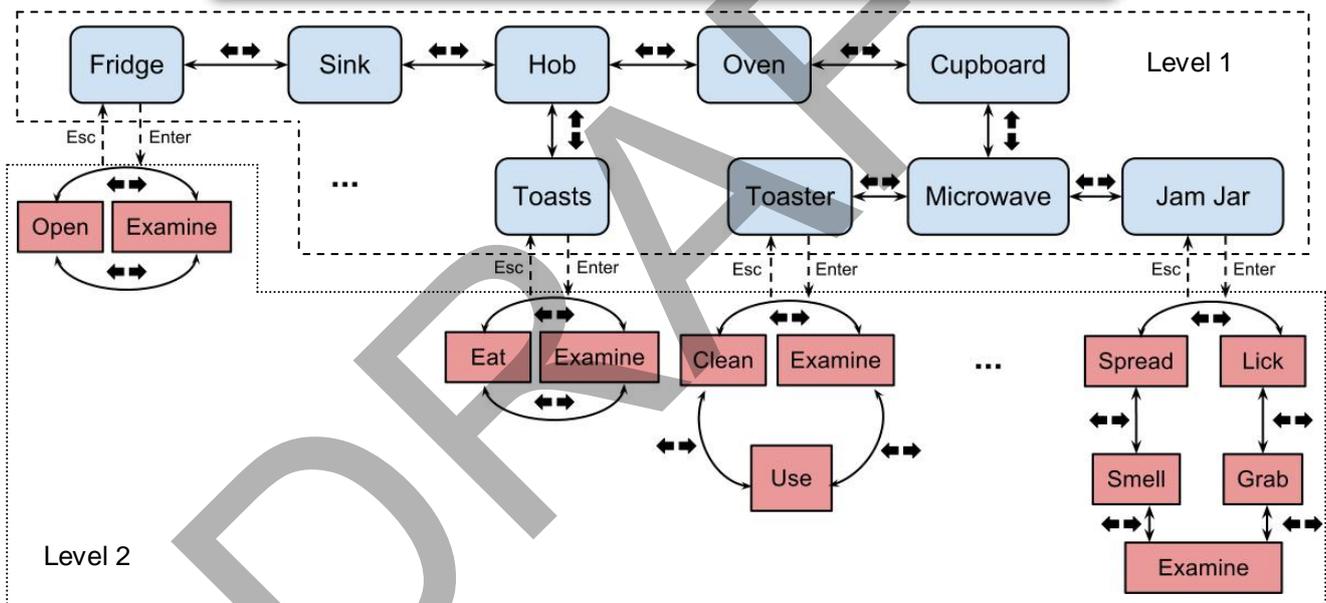


Figure 2. Example of navigation through the elements of a game universe with interface 1 (cyclical navigation system).

This interface was designed to be intuitive, natural and usable for blind users since all actions are accessible within a minimum number of key strokes.

## 5.2 Sonar

This interface guides the player in finding interactive elements using the mouse instead of the keyboard. A 3D positional audio system is configured for the scene (Vallejo-Pinto, Torrente, Ortega-Moral, & Fernández-Manjón, 2011). This system is inspired by the working of a sonar, which helps submarines detect near objects by listening to the echo of pulses of sound as reflected by these objects. Similarly, in our system each interactive element emits a different sound that can be modified if necessary. The position of the element relative to the mouse cursor is encoded by altering the intensity and pitch of the sound. Depending on the distance of the element to the mouse cursor, the sound is perceived with a different intensity. Pitch is used to provide information about the vertical position of the mouse pointer. High pitch denotes that it is near an element, while low pitch denotes that it is far from it.

When the user hovers the mouse over an element, a confirmation is again provided by means of a sound. The user can also activate or deactivate the sonar with the space bar to limit acoustic fatigue. If the game is played in non-full screen mode, a special sound is emitted when the mouse cursor accidentally exits the game window boundaries. The mouse is relocated to the center of the screen each time the scene changes.

### 5.3 Natural language commands interface

With this interface interaction is articulated through short text commands expressed in natural language that the user needs to type. After the command is introduced, the system tries to interpret it and match it to one of the available interactions in the scene, using a regular grammar that defines the structure of the supported commands and a list of synonyms. This system is further described in a previous work (Torrente, Del Blanco, et al., 2009). The user receives audio feedback about the results of this matching and if it succeeds the interaction is triggered.

The feedback after each successfully or failed command is introduced can be modified by the game author. By default, the system will return a random message (e.g. "Ummm ... I'm not sure what you mean" or "I think rather not to do so") depending on which rules of the grammar caused the mismatching. However, it is possible to use the audio feedback system to provide hints if further guidance is required.

In contrast to the cyclical navigation interface (described in section 5.1 and shown in Figure 2), in this case the interactions available are not obvious to the user. Instead, the player has to find them out by try-and-error of different commands.

This interface also supports a list of special commands:

- **“actions”**: reminds the user all interactions that he/she had previously discovered in the scene.
- **“describe scene”**: provides audio feedback with settings of the scene, combining an optional message introduced by the game author and a summary of the elements presented (e.g. there are two exits, an object near character A, etc.).
- **“help”**: provides hints and interaction instructions.

## 6. End-user Evaluation

### 6.1 Participants, Method and Settings

Three games were set up with a different interface each. The games were play-tested by four mid age blind users (3 men and one woman from 28 to 36 years old).

Users #1 and #4 were used to play or have played adapted games intensively in the past. For the sake of simplicity, we refer to these users as *frequent gamers*. One user reported playing mobile games on his iPhone very often, and adapted games or audiogames on his computer (e.g. Papa Sangre, games from AudioGames.net, etc.). The other user said that he had quite a lot of experience with adapted games in the past. He used to play online role playing games although, as he claimed, he did not have the time to play anymore.

In contrast, users #2 and #3 had little experience playing games. In this section we refer to these users as *occasional gamers*. One declared himself a casual gamer having little gaming habits actually. He had played a few adapted PC and mobile games in the past but he does not usually play games at the moment. The other user reported having almost no taste for games, and she had played only a few in her life.

Two aspects were being analyzed:

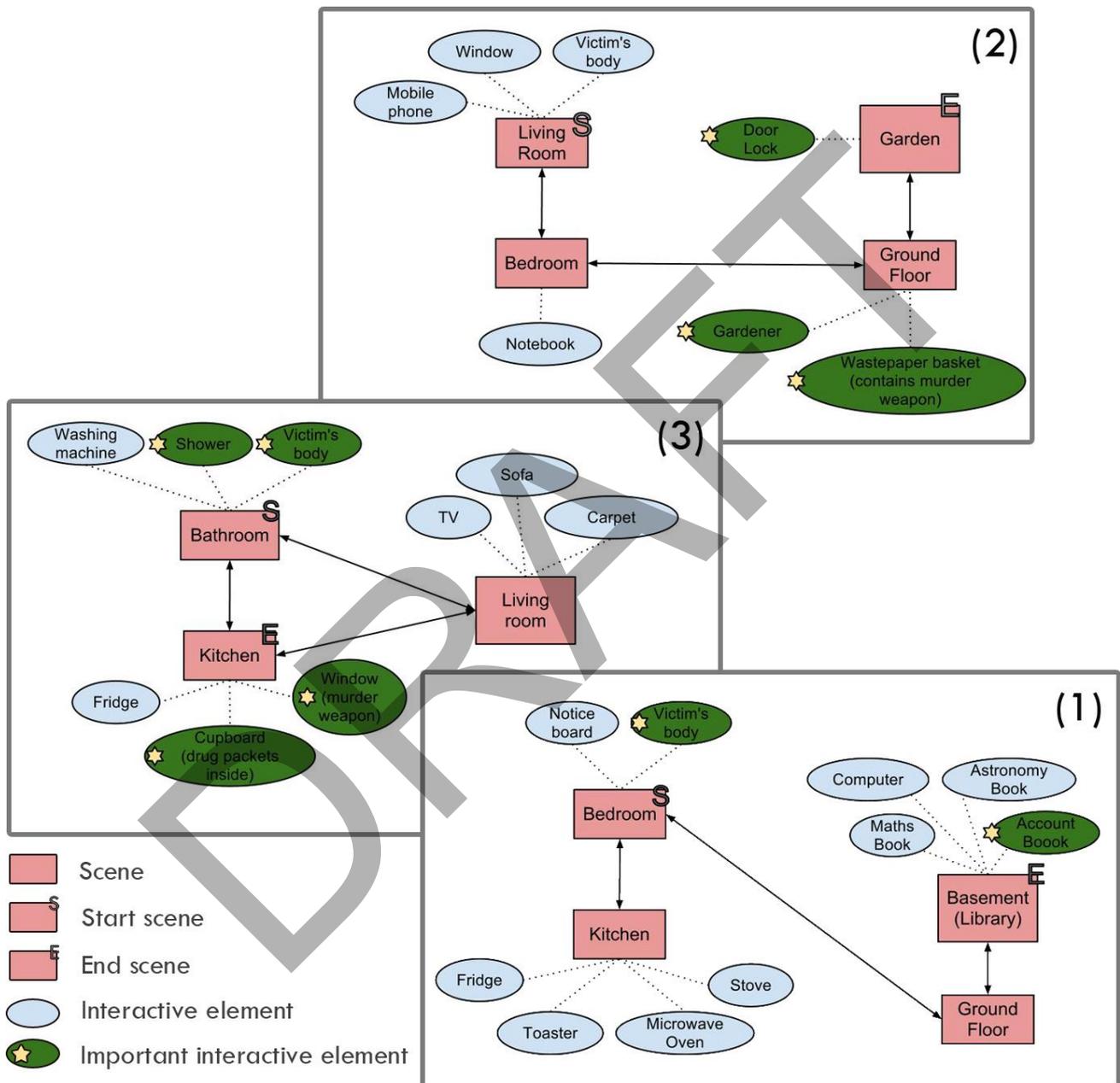
- a) Usability, defined as the ability of players to explore the game scenes, find interactive elements and trigger desired interactions without finding barriers;
- b) Entertainment value provided, defined as the ability of the interface to make the game interesting and appealing to the user.

Two researchers were present during each test: one welcomed and helped users to get started while the other monitored users' activity. The sessions were video recorded for the analysis of the completion times and the number of interactive elements used and scenes visited. We used these numbers as a heuristic to estimate how successful each interface was in guiding users to explore the game universe.

Users completed the evaluation in individual game-play sessions of 60 minutes. They were exposed to each game for about 10-15 minutes on average, and they were asked to provide feedback and rate the usability and entertainment provided by each interface using a 7 point Likert scale. Finally they were asked to identify what interface is the best for point-and-click conversational adventure games, according to their opinion.

## 6.2 The Games

The games used in the evaluation share a uniform design, having similar number of scenes, objects, game mechanics and stories. Each game universe had 3 to 4 scenes and 7-10 interactive elements. Figure 3 shows the composition of each game world.



**Figure 3. Game Universe of each interface (1) Navigation system, (2) Sonar, (3) Natural language commands.**

In each game the player is set out to solve a crime. The game mechanics are simple: the user has to inspect the crime scene and surrounding areas, finding and collecting evidences. The game finishes when all the evidence items are collected and the mystery is solved.

For each interactive element there is one action available. For example "examine body", "inspect stove" or "read book". After interacting with some of the elements in the scene a new clue is revealed. Some of them are

deliberately designed to confuse the player, making the crime more difficult to solve as a mechanism to keep user's interest.

Each game starts with a short explanation of the crime scene and basic instructions about the interaction. For example, game 1 begins with this brief note: "Paula Suárez, 55 years-old, found dead in her bedroom. No signs of forced entry." (see Figure 4). In short, to complete this game the player has to navigate from the bedroom to the basement (see Figure 3), find her company's account book and read it. Then the plot is unveiled - Paula discovered that a colleague was stealing from the company and the thief decided to murder her to silence the affair.

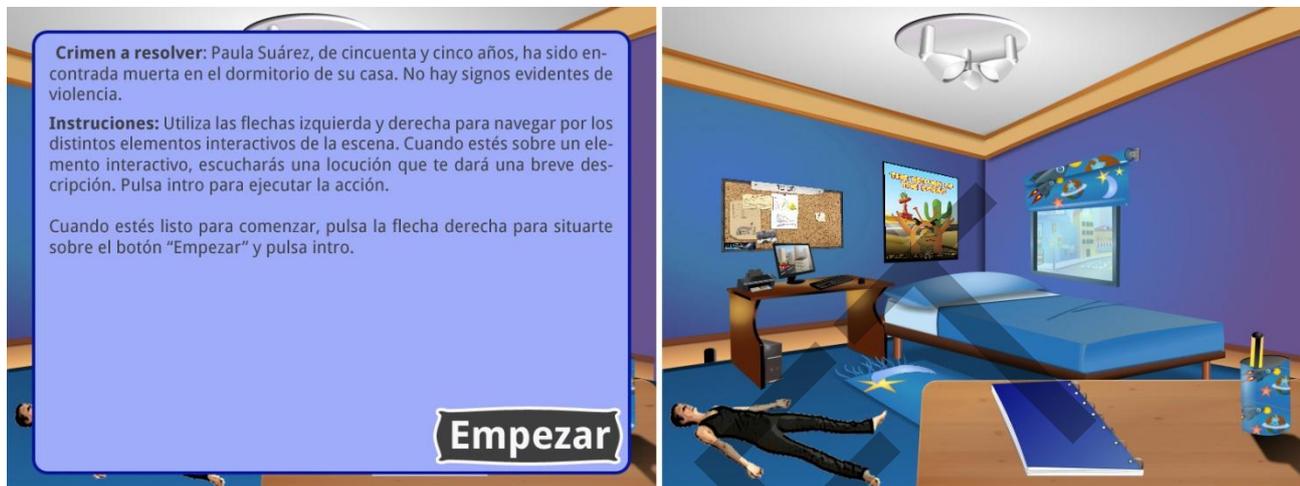


Figure 4. Screenshots of introduction and first screen in game 1.

## 6.3 Results

### 6.3.1 Metrics

Most of the users were able to complete the mini-games. Four users played games 1 (keyboard navigation interface) and 2 (sonar). Due to logistic problems, game 3 (conversational interface) was only played by two users.

All users who played game 1 (4) completed it and found the answer to the riddle that was set out. They needed 3:21 minutes on average (2:54 min, 3:48 max). All of them visited the four scenarios of the game at least once. They interacted with 6 elements out of 10 (60%) at least once on average.

3 out of the 4 users who played game 2 were able to complete it. These three users needed 6:54 minutes on average (6:17 min, 7:21 max). All of them visited the four scenarios of the game at least once. They interacted with 4 elements out of 7 (57.14%) at least once on average.

Game 3 was played by 2 users, who also completed it in 4:19 and 4:34 minutest respectively. They visited 2 scenarios out of 3 at least once and interacted with 6 or 7 elements out of 9 at least once.

### 6.3.2 Perceived usability.

At the end of each play session users were asked to rate the usability of the game interface. A 7 point Likert scale was used (1=very hard to use, 7=very easy to use). Table 1 provides all ratings collected for the four users. All users (4) agreed that interface 1 (keyboard cyclical navigation system) was the most usable (6.75 on average). There was not much difference for interfaces 2 (sonar - 4.75) and 3 (conversational - 5.25).

Table 1. Usability ratings provided by each user (1=very hard to use, 7=very easy to use)

	User #1	User #2	User #3	User #4	Average
Interface 1	7	6	7	7	6,75
Interface 2	3	5	5	6	4,75
Interface 3	5,5			5	5,25

### 6.3.3 Perceived entertainment value

Users were also asked to rate the entertainment value of game interface using a 7 point Likert scale (1=not fun at all, 7=very fun). Since all games were similar in content, mechanics, story and duration, we assume differences in scores achieved can be attributed to the use of a different interface. Table 2 shows all data collected for each user. 3 out of 4 users rated interface 2 (sonar) as the most fun (6 on average). Interface 3 is the next with higher ratings (5.5 on average). Finally 2/4 users rated interface 1 (keyboard navigation) as the less fun (4.75 on average).

**Table 2. Entertainment ratings provided by each user (1=not fun at all, 7=very fun)**

	User #1	User #2	User #3	User #4	Average
Interface 1	4	6	3	6	<b>4,75</b>
Interface 2	6	5	6	7	<b>6</b>
Interface 3	5			6	<b>5,5</b>

### 6.3.4 Final user recommendation

Finally users were asked to identify the best interface for point-and-click conversational games like those evaluated, according to their opinion. It is remarkable that some users argued that the three interfaces could be applied in games, depending on the target audience, the context, and the game design. However, frequent gamers (users #1 and #4) leaned towards interface 2 (sonar). They were both very convinced about their recommendation and provided some reasoning to back up their choice. For example, user #4 voiced that the sonar interface (game 2) is the best because it makes it more attractive. He considered that it is better than the conversational interface, which makes the game have a bit of the taste of old-style conversational games around the 80's. He dislikes the arrow interface a little bit because it is "too cyclical and predictable".

In contrast, occasional gamers (users #2 and #3) preferred interfaces 1 (keyboard navigation) and 3 (conversational) respectively. For example, user #3 expressed that, for her, interface 3 (natural language commands) was probably the best, because it is more interactive and fun than interface 1 (web-like navigation) but it is easier to use than interface 2 (sonar).

### 6.3.5 Technical errors and usability flaws identified

Researchers identified several technical problems and design flaws thanks to the play sessions. In game 1 (keyboard navigation) users complained about two issues, especially the frequent gamers. First, the feedback system (based on a text-to-speech layer) could be gauged to allow faster navigation. Sometimes descriptive sounds overlapped if the user browsed from one element to the next one very quickly, or if there was only one interactive element in the scene, making it hard to understand new information being given. As a consequence, frequent gamers could not navigate through the elements as fast as they would like to. Second, users found the interface too cyclical and predictable. They would have appreciated a more complex way to structure the information (having more levels of aggregation added to the navigation graph).

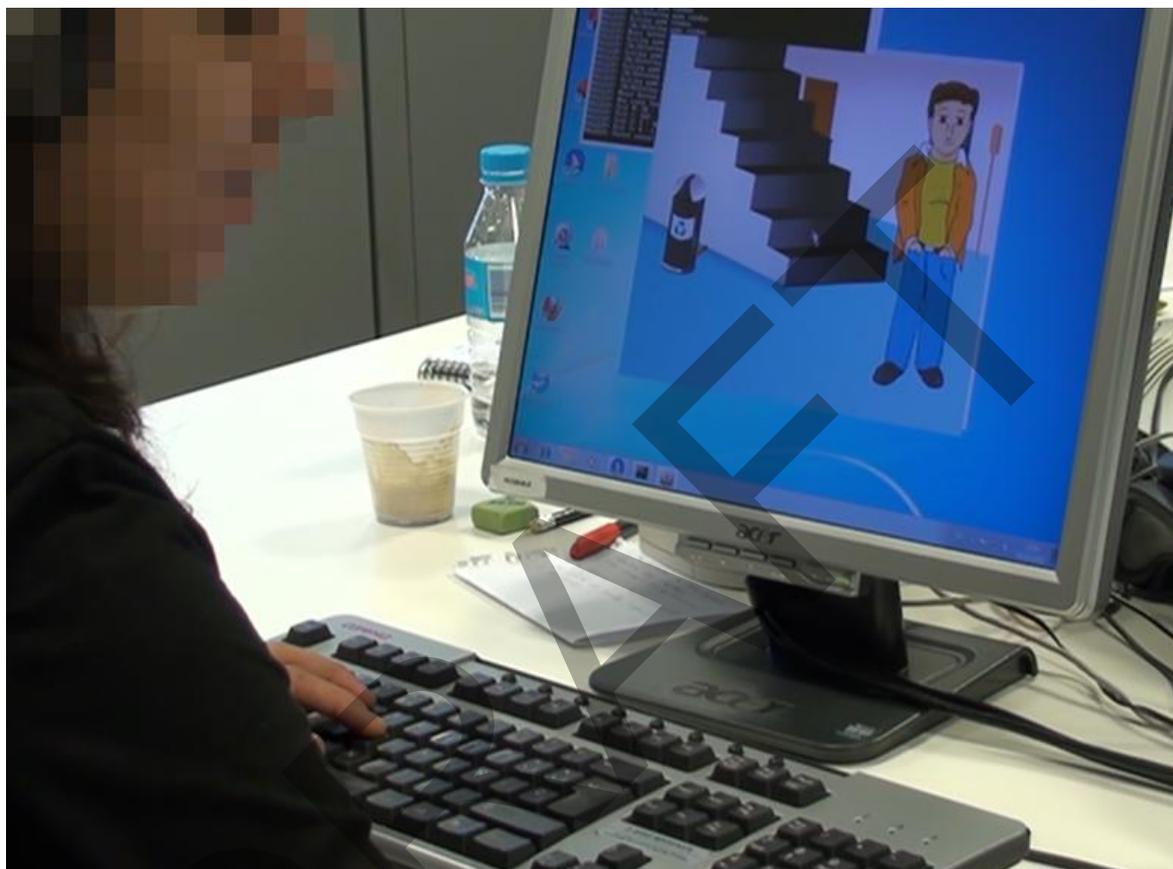
In game 2 (sonar), the text-to-speech system occasionally failed to reproduce the name and brief description of an interactive element when the mouse hovered over the same element two consecutive times. This was caused by a technical bug in the text-to-speech layer that was only noticeable in interface 2 (sonar), as it was impossible to visit the same element twice in interface 1 (keyboard navigation). Interface 3 (conversational) used a different strategy to give feedback to the user.

The sonar also presented other interaction problems. Sound emitted by all the interactive elements was very similar. Users were able to distinguish the source of the sounds in most scenes with 2 or 3 interactive spots. In the dining room, which has 4 interactive spots, users had more problems. In this regard, one of the users proposed using variations in the timbre and intermittency of each source of sound to facilitate distinguishing each source more easily.

Some users had problems with mouse clicks over interactive elements. Sometimes the mouse shifted involuntarily as a consequence of lifting a finger to press the left button. The system did not provide any feedback, leading the user to click in a spot that did not trigger the interaction expected. This usability issue could be addressed by playing a simple audio effect when this happens.

As a minor issue, some users were displeased to have to activate the sonar manually after each scene transition. While this behavior was designed to prevent acoustic fatigue, it became an annoying inconvenient for a couple of users.

Some users complained about the difficulty of remembering all the commands for interface 3 (conversational). Researchers observed many situations where the user knew what to do to go on in the game, but she/he was unsuccessful because the system did not recognize the command formulated. As a consequence, users had to memorize some of the commands. Researchers identified that it was necessary to add flexibility to the syntactic processor that analyzes each sentence the user inputs. Also the number of synonyms included in the thesaurus had to be increased.



**Figure 5. User interacting with interface 3 (sonar).**

### *6.3.6 Discussion.*

The methodological flaws and small scope of this quasi-experiment limits the strength of the findings we can infer. But the eloquence of the evidence collected at least allows us to draw some promising conclusions and make recommendations that should be backed up with further research in the future.

Data suggest that interface 1 (keyboard navigation system) is the most effective in guiding users through the exploration of the game world. Game 1 has the smallest average completion time, and all the users were able to complete the game quickly. Also researchers observed that users could iterate through all the elements very quickly. Users also agreed in rating interface 1 as the most usable (6.75/7 on average). This confirm the initial hypothesis, since it is similar to the interface of a website adapted with a screen reader, which is a kind of interaction blind users are familiar with. However it suggests this interface is not very engaging, given that as the actions are obvious to the player it turns exploration into a trivial process.

But it is also clear that interface 1 was the less fun for the users. It is a very usable interface as it is very simple. However, in games simplicity can turn into a disadvantage if it causes the game fail in providing the player with appropriate challenge, which is necessary to maximize engagement (Chen, 2007). This was the case of users with more gaming habits, who found the first interface boring because their skills surpassed by far the challenge the game sets out.

The most entertaining interface seems to be number 2 (sonar), which achieved the best user rankings (6 on average). Frequent gamers especially appreciated the interface for introducing fresh ideas, like using the mouse as input device, which is unfamiliar to them. Occasional gamers also found the interface enticing. However, it is also the more complex interface. Game 2 required more time from the users to complete it, compared to games 1 and 3. Researchers also observed that users needed full concentration to explore the game universe. This reflects that the sonar interface poses a cognitive load to the user that is significantly higher than the other interfaces. As users were exposed to this type of interface for a short time, it is not clear if symptoms of fatigue could appear in a longer session, which could yield to different conclusions.

It is remarkable that the three interfaces achieved good results in overall. As a consequence, we may say that the three could be used for this type of games. The best choice depends on the context and target audience.

## 7. Conclusions and Future Work

Game accessibility is still a young discipline in the field of human-computer interaction and universal design. In recent years movements advocating towards policies that allow people with disabilities to play digital games have risen. As a result general guidelines to make accessible games are now available (Bierre et al., 2004; Game Accessibility Guidelines, 2012; Grammenos et al., 2007). But research in the field is still incomplete, needing further investigation on how to create games that are usable and engaging for people with disabilities, or how to adapt existing games for such purpose. This research should also cater for diversity. Game play is a unique and personal experience that can be influenced by multiple factors. Therefore personal characteristics and background should be taken into account when designing an accessible game interface in order to deliver user experiences that are meaningful for each player. Dealing with diverse backgrounds is especially relevant when digital games are used in education, as students with very different gaming experience, prior experiences and skills coexist in the same group.

This paper presents a small quasi-experiment that explores three different interfaces for educational computer games. The interfaces were developed for blind people as specific target audience. The goal was to compare the perceived usability, engagement and overall experience provided by each interface for players with different gaming habits. Evidence collected suggest that players' preferences towards game interfaces varies depending on their previous gaming habits. While users with less experience tend to lean towards interfaces that are similar to web interfaces, frequent gamers prefer innovative interfaces because they pose a new challenge for them.

Several limitations of the research constrain confidence in the conclusions drawn. The games used for evaluating the interfaces were very short (around 10 minutes of completion time). Besides, the sequence in which the games were presented to each participant in the evaluation was not randomized. The reduced number of participants is also a limitation, but it is very difficult to recruit players from this target audience. Besides, although a 'think aloud' protocol was set out for the evaluation of the interfaces in order to enhance the amount of data collected, users were not very communicative, hindering our chances to make a qualitative analysis. All in all, this work can be considered the beginning of a promising research line, but further evaluation should be conducted with more and longer games involving more users and using a more rigorous research method.

These three interfaces could be scaled and repurposed for many game genres and other interactive Rich Internet Applications, albeit they were designed for *point-and-click* adventures. They could also be shipped along with mainstream game engines and authoring tools. This would require a considerable effort to make the interfaces more scalable, but it would help to increase the level of accessibility of the games by reducing the effort and cost required and raising visibility and awareness among developers (Torrente, Del Blanco, et al., 2009).

## 8. Acknowledgments

The following sponsors have partially supported this work: the Spanish Ministry of Science and Innovation (grant no. TIN2010-21735-C02-02); the European Commission, through the Lifelong Learning Programme (projects "SEGAN Network of Excellence in Serious Games" - 519332-LLP-1-2011-1-PT-KA3-KA3NW and "CHERMUG" - 519023-LLP-1-2011-1-UK-KA3-KA3MP) and the 7th Framework Programme (project "GALA - Network of Excellence in Serious Games" - FP7-ICT-2009-5-258169); the Complutense University

of Madrid (research group number GR35/10-A-921340) and the Regional Government of Madrid (eMadrid Network - S2009/TIC-1650).

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