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Informative Sound Design in Video Games

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ABSTRACT

The importance of sound is quite well known in video games. Although frequently in the past sound was simply used to increase the immersion of the player. Now there is a growing interest in using sound as a means for providing the player with additional information.

While the use of sound for displaying information has been a topic of research for a number of years, research into the area of informative sound design for games hasn't been widely investigated as such. As a result proper guidelines for game developers to follow when attempting to design informative sound for a game haven't been broadly established. In addition, there has been almost no work done in considering specific genres such as Real Time Strategy and First-Person Shooter games and how sounds can be best used to provide players with information in these types of games. In this work we review previous approaches to sound design including the use of patterns. We then review these approaches in relation to sound design for both FPS and RTS games. Finally we present some key design patterns in relation to these genres.

Categories and Subject Descriptors

H5.1 [Information Interfaces and Presentation]: Multimedia Information systems – *Artificial, augmented, and virtual realities*

General Terms

Design, Human Factors

Keywords

Auditory Display, Design Patterns, Informative Sound, Computer Games, Auditory Icons, Earcons, Speech, Sound Design

1. INTRODUCTION

The role of sound in computer games as evolved since the classic laser sound effects and 8-bit monotone background music used in nostalgic games such as Space Invaders [33]. As game design becomes more complex in structure and quality, the use of sound as well as graphics to deliver information has grown in significance. No longer is sound simply a means to create mood and enhance the look and feel of the game. Sound increasingly has a role to play providing the player with critical information.

Currently most computer game designers focus on understanding the way players rely on visual perceptual cues when designing the game [11]. Indeed game developers often focus their attention on improving the graphics quality in video games and this has seen a trend towards designing near realistic game environments [9, 18]. However, a consequence of this trend towards designing visually enhanced and realistic playing environments is that the design of sounds in games is often neglected or only used to decorate the visual design.

Studies in the field of auditory display have shown that it's possible to integrate informative sound design into games and provide positive results to both developers and gamers alike [5, 13, 15, 32] In popular gaming genres such as First-Person Shooters (FPS) and Real Time Strategy (RTS) games, the design of sound is often critical as it provides players with relevant information about their current situation.

It's important to note the emphasis we are placing on informative sound as opposed to the immersive uses of sound. Since information gathering is particularly relevant in some genres and there can be imitations with displaying all information visually it makes sense that game developers utilize sound in a complementary fashion to visual feedback. For competitive games, additional feedback can increase the overall performance of players by providing information that might otherwise be overlooked.

The current state of sound design in games differs between large and small game developers. Large gaming companies often feature groups consisting of experts and mature sound designers who work closely with the game designers to ideally match and balance the sound design with the overall game design. Smaller, independent based developers however often lack the resources and numbers to create groups solely dedicated to sound design and instead tend to combine roles, resulting in sound that may be poorly integrated with the game mechanics. Larger developers usually have dedicated sound libraries and access to quality sound designers to develop new sound displays in the game. For smaller game developers, knowledge about using sound types isn't as readily available and they are one group that could benefit from better capture and dissemination of knowledge about sound design.

In the following sections we will present a brief introduction to multi-sensory display and the common methods of encoding information through sound. Then we will then analyze in some detail how these sound encoding patterns are used in an existing first-person shooter and real time strategy game. This will allow use to identify a number of sound patterns that may assist designers of informative sound.

2. ENCODING INFORMATION IN SOUND

The design of auditory displays of abstract data is an important field in its own right and is often described as ‘Sonification’ [21]. Within this existing field of study there is much literature to assist game designers. For example, the aviation industry has studied the design of auditory alarm systems for pilots in some depth to produce useful guidelines [29]. Such guidelines can simply be adapted to the design of simulator games.

It must be remembered that all displays rely on human perception and therefore general principles of perception apply when designing sound displays. For example, a user’s perception is influenced by the individual’s knowledge [16]. Furthermore, the sensory feedback that a particular observer pays attention to is determined by factors such as previous learning [35]. We tend to take an active role in perception by seeking out stimuli that are of interest, therefore our attention is important as it directs our senses to the stimuli that we want to perceive and subsequently influences the way the information is processed [16]. Attention can enhance perception of stimuli on which we are concentrating and decrease awareness of stimuli that we are ignoring. For example, in a multi-sensory display, some users may attend closely to the auditory signal where others may simply ignore it.

Where multiple senses are used to control an interface, the term ‘multi-modal’ is frequently used. However, this term has a strong implication that both the input and output of information between the computer and user is involved [37] and so the term ‘multi-sensory’ is often used to emphasise that the primary focus is on the output of information to the user [31]. Once again, some structured approaches for designing multi-sensory displays have been developed and these principles can be helpful when designing auditory displays into games.

It can also be useful to characterise multi-sensory displays as complementary, conflicting or redundant [23,27]. Complementary displays attempt to provide useful, but different, information on each sensory channel. Compared to a single-sensory display a complementary display should allow the user to perform better. If the user actually performs worse with the multi-sensory display then the display is described as conflicting. This is presumably due to some conflicting information that the user receives on the different sensory channels. With redundant displays the same information is displayed to each sense. This may serve the purpose of increasing the user’s confidence or reducing the perceived workload. Although users may report a reduction in workload or an increase in confidence with redundant displays, the performance of the user with the multi-sensory display is the same as with single-sensory display.

All three types of display may be relevant to the design of computer games. For example, complementary displays may improve user performance and they could also act as a reward for players who reach higher levels. In most domains, it would be abnormal for the designer to provide the user with a conflicting display, but a conflicting display could be useful if game designers wished to increase the level of difficulty for the player, or to punish the game player, or perhaps make a task more taxing by increasing the player’s stress level.

On the other hand, redundant displays may give players greater confidence in some situations and this may act as a reward or assist the player to learn skills required in higher levels of the game. In the rest of this section we will now consider some standard approaches related to sonification such as earcons [5], auditory icons [15] and speech and how these can be applied in game designs.

2.1 Auditory Icons

The term, ‘auditory icon’ was first coined by Gaver while exploring the capabilities of using sound as a means of extending the visual desktop metaphor to the auditory dimension. He defines it as a representation based on the naturally occurring sounds we encounter in everyday life. He suggests that humans perceive everyday sounds in the world in terms of the source and environment where the sound was created. Hence, an auditory icon is a pattern based on an instance of a real world sound, which is intended to provide information about an object, function or event [15].

For example, hitting a tin with a stick is an event that generates a sound. The sound itself conveys information about the material and size of the tin and if it is full or hollow. The sound also conveys information about the materials involved, the frequency of hitting and the force of the hitting. This is information we naturally learn to interpret from our everyday experiences.

Importantly auditory icons aim to take advantage of this type of previously learned knowledge, building on naturally developed auditory perceptions that are learned from common sound sources and the events that cause them. Icons simplify the display of information but also have the ability to present a lot of information in a concise and recognisable format [5].

Auditory icons enable us to develop an idea as to what generated the sound, whether the sound was important enough to warrant further attention and if required how we might take action [21]. Consider a simple scenario in everyday life, such as the sudden movement of unexpected footsteps in a dark house. In this scenario, we know that we can’t see what hasn’t been seen. However if we have been listening to our surrounding environment, we can interpret the pace and weight of the footsteps, the type of surface the footsteps were made on, where the footsteps came from, where they are going and perhaps the distance between the intruder and us. We can use then this information to decide how to proceed next. To do this we take advantage of the omnidirectional properties of auditory display examining not only the sound itself but also any echoes. We can gather all this complex information quite quickly from the single sound source.

An important element of auditory icons then is that the information they can convey is multidimensional. A single sound can potentially provide information about many different attributes of its source. For example, the sound of a door being shut might provide information about the size and material of the door, the amount of force used to shut it and even the size of the room in which the door was closed.

Mountford & Gaver [24] suggest that sound can provide information about many different things in the environment. Examples of this include:

- Physical events – whether a dropped glass broke or bounced.

- Invisible structures – tapping on a wall to find out if the surface beneath is hollow.
- Dynamic changes – When a container is filled with water, a listener can hear when it’s full.
- Abnormal structures – a malfunctioning engine sounds different to a normal engine.
- Events in space – the sound of footsteps indicate someone is approaching.

In computer games, auditory icons are used in a natural way to provide a direct link between events, objects and players actions in the game environment. First person shooter games such as Call of Duty: Modern Warfare 3 [18] and Battlefield 3 [9] utilize auditory icons by mapping player actions, objects and events in the game with the equivalent real world sound. Examples of these sounds include the sound of a gunshot, the movement of footsteps on the ground and the shouting of enemies.

The main advantage of gathering information through audible sources becomes more obvious when the player wants to gather vital intelligence on the location of enemy targets without exposing themselves visually to the enemy. An example of this is in the Battlefield 3 campaign mission ‘Fault line’. The player is required to take down an enemy sniper hidden somewhere in a tall building across the road. However the player is unable to visually see the sniper and must rely upon sound to locate and then kill the sniper. In this scenario there are a number of auditory icons that the player can identify. The sound of constant sniper fire notifies the player that the main threat is still active and that they should be careful. This is an example of a symbolic icon as the sniper fire represents constant danger in the area. The sound of bullets chipping the pavement near the player indicates the type of area the player is currently in. The distance and direction between the player and the sniper can be predicted just by listening to the duration of the echo generated by the shot.

There are many other examples of how sound can be used to gather information in a First-Person Shooter environment. However, they can generally be divided into three categories: pre-emptive sounds, reactionary sounds and feedback sounds [17]. Pre-emptive sounds tell the player where the enemies are located before they can strike. These sounds include footsteps walking on different ground surfaces and gunshots in the distance. Reactionary sounds indicate the location of an enemy after the enemy has attacked. An example of this is where the player slowly moves forward after finding out the location of the enemy sniper by listening to the sound of the shot and the echo produced afterwards. Feedback sounds indicate damage to the player’s avatar. The sound of bullet hitting flesh and the sound of a heartbeat as well as the sound of enemy fire are examples of how sound can provide feedback on the current status of the battle, especially if the player is close to death.

In relation to the importance of designing informative sound in games, auditory icons allows developers to create direct links between the player and the game environment in terms of sound events and objects that also occur in the natural world. Due to our everyday knowledge of these relationships with everyday objects the information in the encoding is naturally understood. Using familiar sound signatures gathered from our experiences in the world and linking them with the equivalent events and actions in the game is a simple approach to improving a player’s feedback in a game.

2.2 Earcons

An alternative form of representing information through sound is earcons. While auditory icons are naturally occurring, earcons are abstract, synthetic tones that can be used in structured combinations to create auditory messages [5]. They can be thought of as symbolic and arbitrary sounds such as artificial noises and music, which can be seen as abstract in the sense that they can’t be immediately recognised. Unlike auditory icons, which rely upon intuitive relationships between the sound and the source, earcons use abstract mappings between a music-like sound and the data to convey complex information [22].

Earcons have the advantage of being without context and thus can represent any event or interaction in the interface. Earcons also tend to be more precise than auditory icons. The main disadvantage of earcons is that the user has no intuitive knowledge to draw on when interpreting the sound. Therefore to understand an event, the association between the sound and the event has to be explicitly learnt by the user. If more complex structures are used in the earcon, decoding the message may rely on the listeners’ ability to interpret musical variations.

Earcons are created from building blocks called motives, short rhythmic sequences that can be combined in different ways. Motives are essentially large structures created from the musical properties of rhythm, pitch, timbre, register and dynamics, which are then manipulated to form a range of audio messages of varying complexity.

In video games, earcons can be used to provide detailed information to players in the form of warning signals. For example in Dota 2 [36] these warning signals are provided in the context of a ping command. Pings are short, arbitrary sounds, which can both notify and warn players of various events. These events could include warnings of potential ambushes, notification of allies to attack or defend or for teammates to rally to a certain part of the battlefield. They are a combination of the notification and warning signal function identified by Jørgensen as they can be ignored or used to prompt immediate action in certain situations [19]. Although they are intended to communicate information between players, pings are not naturally occurring sounds and require prior learning before the meaning can be understood.

Another common use of earcons is background music. Despite the immersive properties normally associated with music for both films and games music may still provide useful information in some games. For example providing a player with direct feedback in regards to their current status. For example in the mission “going hunting” from Battlefield 3, two different soundtracks are used to indicate the current situation the players find themselves in. The first soundtrack represents a calm situation as the player is flying with no activities occurring outside the cockpit. However, when the player encounters enemy aircrafts, the soundtrack changes to indicate the player is in danger and direct action needs to be taken in order to avoid their jet fighter being destroyed.

In relation to informative sound design in games, earcons allow game developers the ability to convey complex sound patterns. However the interpretations may need to be learned and the encodings may rely somewhat on both the designer and players musical listening skills.

2.3 Speech

The third common method of encoding information through sound is speech. Speech is the most obvious form of information

carrying sound as spoken language is the predominant form of auditory communication [13]. Speech is a viable alternative to non-speech sounds in situations where the player requires spoken words to convey precise information about the nature of the current game situation. In situations where the number of abstract warning signals is too large to be distinguish or remembered, speech-based signals benefit from not requiring players to learn the exact meaning of coded signals. Understanding the speech is all that is required. Also, because speech is perceived through common cognitive processes, it's potentially more effective in complex situations than abstract tones, where the meaning has not yet been learnt to the same extent and thus requires considerable cognitive effort to decode [10].

In games, speech can easily be implemented to provide instructions to the player as well as providing real time updates of key events. In FPS games, speech-based signals are primarily used to relay instructions, in conjunction with the visuals, so the player can follow orders in the battlefield. Speech has the disadvantage that messages tend to be longer than with non-speech sounds. Therefore while they are easy to decode additional time may be required to hear the full message to. In non-combat situations, using speech to convey information on the current objective as well as other tactical information is ideal, as the player will have time to listen to the message, plan and then take the appropriate action. In combat situations, speech is often used to warn players of potential or incoming dangers and also indicate the status of the current situation in regards to how well the player is currently faring. An example of this is the classic call of 'RPG' from an allied soldier moments before the projectile explodes near the player. Although a player may see the rocket approaching, the auditory sense is more attuned to generating an immediate response.

In RTS games, speech-based signals also play a fundamental role in informing the player when certain events occur or there is some change of status in a situation while minimising disruption to the current task being performed. An example of this is when the player is exploring uncharted areas of the map with a small group of warriors. Because their current visual display only shows what is currently seen on the map, the player will not be able to tell when new units have been trained, when new buildings have finished construction or when their base is under attack by the enemy. This information allows the player to respond accordingly if required before returning back to the current task at hand.

In relation to informative sound design in games, speech allows game developers to convey information in a pattern already familiar to users who speak the same language. However the length of the message needs to be considered, as longer messages will elicit a slower response rate.

3. INFORMATIVE SOUND IN GAMES

In this section we review the existing use of informative sound in two popular computers game genres, namely, first-person shooters and real time strategy games. Battlefield 3 [9] a well-known first person shooter and WarCraft III [7] is a representative real time strategy game. We selected these two games as they are well-known and feature a variety of sounds that are relevant to the context of previous discussions about earcons, auditory icons and speech.

The two games also feature different viewing perspectives (first and third person). Furthermore both genres feature a variety of tasks in the game that the player has to perform in order to

progress in the game. In these tasks, we are interested in analysing how sound supports the players in obtaining information about their current situation and how this assists them complete tasks and therefore improve their performance.

3.1 Battlefield 3

Battlefield 3 is a popular modern first-person shooter video game created by EA Digital Illusions CE (DICE) and published by Electronic Arts as part of the Battlefield franchise in October 2011. This sequel to Battlefield 2 is available for the Xbox 360, PC and PlayStation 3 platforms. The game is split up into two areas: Campaign and multiplayer mode. In the multiplayer mode, players can participate in one of five game modes: Team Deathmatch, Squad Deathmatch, Rush, Squad Rush and Conquest. Each of these modes presents a variety of challenges to players that require players to work together to meet their mission objectives.

In campaign mode, the overall goal of the game is to defeat a worldwide terrorist organization called the PLR. To reach this goal, the player is required to complete a range of mission objectives and sub tasks within these objectives in a particular level in the game in order to advance to the next part of the campaign. Throughout the campaign mode, the player takes on a number of different military roles (a marine, a tank operator, a jet pilot and a Russian operative), each requiring the players to familiarise themselves with the environment (ground, air, night) in order to successfully complete the mission objectives.

While the developers of Battlefield 3 strive for realistic graphics to help immerse the player in their battlefield roles, sound is also used to support this immersion. An example of this is in the game is the soundtrack and sound effects.

However, as Jørgensen has observed [19] music can sometimes help game players identify how well they're faring in the battle and indicate important changes in the current environment of the scene. As previously mentioned, in the mission 'going hunting', there are two types of soundtracks used, a pre action soundtrack and an action soundtrack. The pre action upbeat triumphant soundtrack helps establish a pre-emptive battle mood for the player flying in their fighter jet through enemy airspace towards the enemy airbase. When the player suddenly encounters enemy jets in the air, the music then changes to a dark, tense theme, indicating that the player is no longer in a safe environment and they should react accordingly to the new situation

Sound effects in the game often work alongside the visuals to enhance the realism of war and destruction. Examples include shattered glass, background gunfire, explosions from weapons such as rockets and grenades, bullet clips dropping on the ground and so forth. Despite the immersive properties of these types of sound in the game, some sound effects can also provide players with additional feedback about their surrounding environment and their current performance.

Battlefield 3 utilises the informative properties of sound effects to map player actions, objects and events in the game to their equivalent real world sound. By mapping the sound in the game to the representative real world equivalent, the player quickly recognizes the meaning of the sound and then intuitively responds.

This type of mapping is typical of the way auditory icons can be used to convey information. For example, the sound of a bullet whooshing past the player's head would indicate that the enemy has missed their target narrowly and that the player should be careful about proceeding forward or to take cover. This is an

example of reactionary sound, as the player now knows the location of the enemy after they have fired their weapons and can react accordingly. The sound of a grenade landing on the ground would indicate that it's about to explode and the player should retreat away from the blast zone. This is an example of pre-emptive sound as the player has time to move out of harm's way before the grenade explodes.

As previously explained in section 2.1, auditory icons are also used in the game to provide players with feedback about their character's current health levels. For instance, the sound of bullets hitting the player's flesh indicates that the avatar has taken damage. The sound of a heavy heartbeat and rapid breathing tells the player that their avatar is close to death and they should retreat to recover their strength to avoid dying in the game. As stated previously, these sounds can be divided into three categories: pre-emptive sounds, reactionary sounds and feedback sounds [17]. Pre-emptive sounds tell the player where the enemies are located before they can strike. Reactionary sounds indicate the location of an enemy after the enemy has attacked and feedback sounds indicate when damage has been taken by the player's avatar.

Like most first person shooters, often the visual and sound displays complement one another to provide complete information to the player on various battlefield statuses. An example of this is the mission objective logs during the campaign. During a mission, a player can read the current mission objectives on the top left corner of the screen as well as receive regular updates via speech based auditory alarms.

This allows for vital information to reach the player should one form of feedback be unavailable or is missed. In combat, when a player is struck by enemy gunfire, the screen is filled with splattered blood indicating to the player that damage has been taken. During tense battle scenes however, such visually enhancing screen elements might not be ideal as it could reduce the amount of screen space the player has to work with and could block other potentially important visual elements from the player's attention.

In some parts of the game, sound can be a faster form of gathering information than visual display. For instance, in the mission 'Operation Swordbreaker', the player runs towards a seemingly empty car park. As they are about to walk in, the sound of a bullet suddenly striking the soldier in front indicates the enemy's presence in the area. This is another example of reactionary sound as the player can use the echoes generated from the shot to find the source of the sound. Although we visually see the soldier fall to the ground, the sound of the bullet hitting the soldier is noticed first due to the way our auditory perceptions are connected with our arousal and alert function in our nervous system. When we hear a sudden bang sound, we naturally would take cover especially if we cannot see what object made the sound. Other than sound effects and soundtracks, one of the more common uses of sound in Battlefield 3 is speech.

Speech based sounds tend to be used by the developers to immerse the player into the game world by using traditional army slangs and terms and combining it with the visuals to create a realistic impression of a war torn battlefield. However despite the immersive use of speech by the developers to decorate the visuals, it still has informative values, which can provide valuable auditory feedback to the player in terms of what needs to be done to achieve the current mission objective and to advance further on with the overall mission.

Speech based signals are used in the game to communicate and provide feedback to the player in a number of ways: to convey

information two-ways between the player and other non-playable characters relating to the mission objectives and its subtasks as well as to warn the player of certain events and objects in the environment such as an enemy ambush or enemy vehicles.

Speech is also used to prompt the player into performing some kind of action in response to a situation. For instance, in the mission 'Operation Swordbreaker', the screams of 'ambush' from the allied soldiers alerts the player to the dangers of potential enemy gunfire outside the building. The player is then prompted by a fellow soldier to clear the car park of enemies and to take out key targets such as a soldier armed with a rocket propelled grenade.

In such situations where the player is required to take their time in completing certain tasks when pinned down during enemy engagements, speech is ideal to convey information, as the player will have time to interpret the message and choose the appropriate action in response. Although this information is also provided visually via the caption responses of allied soldiers on the bottom of the screen, in most cases the player eyes is often focus on the top and middle part of the screen and they may miss out any visual based text messages. Speech based messages help reassure the player and provides relevant feedback when required to proceed on with the mission.

Earcon based warning signals also feature in the game as a way to support the visuals. They provide useful non-verbal information such as the current health of a vehicle. An example of this is in the mission 'Thunder Run' where differing levels of alarms are used to warn the player how much damage their tank is taking from enemy tank fire. The rate and frequency of the alarm increases as the tank takes more damage, warning the player they now need to evade enemy fire or risk having their tank destroyed.

In this section, we talked about how sound is used in the first person shooter environment. We discussed how soundtracks and sound effects are related to earcons and auditory icons. We also analysed how auditory icons are used in the game to map the actions and objects in the game to the equivalent real world sound and how meaning is interpreted from this mapping. We described how visual and sound displays can work together and at situations where sound is a preferred way to obtaining information from the environment. Finally we looked at both speech and non-speech signals and the role they play in the game. In the next section we examine how sound is used in a typical real time strategy game.

3.2 WarCraft III

WarCraft III is a medieval real time strategy game created by Blizzard Entertainment as part of the WarCraft franchise [7]. The game takes place in a fictional world called Azeroth where players are involved in an epic struggle to survive in an uncertain world. Unlike Battlefield 3, the player controls multiple units and buildings from a bird's eye, third person perspective above the battlefield. Players can control one of four playable races; the Humans, the Orcs, the Undead or the Night Elves. Each race features a number of unique units and buildings as well as a special character called a hero who can change the tides of battle. To win the game, a player has to destroy all the enemy players' buildings or force their opponent to surrender and leave. In order to achieve this objective, the player has to assemble a base and a formidable army.

Like most real time strategy games, WarCraft III is a highly paced game, where the player must multi-task as they build a base, control their army and expand their resources. Players need to stay informed at all times on events occurring not only in the player's

current point of view but also any relevant off screen events that may be happening. These factors make sound an important source of additional information for players if they are going to control all aspects of their game.

WarCraft III uses sound in the game to provide feedback to a player in the form of speech based and non-speech based warning signals. These warning signals are divided into two categories: Notifications and warnings. Both of these functions play a role in informing the player about various actions and events which may occur in the game.

Notifications provide information about events, which occur in the environment but don't necessarily demand some response from the player. An example of this is when a worker has finished construction of a building; the message 'work complete' is played. The player is notified that the worker is ready to begin a new task. When a research upgrade has finished, the player is also notified that an upgrade for a certain unit or building has finished. In both cases, the player may choose to immediately assign new tasks for the work or new upgrades to enhance their armies.

However in certain situations, such as when the player is attacking an enemy base or defending their own base from attacks, the player may choose to not ignore the notifications as they tend to be low on their list of priorities. Notifications are also used to warn players if they perform an illegal move. For instance, when a player attempts to build on an unbuildable surface (for example water), train a unit or construct a building that the player can't afford, the player is notified by sound that the move is not possible.

Warning signals provide information about threats to the player and usually demand an immediate evaluation and response. An example of this is when the enemy attacks the player's base or their forces, the message 'our base is under attack' is played, immediately letting the player know that they are under attack. Depending on the severity of the situation, a player may choose to not take any action if they believe the situation is under control. In single player games, the majority of auditory feedback signals are speech based. Because the only entity the player interacts with is the game system, speech-based signals are ideal when a two-way exchange of information is required between the player and the system.

Earcon based alarms are usually seen in multiplayer games where there is two or more players per team. They appear in the form of a ping. As mentioned earlier on in section 2.2, pings are short, arbitrary sounds, which can both notify and warn players of various events.

Unlike speech signals, pings can be used to rally allied forces for an attack on an enemy base or a defence of an allied base. They are also used to warn players of certain events such as the last known whereabouts of the enemy. Both speech and non-speech based alarms are used together to provide information to the player on various aspects of the game and then redirect their attention to the screen for further actions. Like Battlefield 3, both the visual and auditory displays in WarCraft III work together to convey complete information about the objects, entities and events in the game.

Since sound extends visual perception, it enables the player to be in control over unseen areas of the map [19]. When a player is busy attacking an enemy base or exploring another area of the map, they might receive messages about the status of their base. These messages provide increased information for the player especially in situations where the player's base is under enemy

attack while they are exploring another part of the map. By utilizing sound to extend the field of focus beyond just the visual field, a player is able to respond faster to critical situations and deal with them before they get out of control.

Combat situations in WarCraft III tend to be chaotic and rapid especially in battles where there are a huge number of army units from two sides fighting at the same time. It can be difficult for the player to see exactly what is happening during combat. The sounds of guns firing, bowstrings and swords hitting shields inform the player what types of units are fighting and screams indicate which units are dying [19]. This example shows how sound can be used to provide information that's difficult to show visually. In her experiment, Jørgensen [20] noticed that when sound was absent, players had difficulty noticing written messages on the screen. This is most likely because of the rapid pace nature of the game and the fact that the player's visual perception is often focused on completing a specific task in the game. Any other visual messages would be distracting to the current task and may delay the task completion should the player be forced to read the visual message.

4. DESIGN PATTERNS

The concept of design patterns was first introduced by the architect Christopher Alexander and his colleagues [1, 2] as a structured method of describing good design practices within a field of expertise.

Design patterns can be defined as the core of a solution to a problem that repeatedly occurs in some environment [3]. A pattern consists of three main parts: the vocabulary, the syntax and the grammar. The vocabulary is a collection of named, described solutions to problems in a field of interest. The syntax is a description that shows where the solution fits in the design. The grammar describes how the solution solves a problem or produces a benefit.

One main characteristic of design patterns is that they are a living body of knowledge. The evolution of patterns is a natural strength of this methodology. A collection is open for additions and each pattern can be challenged, improved or refined [3].

In terms of sound design, there is a strong relation between the concept of patterns and the current needs and characteristics of the area of designing sound in games. The potential knowledge of sound is mostly held informally and not evenly distributed among the large and active community of small, independent game developers. Indeed sound patterns have previously been suggested in terms of sonification [6] as a way to help share knowledge. There has also been a set of cards, containing general sound design patterns explicitly for assisting in game sound design [4]. In the following section we add to this knowledge base by beginning to document some genre-based sound design patterns as typically used in FPS and RTS games.

5. INFORMATIVE SOUND DESIGN PATTERNS IN FPS AND RTS GAMES

In the previous section, we discussed in some detail the common methods for designing informative in First-Person Shooters and Real Time Strategy Games. In this section we highlight these patterns and describe them more formally as design patterns. For each pattern we describe the context, problem, solution and give examples.

5.1 Impending Death

Context: Most FPS games implement death visually through the use of blood and blurred vision on the player's HUD to let the player know their character is close to death and that they need to recover before proceeding on. Recovery may involve avoiding direct fire from enemies for a period of time to slowly regenerate their health or by administering some kind of remedy such as a health pack to instantly gain health.

Problem: The overall effective vision of the player's character is reduced when blood is splattered across the screen and orientation is affected from the use of blurs. Players can get confused and disorientated from these visual elements, which can lead to their character's swift death if no immediate action is performed.

Solution: Health statuses can be communicated by auditory means from instances of real world sounds. Auditory icons provide a couple of advantages when communicating statuses or information compared to visuals. They allow for a more direct understanding of the situation and allows for quicker feedback regarding the player's current health level.

Examples: In Call of Duty: Modern Warfare 3, when the player is fighting a group of enemies to advance to a forward position, they may take damage from enemy fire. When the player is close to death, a very strong heartbeat and heavy breathing dominates the senses, forcing the player to take evasive action to avoid death before they can carry out the mission or objectives.

Rationale: Sound can provide information about the player's current health without obscuring their line of sight unnecessarily. By sonifying the visual elements when the player's character is close to death, the player will react faster and take appropriate action to survive.

5.2 Local/Global Notifications

Context: Most RTS games feature visual based notifications via text messages to notify players about changes in their environment ranging from the completion of certain tasks and upgrades to their army. When an enemy army attacks a base, a small visual icon is placed on the player's minimap in the area the attack occurs.

Problem: Unless the player is not currently occupied with another tasks, they may forget about when certain tasks have been completed. This may delay the start of another task such as constructing an additional barracks to increase troop production or defenses to protect the base. During periods where the player explores new territories, their overall awareness is restricted to the current line of sight. If the enemy army attacks a base, the player may not see it on either the map or mini map from the bottom of the screen. This may result in the player receiving a substantial disadvantage due to the losses obtained as a result of an enemy attack.

Solution: Speech based alarms and earcons can be used together as warning signals and notifications to notify the player of ongoing changes in the game environment. These are referred to as urgency and response signals [30]. Speech allows for direct and precise messages to be communicated to the player in situations where the player has time to respond to the nature of the message. Earcons allow players to communicate with other allies by providing warning signals in points of interest that has been spotted on the map and needs to be addressed.

Examples: In StarCraft II: Wings of Liberty [8], the player is exploring unknown territory with their army to establish a new mining base. Their current vision is restricted to a certain area of

the map. When unknown enemy forces attack one of the player's bases, a speech-based signal is immediately communicated to the player warning them of an attack on their base. The player is then aware of the threat and decides on the appropriate response measure. In Defense of the Ancients 2, a player is currently aware of an impending enemy ambush on their position. Another player uses a ping signal to warn the player to retreat to safety thus avoiding death and ensuring their safety from enemy heroes.

Rationale: Sound can provide information about changes in the environment without being restricted to only what is currently shown on the screen. By using sound to convey important information in a timely manner, players are immediately informed and aware about changes in their environment.

5.3 Progressive feedback

Context: Most RTS games feature a visual based display, which constantly updates according to how the player is progressing in a campaign mission. When the player has completed certain objectives and tasks, new goals are then added and shown on the screen.

Problem: Not every player pays attention to what is written on the screen. During certain parts of the mission where the player is preoccupied with another task, the visual display board may not be seen and could be ignored.

Solution: Speech based notifications and earcons can be used in conjunction with the visual display to keep the player inform about the current objectives and tasks at all times. When the player has completed a task, an earcon can be used to signify that the objective has been obtained while speech can be used to reinforce understanding.

Examples: In the mission 'Welcome to the Jungle' in StarCraft II: Wings of Liberty, when the player collects and delivers a terrazine canister to the command center, Tosh will commend the player on their success. An earcon like sound is played to indicate when the player has completed the objective. During the mission, the player receives periodical speech updates of the current situation from the robotic adjutant computer.

Rationale: Sound can provide steady flows of information to the player to keep track of their progress when completing tasks and objectives. It can be combined with visual based displays to provide an overall view of current progress.

5.4 Damage

Context: Most FPS games displays damage by changing the colour on the screen when projectiles lands on or near the player's character as well as the surrounding environment. In addition, motion blurs are utilized when the character's health reaches a critical level.

Problem: Overusing visual effects to indicate damage taken from enemy projectiles can dazzle and confuse the player temporarily. Visual effects may cause the player to suddenly panic and lose control of the situation, as they don't know how much damage their character has taken.

Solution: Auditory icons can be used to indicate when projectiles have hit the player's character or the surrounding environment such as a bullet sinking into the flesh and bullets shattering glass. When the player has reached critical health levels, the sound of slow, dull heartbeat and heavy breathing can be used to indicate that death is very close unless action is taken to avoid further damage. Related to Impending Death.

Examples: In Battlefield 3, sound is used to indicate when bullets have hit the flesh of the player or the enemy soldiers. When projectiles land near the player or hit the surrounding environment, the appropriate sound is played indicating the potential damage caused by the weapons.

Rationale: Sound can be used as a measure of damage. By using sound, players are less distracted by the visual effects and therefore most likely be able to perform tasks more successfully.

5.5 Environmental Awareness

Context: In FPS games, the player is required to continually monitor and scan their surrounding environment for potential threats and dangers.

Problem: The information received by the player in regards to their environment is limited to the current line of sight. For hidden dangers or unfavorable conditions such as a change in the weather or time of day can prove problematic when trying to obtain information on the current situation.

Solution: Auditory icons can be used to indicate movements and general noise from enemy troops as well as enemy gunfire from hidden targets such as a sniper. Earcon based alarms and speech signals can also be used to indicate when the enemy is aware of the player's presence.

Example: In the mission 'Operation SwordBreaker' from Battlefield 3, the player is seen advancing towards the objective before a sniper shot lands on an allied soldier. The player is now aware of the potential threat of the sniper and proceeds with appropriate actions to counter the threat.

Rationale: Sound can be used to provide information where visual means aren't possible due to unfavorable conditions where visual is not ideal in the collection of information about the surrounding environment.

5.6 Impairment

Context: Most FPS games alter the vision and movement of the player's character when they are struck with projectiles such as flash grenades and rockets.

Problem: Players may not pay attention to the ground where a potentially deadly projectile has been thrown near or at the player's character. When the projectile has exploded, the player is caught off guard and quickly loses orientation of their surroundings.

Solution: Use earcons to alter the hearing levels of the character. Auditory icons can be used to associate different types of projectiles with familiar sounds.

Example: In Call of Duty: Blacks Ops 2 [34], flash bang grenades produce an ear piercing sound when it explodes near players. In addition, bouncing betty's produce a buzzing sound before they are detonated.

Rationale: Sound can be used as deterrent to caution players on their actions and increase difficulty. It can also be employed as a weapon to temporarily deafen hearing and complements the visual effects of blindness.

5.7 Time Limits

Context: In FPS games, time limits are visually displayed away from the main viewing area of the screen. Time limits are usually used to inform the player the duration of time remaining before the mission ends. In RTS games, time limits are usually used to indicate how long certain abilities from units and buildings are on cool down before the player can activate them again.

Problem: Players are often too preoccupied with other more important tasks, which require their visual attention to be able to continuously monitor the amount of time left remaining.

Solution: Auditory icons such as the sound of a clock ticking can be used to help players mentally count down the time. Speech can also be employed to periodically remind players when certain stages of time have passed.

Examples: In the multiplayer game mode 'Domination' from Call of Duty: Black Ops 2, players are gradually notified via speech updates from the commander as the time limit for the round approaches. In Dota 2, both the sound of a clock and the speech remark hero reminds players when abilities are on cool down.

Rationale: Sound can be used as an alternative to keep track and monitor time while players can focus their attention to more important tasks.

6. CONCLUSION

There are two basic approaches designers can take when adding auditory cues to a game interface. Firstly, designers can aim to improve the player's feeling of satisfaction or enjoyment of the experience. For example, background music and sound effects have long been used in motion pictures to augment the experience for the audience. A similar strategy has carried over into game design, where sound can assist players to become absorbed or immersed in the 'reality' of the game.

The second way that designers can employ auditory sensory cues is to design the feedback so that it assists the player to perform essential tasks. The emphasis is on providing the player with useful additional information. For example, an auditory alarm may be used to warn players in a first-person shooter game that they are running low on some vital resource, such as health or ammunition. The general assumption is that, by increasing the number of senses used in the interface, we can somehow increase the amount of information the player receives.

In this paper we've highlighted the growing importance in utilizing sound as an additional source of information. The field of auditory display has shown that it's possible for designers to create informative sound displays, which can support the visual system by complementing the flow of information when required. As the quality of game design becomes more advanced, the level of information and detail within these games will also increase. It's important that designers consider designing sound which assists the visuals in providing information about the game environment to players.

Sound designers can acquire knowledge from the common methods to encode information through sound to help guide them in the design of informative sound in their games and develop guidelines which can be adopted in future iterations. Popular competitive games such as Dota 2, StarCraft II: Wings of Liberty and Call of Duty: Black Ops 2 are all examples of games which feature and benefit from the design of informative sound for both users and designers.

After presenting a small range of informative sound patterns in both FPS and RTS game genres, it's hoped that this knowledge can be shared across the broad community of both large and small sound designers to further improve and highlight the significance of integrating informative sound design in future video games. Further research in this field will help identify additional informative sound patterns in other games genres such as RPG in addition to both FPS and RTS games.

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