

An analysis of information conveyed through audio in an FPS game and its impact on deaf players experience

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Abstract

Mainstream games usually lack support for accessibility to deaf and hard of hearing people. The popular FPS game Half-Life 2 is an exception, in that it provides well constructed closed captions to players. In this paper, we performed a semiotic inspection on Half-Life 2, seeking to identify which strategies were used to convey information through audio. We also evaluated how the loss of information in each of them may impact players' experience. Our findings reveal that six different strategies are used and how they may compromise player experience.

Keywords: accessibility, games, deaf, hard of hearing, human-computer interaction, semiotic inspection

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1. Introduction

Game accessibility is the ability to play a game even under functional limitations, or disabilities. Ensuring access to digital games to people independently of their conditions is a matter of social inclusion as "*disabled game players are consumers and access to digital games is a matter of quality of life*" [Bierre et al. 2005]; and also a business opportunity, since it represents a great potential of market expansion for the game industry as a considerable portion of the population in the world has some kind of disability [IGDA 2004; Yuan et al 2010].

A review conducted by the *Information Solutions Group* [Chouteau & Orr 2008] reveals that more than 20% of casual game players are, in some way, disabled and 94% of them say that the experience of playing benefits them physically or mentally. Moreover, the American census revealed that 12% of the population of that country manifests some disability [Bureau 2008] and, in Brazil, the census showed an even higher percentage, 14% [IBGE 2000]. Deaf and hard of hearing people represent 2.35% of the population in the US and 3.38% in Brazil, that is, 5.735.099 Brazilians.

Beyond the obvious problems of not being able to hear game music and audio cues, those people whom became deaf before an adequate contact with the sound world (usually before 2 years old, also called prelingual deaf) do not acquire in a natural way the oral language of the country they live in and, very frequently, their native language is a sign language.

The acquisition of the oral language by them is influenced by problems like the unpreparedness of schools and the educational system, late learning of the sign language and self-stigmatization characteristics pointed by Botelho [2005]. Those problems often lead to difficulties with reading and writing [Bernardino 2000; Botelho 2005].

In this paper our goal was to characterize how audio is being used to communicate with users in First-Person Shooter (FPS) games. To do so, we applied the Semiotic Inspection Method (SIM) to Half-Life 2 and identified which strategies were used for communication through audio – that is, what type of information is transmitted by each type of audio sign in the game.

We chose the FPS genre because games of that style frequently use sounds to convey vital information to player that aid in their survival and progress in the game. We also applied a questionnaire to deaf and hard of hearing people and found that a lot more people reject FPS games than accept them. Half-Life 2 was chosen to be evaluated because of its huge popularity and the fact that it provides closed captions as an alternative to dialogues and various sound effects.

The inspection revealed that audio is used in six different strategies in Half-Life 2 to convey information. We also present an evaluation on the impact on accessibility of those strategies to deaf and hard of hearing players, as well as reveal how sound information was replaced by other strategies of communication in the game. We believe these results provide epistemic knowledge that can help game designers to build games accessible to those who cannot hear.

In the next section we present an overview of recent research and initiatives of accessibility in games. Section 3 describes the methodology adopted. Sections 4 and 5 present our findings with the questionnaire and the inspection. In the last section we present our conclusions and the next steps.

2. Related Work

Providing access to games can be viewed as removing barriers that may limit players' ability to play due to limiting physical and cognitive conditions. In an extensive survey on game accessibility, Yuan et al. [2010] proposed a generic interaction model for games,

in which player interaction can be described in three steps, namely, receiving stimuli (step 1), determining response (step 2) and providing input (step 3). Stimulus was classified according to the relevance of the information it provides to players: primary stimuli must be perceived to enable gaming experience, whereas secondary stimuli is supplementary to primary, but does not fully compromise gameplay. The vast majority of games rely heavily on visuals, what frames it as a primary source of stimuli. Audio and haptic feedback usually supplement visuals, being considered secondary in most cases.

An international classification of impairments is defined in a World Health Organizations manual, which spans four groups of impairment: visual, hearing, motor and cognitive. For each of those groups, Yuan et al. [2010] discuss which steps of the interaction may present barriers to people with those types of impairments and how those barriers can be attenuated or removed.

Cognitive impairments are very broad, spanning memory loss, diverse mental disorders, autism and learning disabilities like dyslexia, among others. They may compromise mainly the players' ability to cognitively formulate a response (step 2). Some guidelines have been proposed to aid in the design of games for people with these types of disability [Yuan et al. 2010] and a few games have been developed targeting specific cognitive impairments like one addressing children with down syndrome [Brandão et al. 2010] and another addressing people with autism [Ohring 2008].

Motor impairments include weakness, involuntary muscle control, paralysis, joint problems and lack of members [Bierre et al. 2005; IGDA 2004] and compromise providing of input (step 3). A common guideline to enable access to people with this kind of impairment is by providing different forms of input that can range from special types of keyboards, mouse and joysticks, to speech, eye tracking [Jönsson 2005] and even a single button that enables control of the entire game [Colven & Judge 2006; Ellis n d; Folmer n d]. Enabling access to a mainstream game as a one switch button has already been done before [Folmer et al., 2011], in this case it also requires that some parts of the game be automated to players.

Visual impairments range from color blindness to low vision to total blindness and compromise reception of primary stimuli (step 1). People with low vision or blindness may also have a barrier with providing input. Despite the similar nature of the impairments, each one has been approached differently [IGDA 2004]. In case of blindness, a common approach is the creation of audio games, in which players use only audio stimuli to receive instructions [Westin 2004]. Another

approach is the use of haptic stimuli [Yuan & Folmer 2008]. Players with low vision may benefit from the use of screen magnifiers and the possibility of using a high contrast filter in the game. Color blindness may be approached by using an adequate color palette to objects that could be identified by color or by letting players change those colors by their own [IGDA 2004; Yuan et al. 2010].

Hearing impairments may vary from mild hearing loss to profound deafness and affect mainly the reception of stimuli (step 1). They can be classified in four levels according to frequency range [Kano, Mezzena, & Guida 2009; Pereira 2008]:

- mild hearing loss (26 to 40 dB),
- moderate hearing loss (41 to 70 dB),
- severe hearing loss (71 to 90 dB),
- profound hearing loss (91 dB on).

When hearing loss occurs in childhood, Pereira [2008] describes the degrees of hearing impairment as:

*"Children with **mild hearing loss** speak almost perfectly, forgetting one or another phoneme. Children with **moderate hearing loss** only perceive the strong voice and have difficulty in speech, with many errors. Children with **severe or profound hearing loss** have no contact with the world of sound and have great difficulty in learning oral language by natural means."*

In games, sounds are usually used as secondary stimuli, supplementing visuals. In this case, not perceiving them may still enable those games to be played by deaf and hard of hearing people. However, this is not always the case, as sometimes relevant information is conveyed exclusively through audio, like the sound of footsteps in a FPS game, causing a reduced game experience [Yuan et al. 2010]. Many games already provide subtitles for narration and dialogues. But only a few provide closed captions that also transcribe sound effects, such as Zork: Grand Inquisitor (1997), Half-Life 2 (2004), Doom 3 [CC] (2004 - an unofficial modification of the game Doom 3) and Left 4 Dead 2 (2009). In those games, captions are presented following a formatting code with different colors, use of italics, bold or regular format, brackets etc., to indicate whether a caption is from a speech or a sound, who is talking (in case of speech), among other kinds of information.

As previously said, by having little to no contact with the oral language, prelingual deaf people usually present insufficient reading and writing skills. So, people with this profile may not be entirely benefitted from captioning. In this case, other approaches have been used exploring visual space instead of using textual replacements for sounds [van Tol 2006; Yuan et al. 2010]. Figure 1 shows games that use this

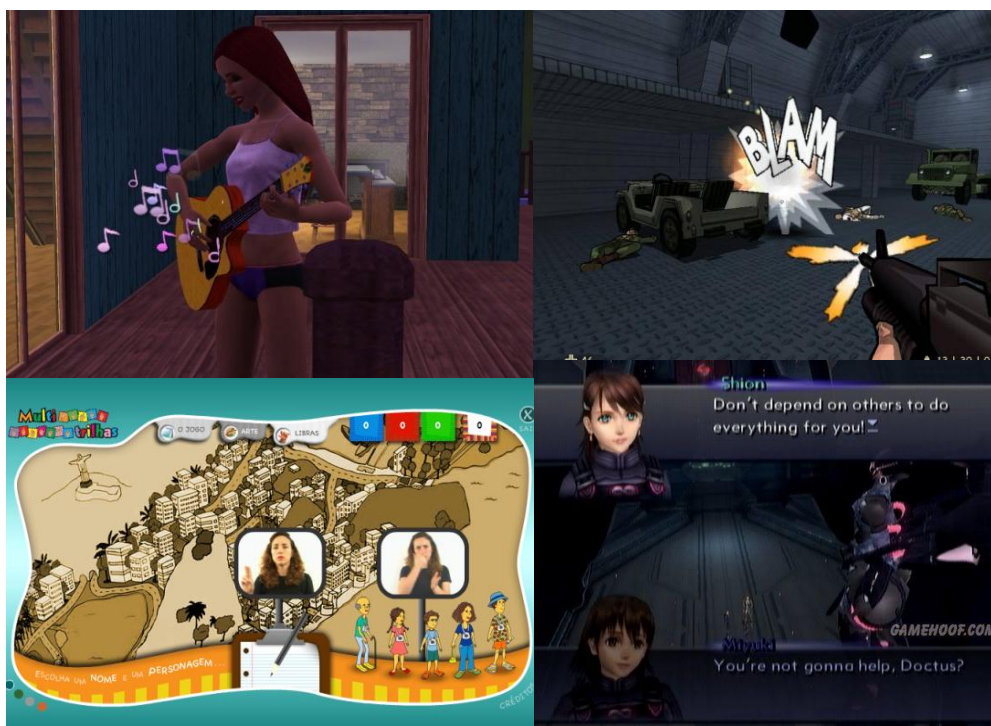


Figure 1 - Screens from games (a - top left) The Sims 3, (b - top right) XIII, (c - bottom left) Multi-Trilhas and (d) Xenosaga III.

strategy: (a) depicts sounds as if they could be seen, using colors, shapes and animations as a metaphor to how they sound: a ringing phone emanates a series of concentric circles, a guitar emits colorful song notes and so on; (b) uses onomatopoeia to represent sounds where they are emitted, just as it is typically done in comic books; (c) is an educational game specially crafted with the purpose of helping deaf children learn written Portuguese as a second language by using videos with instructions and vocabulary in Libras (Brazilian Sign Language) [Couto et al. 2005]; and (d) does not replace texts, but uses character portraits on dialogs to emphasize which character is currently speaking. Except for the game in (c), all others are mainstream games that have not been specially crafted for deaf and hard of hearing people, but have uncovered resourceful strategies to improve game accessibility to them.

Another interesting approach is illustrated by CopyCat, a game that uses a developed technology to recognize gestures as input so that the game may help young deaf children practice American Sign Language (ASL) skills [Brashear et al. 2006].

Despite those approaches, so few mainstream games have been developed with accessibility for deaf and hard of hearing as an objective. All the solutions used in those games are mostly based on closed captioning, but as we'll show later on section 5, closed caption alone may not be able to convey all vital information to players. Moreover, considering the issues with reading and writing by prelingual deaf people and our findings in the questionnaire, exploring

the visual stimuli with images and animations may be a lot more beneficial for them. Another subject that has not been discussed in the literature yet, as far as we know, is the communication among players mediated by games in multiplayer modes.

In this paper, we identify all strategies that are used in an FPS game, namely, Half-Life 2, and the accessibility impact for deaf and hard of hearing players, so that this information can be used later for at least two objectives: (1) game designers may use them to build new games that use the same strategies for communication through sound, (2) same as before, but also providing accessible alternatives for deaf and hard of hearing players and (3) researchers may implement completely new strategies that better conveys sound information than closed captioning alone.

3. Methodology

Our first step was the application of a questionnaire to people with some degree of hearing loss. We wanted to gather information about good and bad game experiences they had had and how games could better fit their needs. Later on, we made a semiotic inspection in Half-Life 2 in order to determine which strategies were used to communicate through audio.

3.1 Questionnaire

The questionnaire was composed of 20 questions in a mix of open and multiple choice questions. They were divided in 3 parts: profile, game experience and subtitles/closed captions. In the profile part, participants were asked about their degree of hearing

loss and what languages they used to communicate, among other things; in the game experience part, they were asked about games they had played and liked or disliked, platforms on which they had played and if they had experienced difficulties when playing due to hearing impairment; and in the last part, they were asked about the use of subtitles and closed captions in television and movies.

As the questions were written in Portuguese, we carefully crafted their text so they could be understood by people who do not have good Portuguese reading skills. It was published mainly on the Internet in Brazilian deaf-related social networks communities, discussion groups, email lists, blogs, but also in deaf culture associations from different states in Brazil.

Our objectives aimed at finding out what their game experiences were/had been like – good or bad, and why, and if the hearing loss had impacted their game experience somehow.

3.2 Semiotic Inspection

To identify communication strategies we used the Semiotic Inspection Method (SIM), an inspection method based on the Semiotic Engineering Theory (SemEng) [de Souza 2005]. SemEng is a theory of Human-Computer Interaction that perceives interactive systems as a form of communication from their designers to their users. This (meta) communication can be modeled as what SemEng calls a *meta-message*, that is a conception of who the users are, what are their needs and expectations and, more importantly, how the system's designer chose to meet these requirements through an interactive artifact [de Souza 2005]. The process of communication between designers and users may be measured by how effectively and efficiently it occurs and this quality of user experience is called communicability [Prates et al. 2000].

According to de Souza [2005], communication is achieved in software interfaces by codification and later interpretation of signs (anything that represents something to someone). In the context of software interfaces, SemEng defines three types of signs: (a) metalinguistic, (b) static and (c) dynamic. Metalinguistic signs refer to signs that refer to other signs of the interface, usually static or dynamic; static signs are those that can be interpreted independently of user interaction, taking into account only the interface; and dynamic signs depend on causal and temporal relations to be interpreted, i.e., it requires user interaction.

SIM is an inspection method to evaluate the *emission* of communicability, i.e., how designers' communication is being transmitted through software to users. It consists of the designer's meta-message segmentation for each type of sign separately followed by a contrast and later reconstruction of the designer's meta-communication. As a side effect of the

inspection, signs of the interface relevant to the designer's meta-communication are identified and potential breakdowns in communication revealed. That's where our belief of the method's appropriateness to our interests lies.

The method has been used in a scientific context to evaluate a simulation game before [Peixoto et al. 2010], but this is the first time it was used to evaluate an action game. We chose Half-Life 2, an FPS game that was awarded the "Game of the Year" title by 39 different publications in 2004 and had sold more than 6.5 million copies by 2008. As stated before, the game provides audio transcriptions in the form of closed captions and has been appraised by deaf and hard of hearing players.

4. Questionnaire

We present our findings with the questionnaire, which was analyzed statistically and also qualitatively.

4.1 Execution

A total of 111 people with a certain degree of hearing loss ranging from mild to profound, distributed in five regions of Brazil (North, South, Southeast, Northeast and Midwest), responded to the questionnaire. Of these, 68 participants (61%) play or have ever played games. In the following analysis only the participants who had game experience were considered.

4.2 Results

Of those participants that had had contact with games, 6 had mild loss, 3 had moderate loss, 21 had severe loss, 31 had profound loss and 7 didn't know their degree of impairment. Figure 2 shows how many of those participants play/played each gaming platform.

When questioned about games they had liked or disliked, the majority of participants cited as having liked those with simple mechanics and easy to learn rules like Platform, Puzzle, Racing, Social, Cards and Adventure (see Figure 2). Of those genres, only one of them (Racing) had a game cited as disliked.

On the other hand, results showed some genres with higher levels of rejection than acceptance like FPS, Fighting, Music, RPG, RTS and Simulation. The two first had rejections of 44% and 39% respectively and acceptance of 11% (both). Except for Music, the games cited from those genres present steeper learning curves (RPG, RTS, Simulation), or rely heavily on reading and interpretation of texts and rules to progress (RPG) or require players to have short reaction times (FPS). This may point that games that rely heavily on reading and interpretation of texts are less accessible to deaf users.

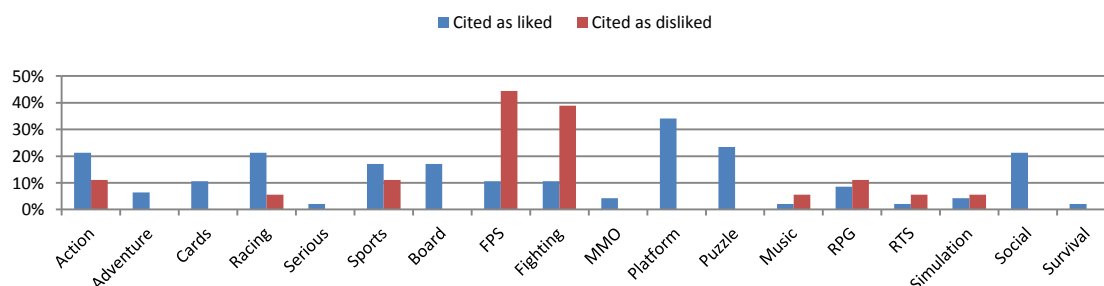


Figure 2 - Graph showing the percentage of deaf/hard of hearing players that cited games that they liked or disliked (we grouped them by game genres).

The listing of the difficulties they had to play (see Table 1) also corroborates this fact, as some participants reported they had difficulty playing due to inaccessible vocabulary or the use of too complex rules, among other reasons.

Only 28% of participants that play/have played games reported having had difficulties to play due to hearing loss, 57% reported not having difficulties and the remaining (15%) reported not remembering or did not answer the question. Those who said they had trouble playing because of deafness, were asked to write about difficult situations they had experienced. This information was classified into three types of problems which are listed in Table 1:

Table 1 - Classes of reported difficulties to play.

Language related	Games in foreign language. Vocabulary unknown to players. Instructions in foreign language. Instructions were not understood.
Audible feedback	Some games require the use of audio cues in game progress and do not provide other alternatives of communication other than auditory.
Complex rules	Rules are difficult to comprehend.

The reported problems show indeed that not perceiving information conveyed through audio may present a barrier to game experience to the extent that it may even prevent players to progress in the game. Below, a very interesting story reported by one of the participants who had to be assisted by his family to resume making progress in the game:

"In the only game that had spent a week trying to solve a puzzle and after finishing it I never replayed it was Resident Evil 3 - Nemesis, because the part that was needed to plug a pin that was necessary to hear. I even had help from relatives [...]"¹

¹ The story was written in Portuguese by a participant in the questionnaire and literally translated to English, including the difficulties to express himself orally.

Moreover, the same story shows that some elements of the recent games contribute to provide access for people who cannot hear:

"[...] And the other shooting games, mostly, I was looking for shots of the enemy, but today has facilitated because of the radar and when I am hit the red image appears with the alert."¹

In regard to subtitles, all complaints were related to the use of difficult words that hinders the comprehension of the text. Closed captions, had complaints about the presence of typing errors during live transcripts (in case of television).

At the end of the questionnaire, participants were asked to suggest improvements in games so they could be better suited to people with some degree of hearing loss. Suggestions were grouped in classes and those that are most relevant can be seen in Table 2. Three very frequent suggestions were use of subtitles, closed captions and videos in sign language. It was also suggested that the language of communication between game characters should be Libras (Brazilian Sign Language). Nor can we skip mentioning that some respondents stated unnecessary adjustments in games to make them more accessible for people who are deaf or hard of hearing.

Table 2 - List of most relevant suggestions made to improve games to those with some degree of hearing loss. Texts in italics are literal translations from Portuguese to English as they were written in the questionnaire by participants.

Dialogs in sign language
Communication happening in Libras inside games. Exploration of other manifestations of communication as acting and dancing.
Employment of visual content
Use of images in conjunction with texts <i>"since symbolic elements are better understood by the deaf"</i> .
Use images whenever possible so both adults and children may better comprehend games.
Providing of transcriptions
Closed captions: <i>"Explanation of sounds"</i> .
Subtitles: <i>"Use of subtitles to enable comprehension of what is being said, what is happening."</i>

Use of videos in sign language
Instructions in Libras.
Translation of texts to Libras using videos.
Haptic feedback
Vibration in joysticks and other input devices.
Use of low frequency sounds so they feel its vibration.
Other suggestions
To create games with Deaf Culture and Libras themes.
Exploring games with educational purposes for deaf.
Use of more accessible vocabulary.

4.3 Discussion

The analysis of the questionnaire allowed us to make at least three relevant observations: (1) deaf and hard of hearing people may be potential game players as 68% of participants have at least played games at some time; (2) Some game genres were more rejected than accepted, among these FPS and Fighting had the worst acceptance rates. Part of this may be due to the violence component inherent to both genres, but as we could observe from their declarations about difficulties to play, accessibility plays a bigger role on the matter; (3) their answers throughout various questions show that textual replacements like subtitling and captioning have been greatly appraised by those who had got to play games with those features, but there are other approaches they believe would prove useful strategies for enabling access to deaf and hard of hearing people.

5. Semiotic Inspection

As already stated, the purpose of this inspection was to conduct a survey of sound based communication strategies in games. More precisely, we were interested in finding out what types of information were broadcast through audio and their importance to gaming experience.

5.1 Execution

SIM was applied to answer our research question that was *"what communication strategies through audio do games use?"*. To answer the question, our focus was less on the segmentation and reconstruction of designer's meta-communication, and more on the identification of audio signs and communication breakdowns. As a result, we came up with a list of strategies that use audio signs to communicate. Also, we used the potential breakdowns in communication we found to evaluate the probable impact of those strategies to deaf and hard of hearing people.

By definition from de Souza & Leitao [2009], signs are considered to be static if they can be interpreted within the context *"present on the interface at a single moment in time"* (p.19), whereas they are considered dynamic if their interpretations require interaction, as they're *"bound to temporal and causal aspects of the interface"* (p.19). Based on those definitions, we considered the game music and ambient sounds to be

static signs, as they can be heard independently of player interaction; on the other hand, we considered sound effects to be dynamic signs, as they require player interaction or may be triggered by time-based events.

For each audio sign, we identified which information was being conveyed to the player; again, for each type of information, we answered the following questions: (a) What features of the sound effect were used to communicate that information? (b) Was there redundancy of that information in other signs? and (c) To what extent could missing that information impact game experience?. Then, similar sound effect features were consolidated into classes that were used in our reconstruction of the communication strategies. Finally, we evaluated the accessibility of those strategies based on a scenario of a profoundly deaf game player.

For the sake of feasibility, we restricted the inspection scope to the first 3 (of 14) chapters of the game: "Point Insertion", "A Red Letter Day" and "Route Kanal". As our interest rested only on communication through audio, our inspection was limited to the evaluation of audio signs.

5.2 Results

In this section we describe the classes of sound effects features we found to be used to convey information to players. An overview can be seen on Table 3.

Table 3 - Overview of sound feature classes identified during the semiotic inspection.

Dynamic signs		
Sound volume	Sound distribution	Distinctiveness
Timing	Speech	Tempo
Static sign		
Music		

Class 1: Sound volume - The sound volume is used as a clue to how far its emission source is from the player's character: the more intense it is played, the closer the player is to its source.

Class 2: Sound distribution - The game sound volume is split among stereo channels to simulate the direction of its source relative to player's character's position in 3D world. In other words, if players use properly placed speakers or headphones, they can distinguish the direction of an emission source by taking into account the volume of the sound perceived by each speaker.

Class 3: Distinctiveness - Some characteristics make sounds distinct from each other, like frequency, timbre and voice. Considering those characteristics, players are able to distinguish interlocutors in a dialog, enemies, situations, events etc.

Class 4: Timing - Timing is not a characteristic of the sound effect itself, but rather of which moment in time it is played, ceased or substituted by another sound. It indicates change in the state of the game at some level, e.g., an enemy starts to emit a different sound prior to attacking the player's character.

Class 5: Speech - The content of speech is used to contextualize the player and also to give instructions.

Class 6: Tempo - Some things in the game may be viewed as a magnitude and measured in a scale, like the player's walking speed. The pace in which the sound effects are played is used to represent a value in that scale, e.g., when a player is running, his footsteps sound effects have a faster pace than when he is walking.

Class 7: Music - Music by itself is a form of communication that can stimulate feelings and emotions in players.

Based on the use of audio signs observed, we reconstructed the game's audio communication strategies. We now present those strategies, linking them to examples of use and evaluating their accessibility to deaf and hard of hearing players.

Strategy 1: Enabling inference of approximate location of sound sources

Together, classes 1 (sound volume) and 2 (sound distribution) are used to provide clues on the location of enemies, NPCs, or anything that is also a sound source and is positioned in the 3D world. This strategy is complementary to location by visual signs in that it enables location of game elements without (or before) making visual contact with it.

We extracted a snippet of the final reconstruction of the metacommunication that illustrates the use of this strategy:

"Throughout the game you will encounter flying robots called Scanners. They will not attack you directly, but observe you and eventually try to dazzle you with a flash. When that happens, if you're looking at them, you will become unable to see for some time, what may cost you health points if you are being attacked by other enemies at the same time. Therefore, to avoid the obfuscation, you cannot keep them in your visual field when the flash becomes imminent. In this situation, you can try to infer the approximate location of robots and if there is threat of obfuscation through sound effects or closed caption. The latter sign does not communicate the position and direction of the robot nor its initial approximation, only the moment it is about to use its flash."

Players that cannot hear are unable to infer approximate locations of sound sources, what makes them slightly-to-moderately disadvantaged in the game. In the example, the closed caption may soften

the communication breakdown, but as it does not convey positional information, those players may be more susceptible to the obfuscation effect. Furthermore, in order to read the closed caption they may have to take their attention off other important visual elements of the game.

Strategy 2: Characterizing game elements

Class 3 (distinctiveness) applies naturally to every sound effect in the game in that it refers to their uniqueness. This strategy is the use of that property to make elements in the game world distinguishable thus characterizing them. There is more than one reason to properly characterize game elements, but one that justifies characterization per se is to provide immersion to players.

Immersion is known to be an important part of game experience and Brown & Cairns [2004] found that players tend to be more immersed towards games they consider to have provided a cohesive atmosphere by composing visuals, plot and sounds in a convincing way. Another characteristic found to enable immersion is empathy, which is the growth of attachment the player has with the game atmosphere. In special, in games that excel for realism like Half-Life 2, the sound effects in composition with graphics and physics work together to compose a convincing experience.

Ambient sounds also play an important role on game atmosphere, as was depicted in another snippet of the reconstructed metacommunication:

"In the different scenarios where your character will pass through in the game, I added typical sounds of the environment and situation to increase the realism and try to make you feel "inside" the game. If you cannot hear, the game does not give you the opportunity to receive this information."

The loss of this information may not impose disadvantages on players, but it has yet to be further studied its impact on immersion and then on game experience as a whole.

Strategy 3: Communicating threat

In an FPS game like Half-Life 2, the player must keep his character alive while managing to progress in the plot. The game supports players on the task of survival in a variety of ways using audio signs to advise them about risks.

For example, as the game uses the features in classes 1 (sound volume) and 2 (sound distance), players can infer that someone is coming their way, before having visual contact, thus being able to be prepared for the encounter. In addition, because of the feature in class 3 (distinctiveness), players may also manage to identify what kind of enemy is coming their way, enabling them to choose better strategies for the encounter.

An interesting sign identified during inspection is the sound effects of player movement, which varies according to the type of surface the character is moving on. So, by interpreting that sign, players can infer the type of surface they are on, which happens to indicate which kinds of enemies they might encounter there. Some enemies can appear more in a type of surface than in others. An example is the Barnacle (Figure 3), which is stuck to the ceiling and is usually found where the ground is moist and sticky. When players walk on this type of terrain, the sound of their footsteps refers to viscosity which, in turn, may remind them of the threat presented by Barnacles.



Figure 3 - An enemy of the kind Barnacle, very frequent in places where the ground surface is wet and sticky.

The use of class 4 (timing) also conveys to players information about risk level. One example is the Scanner robot that emits a slightly different sound (and blinks his light) a few moments before flashing. In this case, a caption [Scanner Click] appears at the same time, helping deaf and hard of hearing people to be aware of the risk. On the other hand, the helicopter in "Route Kanal" has a similar behavior to the robot and changes his sound effects to demonstrate it is going to start to fire accordingly, but neither caption nor visual sign complement the sound.

Another example of a sign that communicates threat to players uses class 6 (Tempo). At a certain point in "Route Kanal", some radioactive material puddles are scattered throughout the scenario and stepping on them may kill the player's character. The game informs players about the danger by playing a statics sound effect that has a faster pace when the character is closer to those puddles.

During the game, when the player is under attack by firearm, he can again use classes 1 (sound volume), 2 (sound distance) and 3 (distinctiveness) to identify his enemies and adapt his strategy accordingly. When hit, if shooting was done outside his view range, a red sign evoking blood is displayed on the HUD indicating the direction from which the shot was fired (Figure 4).

Not receiving the information communicated through this strategy greatly compromises game experience as players may become frustrated for not being able to keep their character alive. The inspected portion of Half-Life 2 showed only one severe

communication breakdown in this strategy (the helicopter); on the other hand, it presented an elegant solution to the problem of locating shooting enemies (red sign evoking blood).



Figure 4 - Effect (in red, to the right) displayed indicating that the player's character received a shot that was fired from somewhere to his right.

Strategy 4: Interaction feedback

Sound effects are also used as feedback from player's interaction. They usually complement visual feedback, like when reloading the gun, opening a door and shooting.

Deaf and hard of hearing players can use closed captions which provide a nice replacement for this strategy.

Strategy 5: Speech

The speech itself conveys information in an oral language but can be easily transcribed to subtitles or closed captions. However, as pointed earlier in this paper, prelingual deaf people tend to have difficulties reading complex texts.

In Half-Life 2, missing the speeches and dialogues may not lead to disadvantages, but rather may compromise players' engagement with game plot, which may represent a barrier to immersion [Brown & Cairns 2004].

Strategy 6: Triggering emotions and feelings

The game does not use constant background music as is quite common in other games genres. However, at times, short clips of music are played with the goal of evoking feelings and emotions on players.

For example, in chapter "A Red Letter Day", when the player's character wears the same equipment he used throughout the entire predecessor game (Half-Life), the theme song of the developer company is played, giving the feeling of nostalgia to those who had played the previous game.

As another example, in some situations of longer and more dangerous battles, a hectic music begins to play, which contributes to creating an atmosphere of tension and alerting the player.

5.3 Discussion

With the semiotic inspection, six strategies of communication through audio signs were identified and revealed very distinct usages of sounds. While some of them (strategies 2, 4 and 6) were used mainly as a contribution to the game atmosphere and thus, enabling deeper immersion for players [Brown & Cairns 2004], others (strategy 1, 3 and 5) conveyed important-to-vital information that, if lost, may decrease players' chances of progress in the game.

A good portion of the information conveyed through audio is represented textually by closed captions: dialogues, radio transmissions and the large majority of sound effects that give out information relevant to gameplay. The portion that is not represented may not prevent players from making progress as the game provides functions that enable changing of difficulty levels and retrials, like anytime saving and auto-save. However, there's a chance that deaf and hard of hearing people may have a reduced gaming experience.

The closed captioning approach used in Half Life 2 does not indicate positional information about the origin of sounds in space, which represents the loss of useful information to deaf and hard of hearing players. This issue was circumvented in Doom3[CC] by providing a sound radar on the HUD that indicates where sounds are coming from (Figure 5). Considering prelingual deaf people's frequent problems with reading, there is an even deeper problem with using textual alternatives to enabling access. It has been suggested by participants in the questionnaire the use of simpler language constructs and less elaborate vocabulary. Another general problem with replacing speech by text is that paralinguistic information like intonation and voice is lost. However, this problem is unlikely to impact deaf and hard of hearing players' chances to make progress in the game.

An alternative to closed captioning that was not explored much is the use of visual metaphors to somehow represent sound. This alternative was outlined in some participants' suggestions in the questionnaire and has already been used in the game The Sims 3. In Half Life 2, the only usage we could identify of this alternative is the blood effect on the HUD (Figure 4). Another alternative that was also outlined in participants' suggestions and has already been used in educational games [Couto et al. 2005] is the use of sign languages in the game, which would be less costly as there already is a functionality in Half Life 2 that allows characters in the game to change their facial expressions.

As stated before, we have yet to study the impact of not perceiving sounds and music in game immersion for deaf and hard of hearing players.



Figure 5 - Closed captions in Doom3[CC] and the sound radar that shows on the HUD the positions of sound sources relative to player's character. Note that the same color that is used in the closed caption is also used in the radar.

6. Conclusions and Future Work

To investigate the use of audio as a form of communication in FPS games and its impact on the game experience of deaf and hard of hearing players, we performed a semiotic inspection on the popular game Half-Life 2. We were able to identify six different strategies to convey information through audio. They were, then, evaluated in regard to the relevance of what they were communicating to players. The use of the Semiotic Inspection Method proved a useful tool for the evaluation of the game.

By identifying and characterizing those strategies, we hope to have given one step into providing epistemic knowledge about designing games accessible to deaf and hard of hearing people. With the characterization of strategies, new approaches to solving accessibility issues to those players can be proposed.

We used the results from a questionnaire applied to deaf and hard of hearing people about their game experiences as both a motivation for the choice of an FPS game and also for collecting information on difficulties they might have had playing and suggestions for enabling access to games.

Through the development of this research, we tackled three issues that were not found in the reviewed literature that may be part of a future work: (a) What is the impact on immersion of not hearing music and sounds that compose the game atmosphere by deaf and hard of hearing people?; (b) If immersion is indeed affected by not hearing music and sounds, how could they be depicted in alternative ways?; (c) Are there different profiles of deaf and hard of hearing people that require different accessibility approaches to gaming?

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