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**An Investigation into Online Multiplayer Battle Royale  
Games to help Deaf People**

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## **Abstract**

Online multiplayer battle royale games (OMBRGs) gaining popularity day by day. Generally, OMBRGs played as a solo, duo, and squad match up to four players in each team. As a duo or squad players able to communicate with each other through voice chat. And other important features of OMBRGs was the use of sound and audio information. Research has shown that audio or sound information in video games creates barriers for deaf people. Most of the research has done providing accessible subtitles in a video game to help deaf people. But the OMBRGs was different than what previous research has done for deaf people. This research aims to identify the problems and issues experienced by deaf people in OMBRGs. And try to find subtitle and caption were enough to make video game accessible for deaf people.

Previous studies show that implementing subtitles and captions in video games helps deaf people to play video games and increase their gaming experience. A combination of methods was used where content analysis and game guidelines review were chosen to find the problems and issues experienced by deaf people in OMBRGs. The feedback of deaf players was analyzed from the discussion and feedback platform of PlayerUnknown's Battleground (PUBG). The analysis of deaf player's feedback shows two major problems lack of text chat as an alternative to voice chat to communicate with team members and lack of visual feedback elements as an alternative to sound or audio. Due to a lack of text chat and visual feedback elements in PUBG, deaf players use external text chat and visualization plugins that allow them to text chat and represent visual cues of sound activities. But deaf players also mentioned the problems of text chat and visual representation of sound activities such as difficult to type text in a rush

situation, text chat distract focus from the game and visual representation was not accurate and reliable. So, Game testing carried out using game accessibility guidelines to identify the problems in current OMBRGs to support the finding of deaf player's feedback. The problems and issues which were not identified from deaf player's feedback were checked by the game testing process. The finding suggests that some OMBRGs implemented text chat and visual feedback elements.

The next phase designed to test how deaf player's gaming experience can be improved implementing text chat and visual feedback elements in OMBRGs. Two game samples were created: first sample with wheel predefined voice phrases and visual feedback of sound activities, and second sample with typing text chat and no visual feedback of sound activities. The test was conducted with 10 participants where participants played both game samples without sound. The results show that wheel predefined voice phrases and visual feedback of sound activities in video games help to improve the gaming experience of deaf people. The finding shows that text chat and visual feedback elements in OMBRGs need to be studied. The current findings only suggest implementing text chat and visual feedback in OMBRGs helps deaf people. Further investigation requires to implement accessible text chat and visual feedback elements in OMBRGs.

Keywords: Online multiplayer battle royale games, PlayerUnknown's Battleground, Text chat, visual representation, deaf people, accessible video game

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## **LIST OF ABBREVIATIONS**

ANOVA	Analysis of Variance
APX	Accessible Player Experiences
CoD	Call of Duty
FPS	First-person shooter
OMBRGs	Online Multiplayer Battle Royale Games
PC	Personal Computer
PUBG	PlayerUnknown's Battlegrounds
SUS	System Usability Scale
TPS	Third-person shooter

## **Chapter 1: Introduction**

Video games are becoming popular and advanced. It attracts millions of people from different places with different ages, occupations and disabilities. Advancement of video game allows user to play along with other players from different places through online. Recently, online games are very popular and playing over worldwide. The popularity of online game increases because of its social service facilities (Kowert, Vogelgesang, Festl, & Quandt, 2015). Online game allows players to play along with number of players. These games provide a virtual world where real people use to play using different character in a game with different players. Video game has gained so much popularity with its impressive gaming environment. With the change of Information technology in lightning speeds that enhance gaming experience to another level. (Mashable, 2015) states that video games are an entrenched part of our cultures and routines. Video game can be played in different platforms such as PC/Mac, console (Xbox, PlayStation), smartphone and handheld console (Nintendo, vita). According to (Statista, 2016), popularity of gaming platform stands, mobile platform with 37%, PC/Mac platform with 29% and other gaming console (Xbox, PS, vita and handheld console) 34%. People with disability are also attracted towards the video game. Most of the disable people are familiar with video game and spend their time playing video game. There are different disabilities such as blind, motor and deaf. When it comes to the disable people, video game requires accessible features that assist player with disability to play game. People with disability have issues or challenges playing video game such as, no audio clues, no subtitles, poor interfaces design, and poor controller setup. People with hearing impaired are unable to receive the audio or sound information. In video game, there are so many cinematic clips and audio

conversation where subtitles are missing. Such situation affects the gaming experience of deaf people.

Among the disability group, Deaf people perform well playing video game. Deaf people can play video game if it does not contain audio or sound. The sound clips, audio dialogues, and other sound effects raises the issues and challenges to play the video game for deaf people. To increase accessibility for deaf people in video game, subtitle and closed caption were implemented. Most of the game follows the practice of implementing subtitle and closed caption in video game help player with hearing impaired. Now, the popularity of gaming was shifted to online multiplayer game. Some of the popular online multiplayer games and its popular gameplay were discussed below:

### **World of Warcraft (WOW)**

World of Warcraft (WOW) become most popular Massively Multiplayer Online Role-Playing Games (MMORPGs). It provides different features in a game such as role playing, multiplayer online and offline playing. Player used to select an avatar or character to play game. There are various character or avatars available in the game which is unique and different. WOW is more like strategical and planning game that requires strategy, planning and coordination (Silva & Mousavidin, 2015). This game provides virtual environment where player is focused to make strategy and planning to play. Role playing feature explore the story line of each character. Role playing allowed player to explore story of character. WOW is supernatural story of demon and human. It consists of story about monsters and human races. Character will be upgraded based on the gained points and rewards by completing task and quest. Raiding is one of the most popular features where guild used to fight against boss. It is multiplayer gameplay where numbers of player use

to play at a same time. Guild is a group of players with limited number range from 10 to 20 players. Guild allows player to select leader among players and use to communicate with each other to make plan and strategy. In guild, different operations done like hiring and kickout players and editing guild appearance. During battle against boss, coordination, planning and strategy are crucial things. Basically, guild used to raid in WOW where players battle against "boss". Bosses are not easily defeated so players have to work together and perform their skills during the battle or fight (Theodore lim). Player use Ventrilo software to make oral communication in guild during battle. As multiple players are involved in raiding the boss, they must coordinate each other and play as a team to win the battle. Hence, communication plays important role during the battle. This game use to consist of more cinematic scene where audio and visual contents are more used. WOW attracts players with different disabilities such as hearing impaired, blind and motor. Obviously, to play this kind of game with hearing disability player depends on visual information. If player must be dependent on subtitle to play the game then, it's important to have understandable subtitle. Moreover, there is oral communication used during the battle in raiding. Being deaf and raiding in guild is not easy. Mostly, guild will not accept deaf player because of their hearing impaired. While raiding in guilds they have to trust and believe each other (Lothian et al., 2015). They are unable to listen and cannot cooperate with player so, they will kick out or not accepted by any guilds. To make eligible to raid properly and cooperate others, software will be developed that is responsible for converting team members oral communication into text and text to oral.

## **Counter Strike (CS)**

Counter Strike (CS) is a multiplayer video game. The concept of game is first player shooter and last man stand to win. CS provide both online and offline feature where online play allows multiplayer to play at a same time where offline play allows player to play against artificial character developed by game. Game allows player to create clan where numbers of player are engaged. In multiplayer, one clan used to battle with another clan. Progression of clan depends on winning the battle. CS introduced various series since 1991 to till present i.e. Counter-Strike: Condition Zero, Counterstrike: source, Counter-Strike Neo, Counterstrike: Global Offensive, Counter Strike Online 2 and Counterstrike Nexon: Zombies. Game becoming more advanced and allows different features to make game more realistic. Deaf player can play this game but not efficiently. CS is based on the shooting other player so; player must act fast and quick. If player is not fast and quick enough then other will kill them easily. So, player must be careful watching monitor screen as well as sound of the game. CS provide sensitive sound effect in game like footstep, breathing and sound of equipment's. Sound effect provide hint of player action in the game of CS. (Offensive, 2014) stated that deaf players are not welcomed to play with other players. With increment of game level, game demands for strategy and planning where deaf or hard of hearing player face problems. CS offers player to make voice chat. Both WOW and CS gameplay was similar players need to help each other in a squad match where voice chat and other communication features were available.

Visual information is primary source to play video game for the deaf player. Deaf people only receive visual information and response based on what they saw. Advancement of technology change the design and presentation of video games. Both audio and visual components used in video game offers players more realistic virtual environment. As a

deaf player, video game consisting audio dialogue and sound activities creates challenges and barriers. So, subtitle was used as an alternative that display text format of audio dialogue. While displaying subtitle of audio dialogue and sound activities, accessible text format offers deaf players to read and understand easily. The major problem faced by Deaf player in a duo or squad match, due to lack of communication during battle or fight between clans and guilds. Mostly, player use oral communication during battle to make strategies and plans. During battle it was very important to make a communication between the players to increase efficiency and better performance. DHH players are unable to receive that voice information and might be responsible for losing battle and other negative consequences. So, to improve performance of Deaf player during battle alternative to voice chat and sound activities in video game must be provided.

### **Online Multiplayer Battle Royal Game (OMBRG)**

In the online multiplayer battle royal game, player experience extreme survival game-mode that plunges into fast paced, last man standing matches, with one chance to win (Gamespot, 2018). The game rules were based on the last man standing and last survival in the game which start with numbers of player in an area where weapons, health kits and other accessories for the survival were available to eliminates other players. The area where players were landed continuously shrinking that reduces players health if they stay outside the safe zone. Players can also team up with two or 4 players to compete as a squad and they can communicate, share equipment and help each other in the game. Player can choose to play as a solo, duo (two people) or squad (four people). The duo or squad match can be played with friends or game will assign randomly with other players.

Before the match start, players were sent to lobby room where they must wait until hundred players were assembled. It takes around 20 to 40 seconds waiting time in lobby room. Game start carrying hundred players in an airplane with large map where players can decide where to jump, player can jump individually in solo mode and four or two players can jump same time in squad or duo match where player must follow each other. Each player assigns with parachute and they can select the location where to land. The area in a map consists of buildings, cottage and places where weapons, health kits, and survival equipment were available. Players rush to the building or any places nearby to find the weapons and other equipment as soon as they landed. The area of the map gets smaller and smaller every minute and assign new safe area where player need to go. As soon as players landed, they start to eliminate each other's. The last player or last team only become the winner of the game.

Battle royale games offer the players deathmatch with the goal to be the last player alive and win. In duo and team mode gameplay, there are other players involved as a teammate. While playing as a team, there must be coordination, cooperation, planning and strategy to play the game. In order to build strategy, planning, coordination, cooperation among the team players, communication plays the vital role. Online multiplayer battle royal game has both voice chat and text chat communication features where players can communicate with each other. In the context of the deaf people, text chat is the possible way to make communication. Currently, PlayerUnknown's Battlegrounds (PUBG) become one of the most played games in 2018. This game has been downloaded more that 100 million and got 4.5 stars rating from the more than 11 million players (Tencent, 2018). Other similar game like, Fortnite, Call of duty, apex



legend also popular as a battle royale game. Players prefer to play in squad and duo match with friends or random players.

The current states of the gaming world show that subtitle and caption in video game was not enough help for deaf players.

### **1.1. Problem Statement**

The popular game offers players to communicate through voice chat and maximum use of sound and audio information. The previous research on video game was focused on solo and offline role playing where dialogues and audio were scripted by the game developers. Such scripted audio clips and sound were presented as subtitle and caption in previous video games. But the online multiplayer game offers players vs players environment where each players movement acted by players action in real time and players also use voice chat to communicate. Hence, this research investigates the problems and issues in OMBRGs for deaf people.

### **1.2. Aim of this research**

The aims of this research included;

- Identifying problems and issues experienced by deaf people in OMBRGs
- Suggesting the potential solution to overcome the identified problems of deaf people in OMBRGs

### **1.3. Research Question**

The focus of the research was to identify the problem in OMBRGs for deaf people. Most of the previous research suggest subtitle and caption must be implement in video game

to enhance accessibility and usability for deaf people. But online multiplayer game allows several players to play together or against each other where voice chat and several sound activities used. The OMBRGs popularity increasing among deaf people. The reason of increasing popularity was OMBRGs available in all gaming platform such as PC, mobile, Xbox and PlayStation. Hence, the current research focuses on finding problems of deaf people in OMBRGs. The research question are as follows:

**RQ1.** What are the problems experienced by deaf people in Online multiplayer battle royale game?

**RQ2.** Does text chat and visual representation of sound activities in OMBRGs help to improve gaming experience of deaf people?

The first research question investigates the problems and challenges of deaf people in OMBRGs. The second research question address the importance of text chat and visual representation in OMBRGs.

#### **1.4. Thesis Structure**

This master thesis structure begins with introduction, literature review, methodology, discussion and conclusion. The details structure of this thesis listed below:

- **Chapter 1: Introduction**

This chapter introduced the research, problem statement, aims of the research and research questions.

- **Chapter 2: Literature Review**

This chapter describes the state of deafness and hearing loss, previous finding related to video game and deaf people, about OMBRGs and its importance, and analysis of accessible video game design for deaf people.

- **Chapter 3: Methodology**

This section explains the methods used in this research and the reason for choosing methods. The methods for collection and analysis of data were discussed.

- **Chapter 4: Analysis of deaf players feedback**

This chapter explores the problems and issues of deaf players in OMBRGs and explains the findings.

- **Chapter 5: Game testing**

This chapter identifies accessibility issues in current OMBRGs. The finding was discussed.

- **Chapter 6: User testing**

The user testing procedure and how it was conducted explained in this chapter.

- **Chapter 7: Discussion**

The results were interpreted, limitation of research and recommendation were presented in this chapter.

- **Chapter 8: Conclusion**

This chapter summarize and reflects the research findings.

## **Chapter 2: Literature Review**

This chapter presents analysis of several literatures that helps to generate research question. This chapter starts with providing overview of deaf and hearing loss, importance of subtitles and caption in video games, overview of OMBRGs and squad match, and analysis of accessible video game design for deaf.

### **2.1. Deaf and hearing loss**

People suffering from deafness and hearing loss became the 2<sup>nd</sup> largest disabilities, it can be occurred at any age. According to (World Health Organization, 2018), people with deafness and hearing loss disabilities reached around 466 million people with over 5% of the world's population. In 2050, over 900 million people will be affected by hearing loss disability. Approximately 1.1 billion people age between 12 to 35 years are at risk of hearing loss due to exposure to noise in recreational settings (World Health Organization, 2018). Hearing loss can be occurred due to genetic causes, complications at birth, exposure to excessive noise, ageing, certain infectious diseases and chronic ear infections. Due to heavy plant operation, using headphone with loud volume, noise over subway and traffic causes noise population which can affect permanent damage to hearing. Deafness and hearing loss people suffered from audio or sound system interaction. In technical term, deafness can be caused by two major factors either congenital or acquired. Congenital deafness occurs during birth due to hereditary and complications during pregnancy and childbirth. Acquired deafness occurs at any age due to infections, noise population, injury, ageing, collection of fluid in the ear and chronic ear infections. There are four types of deafness or hearing loss (Deafness, 2020)

- **Conductive:** This type of deafness refers to due to block sounds and stop to pass efficiently through the outer and middle ear to the cochlea and auditory nerve.
- **Sensorineural:** Generally, sensorineural deafness recognizes as permanent deaf or hearing loss and caused by the problem in the inner ear where hair cells in the cochlear was damaged or malfunction.
- **Mixed:** It is a combination of the both conductive and sensorineural deafness.
- **Auditory Neuropathy:** This type of deafness refers to the problem in auditory nerve that fails to transmit the signals from cochlea to the brain. This can be cause by the lack of oxygen or some neurological conditions.

The hearing impaired can vary the degree of hearing such as mild, moderate, severe and profound hearing loss. Mild and moderate deaf can heard loud noise but unable to recognize where severe and profound deaf were not able to hear anything at all. Generally, “deaf” word refers to the those who were unable to hear anything. In the accessibility term, deafness refers to being unable to interact with audio or sound and only perceive information through from visual sensory. Deafness and hearing loss can be treated in early stage by identifying and implementing different solutions. Different treatment methods are available to prevent deafness and hearing loss such as, using assistive devices, sign language learning and use of hearing aids. This paper focused on the people with hearing impaired. People with hearing impaired are unable to receive the audio or sound information.

## **2.2. Importance of subtitles and caption in Video game**

Most of the video games used cinematic clips, dialogues and sound information that provides important clues or hints to the players. Such audio information implemented to make game more realistic and interactive through visual and audio. Among the disability group, Deaf and hard of hearing assumed to face least barriers while playing video game. Deaf people perform well playing video game if game does not consist any audio or sound information. The sound clips, audio dialogues, and other sound effects raises the issues and challenges to play the video game for deaf people. The possible way to make video game for deaf people was to provide visual information such as text, image and icon in the video game. To provide accessibility for deaf people in video game, subtitle and closed caption were provide as an alternative to audio or sound. Subtitle refers to the translation of the audio dialogue into text where closed caption refers to the describing background noises, footstep and other audio cues (Chris, 2015). Subtitle and closed caption implemented in video games to increase the accessibility for players who were unable to hear. In video game industry, the only means of providing accessibility in video game for players who were unable to hear was subtitle and caption. While exploring the term subtitle and closed caption, there are various research done to provide suitable subtitle and closed caption. Suitable subtitle and closed caption refer to presenting text information in standard way that can be presented alternative to sound or audio. So, only providing subtitles and caption in video game was not enough to increase accessibility.

In 2016, article called "Reception of game subtitle: an empirical study" suggest the best way to present subtitle in video game that helps to increases accessibility for deaf players (Mangiron, 2016). Subtitle plays important role in video game providing essential

information to deaf people. This article presents that deaf people agreed that subtitle plays important role in video game. To present accessible subtitle in video game following suggestion should be implemented (Mangiron, 2016);

- Subtitle should be presented in directly on game screen
- Font size should be big enough and contrast between text and background
- To identify which character was speaking in the game, character's name with color should be tagged with the subtitle.
- There should be limited word and break into two lines
- Subtitle should be presented center of the game screen

The finding suggested by this article was based on the prototype of the game. The perception of real game was totally different. It varies based on the genre of the video game. Video game consist of both audio and visual content to provide information about game. The visual information helps to figure it out what are the contents of the video but unable to understand if audio were attached with it for deaf players due to lack of hearing ability. Subtitle does not display the text of the audio or voice data but also become the part of the learning process. Viewers will get opportunity to learn more with the help of subtitles (Wang, 2008). Subtitle provide the supportive information more accurate and understandable when audio or voice is not clear enough to understand. To find the effects of the subtitle with research has been done by providing video without subtitle and video with subtitle (Shepherd, Simonian, & Trussler, 2017). It was found that subtitle can help both hearing impaired and non-hearing-impaired viewers. Finding more on how much subtitles value in video content clarify important of it.

Advancement of technology allow machines to recognize human voice. In 2011, (Yoder, 2011) stated that it is possible to write using voice commands without typing. Time has been changed and technology allows human being to act beyond imagination. Software were already existed that can do all the manual work such as writing, reading, grammar checking and a lot more with low effort. Such speech recognition Software makes work easier for deaf if such software were implemented in game were players communicate using voice chat. Voice recognition (VR) is more advanced with converting speech or audio and auto correcting spelling. Voice recognition can be trained for the better result. Voice recognition such as windows speech recognition, dragon naturally speaking, speak and see accessibility suite and talk it type it 2 ultra, working very effectively with best outcome (Yoder, 2011). VR are operated in Windows, Vista and Mac operating system. In 2016, voice-controlled human-robot interface was developed and human finds more comfortable to perform task using voice recognition (Khaewratana, Ramkumar, Lee, Raisanen, & Ramkumar, 2016). Voice recognition can even understand various languages due to advancement of technology. Moreover, robots are operated using voice recognition to perform task. Voice controlled human robot interface use automatic speech recognition and convert it to the text to make it understandable for computers.

Dragon naturally speaking for dummies released in 2013 that provides accurate text data of audio or voice data (Diamond, 2013). Using Dragon software, working in computer seems very easy and comfortable. It provides more real and accurate data (converting voice into text using voice recognition). Dragan NaturallySpeaking allows user to choose option what type of accent they are going to use such as British, Australian, Indian, Chinese, Russian and still adding different.



There was various factor that affects subtitle accessibility such as position, speed, accuracy, presentation, character identification and sound effects. The subtitle used in TV, DVD and cinema is better than video game (Mangiron, 2018). The subtitle in video game increase the gaming experience of deaf people .TV, DVD and cinema used very suitable subtitle where viewers find comfortable to read that information. The aim of the video clips and cinema is to entertain viewers. Film industry has been improving presentation of subtitle to facilitate DHH viewers. Similarly, gaming world also becoming big and popular among all the users including people with disabilities. DHH player use to understand the story line or video scene with the help of subtitle. So, the most important input source for DHH player is subtitle. Subtitle can be more understandable and meaningful by improving its parameters such as presentation, position, speed, character identification and sound effect (Mangiron, 2018). Similarly, they find out some solutions that can improve gaming experience of DHH player. The following improvements can be done for better and suitable subtitles in games: setting should be provided for the presentation of the subtitle where player find more customized and friendly, speed should be readable, while character speaks subtitle in bubbles can be used.

Generally, accessible video game refers to providing subtitle and caption of every audio or sound used in game. The majority of deaf gamers preferred to present subtitle and caption in video game than visual icons (Brook & Brook, 2017). When it comes to the gameplay of different genre of video games deaf people perceive subtitle and caption as a best option for audio or sound. Comparatively, text used in the video game preferred by deaf than other visual means of feedback as an alternative to audio or sound. (Brook & Brook, 2017) papers demonstrate that the survey among the deaf people about what

can be the suitable as an alternative to audio shows subtitles and caption. As, many more papers suggested that accessibility of video game can be increase using subtitle and caption.

### **2.3. Online Multiplayer battle royale game and barriers for deaf**

All the previous research to make the accessible video game was focused on subtitle and caption but the advancement and rapid development of gaming world upgrade game features that offers more advance features and gaming experience to the game players. The thesis topic focuses on online multiplayer battle royale such as PUBG, Fortnite, Call of duty, Overwatch and Apex legend. In the online multiplayer battle royal game, player needs to communicate with each other in order to win or play the game. Communication is very crucial in battle royal games. To make planning, strategies, understanding and improvement communication n done between players. (Lee, Choi, Kim, Park, & Gloor, 2013) states that communication between team players help to motivate and improve the performance in the game. It has also mentioned that while playing the game, communication plays vital role.

According to (Lim & Nardi, 2011), deaf player are unable to play as a team player with hearing players due to communication gap. As a team, players are guided with the team strategies and planning. Due to communication gap among the players, deaf people suffering from the bad experience playing MOGs. Text chat which is very helpful for the deaf people to communicate while playing .(Susan C. Herring, 2009) explores the hidden part of the video game: text chat, which has not been explored before can help deaf people to play MOGs.

Being deaf, allows to only use visual information. To play along with the other players deaf people suffered from the demotivation, frustration and discriminated. Players are friendly to use voice chat in the game because it's very easy to use and can play effectively and efficiently. Use of the voice chat mostly in the game emerge the barriers to the deaf player. Deaf player has only choice of text chat to communicate in the game. So, to be involved in the game where voice chat has the majority created problems for deaf player to use text chat.

OMBRGs consists of two game mode: First Person Shooter (FPS) and Third Person Shooter (TPS).

- **FPS:**

This allows players to see only hands or weapons carried by the character in the game. This provides exactly same scenario of real world when see through eyes.



Figure 2.1: First-person shooter game screen

- **TPS:**

This allows players to see behind the character in the game. Generally, players can see the body of the character and controls the character seeing from behind.



Figure 2.2: Third-person shooter game screen

#### **2.4. Accessible video game for deaf people**

There were few accessible guidelines for video games. The term accessibility rarely used in video game design because there were several genres in video game. The research in one genre of video game was not enough to predict same result from another genre of video game. As the purpose of the video game was to provide entertainment and fun. So, there must be possible way to experience the motive of video game by the people with disability. There were some guidelines that allows game developer to increase accessibility in video games.

The accessibility guidelines for video game found as a living document named as “game accessibility guidelines” (Guidelines & n.d.). This accessibility guidelines suggest that accessibility in video game allows players with disability to enjoy or experience the video game fully. The guidelines focus on disability including motor, cognitive, vision, hearing, speech. The guidelines for each disability were categorized into three levels, basic, intermediate and advance. For instance, accessible guidelines of video game for hearing impaired listed below (Guidelines & n.d.):

### **Basic**

- Provide subtitles for all important speech
- Provide separate volume controls or mutes for effects, speech and background/music
- Ensure no essential information is conveyed by sounds alone
- If any subtitles/captions are used, present them in a clear, easy to read way.

### **Intermediate**

- Keep background noise to minimum during speech
- Provide subtitles for supplementary speech
- Ensure subtitles/captions are or can be turned on before any sound is played
- Provide captions or visuals for significant background sounds
- Provide a visual indication of who is currently speaking
- Allow subtitle/caption presentation to be customized
- Support text chat as well as voice for multiplayer
- Provide visual means of communicating in multiplayer

- Allow a reference to be set for playing online multiplayer with players who will only play with/are willing to play without voice chat
- Ensure that all important supplementary information (example, the direction you are being shot from) conveyed by audio is replicated in text/visuals
- Provide a stereo/mono toggle

### **Advanced**

- Ensure that subtitles/captions are cut down to and presented at an appropriate words-per-minute for the target age-group
- Provide signing
- Use symbol-based chat (smileys etc.)

This accessibility guidelines of video game for deaf people written and presented in a suitable way with examples. Most video game developers, video game industry and game designers approved this game accessibility guidelines (Guidelines & n.d.).

Accessible player experience (APX) stands for allowing players with disabilities to experience the any video game what they offer (AbleGamers & AccessibleGames, 2018). APX helps to increase accessibility of existing video game. Every video game should able to provide what the motive of the game to each player. The design patterns proposed by APX was listed below (AbleGamers & AccessibleGames, 2018):

- **Second channel**, additional channels of information via different modalities so players reliably take in information from the game or its interfaces
- **Same controls but different**, allow controls to be remapped in the game
- **Personal interface**, interfaces to be resize, show, hide or rearrange

- **Leave it there**, setting of controllers and interfaces should be saved and retained
- **Flexible text entry**, allow players to enter the text into the game
- **Improved Precision**, allow players to adjust precision of actions so they can successfully target, move, or navigate in the game or its interface
- **Flexible controllers**, allow players to replace or change input devices to interact with the game and its interface
- **Flexible displays**, allow players to replace or change the display setting in the game
- **Clear text**, allow players to change the presentation of text in the game
- **Do more with less**, reduce complexity and increase simplicity
- **Distinguish this from that**, allow player to chat presentation of information so they can understand better and easy way
- **Clear channels**, allow players to adjust the attributes of information in channels
- **Total recall**, allow players to see anytime the help information in the game
- **Moderation in all things**, allow players to avoid strong emotional content
- **Helping hand**, aid the players if they want in the game
- **Training ground**, allow players to practice by themselves to increase their game skills
- **Slow it down**, allow players to reduce the speed, volume and variety of events in the game
- **House rules**, allow players to choose their preferences so they can play along with other players with same interest or disabilities
- **Bypass**, allow players to bypass the difficult stage in the game



- **Play alongside**, allow players to play along with another player
- **Save early, save often**, allow players to save progress and often
- **Undo redo**, allow players to confirm or reverse choices in the game

APX video game design patterns to increase accessibility lack specificity. Lack of focus or target group found in APX video game design patterns.

### **Chapter 3: Methodology**

This chapter presents the overview of the research methods used in this research. The nature of this research was exploratory where issues and challenges of deaf people in online multiplayer battle royale games were identified. The finding helps to improve gaming experience of deaf people in online multiplayer battle royale game. As, many researchers have done research about the difficulties of deaf and hard of hearing people in video game and suggest solution to help deaf and hard of hearing people. But there was still lack quality study in online multiplayer battle royale game. So, the purpose of this study was to explore the area where problems were still existing. To study further, combination of methods was used in this research. As, combination of methods allows to mix both qualitative and quantitative methods for collecting, analyzing and interpreting data. Qualitative methods allow to collect and analysis of non-numerical data such as text, video, audio and image through direct observation, interviews, open-ended surveys and focus groups (Crossman, 2020). Quantitative methods allow to collect numerical data through polls, questionnaires and surveys where statistical tools were used to analyze and interpret the data (libraries, 2020). It means that to explore the study of identifying issues and challenges multiple methods can be used to support each other. Also, each levels of finding helps to provide direction of the next one. The process of this research starts by studying deaf people who plays OMBRGs, game testing using game accessibility guidelines. To identify the problems of deaf people in OMBRGs, deaf people feedback about PUBG PC was studied and OMBRGs in mobile platform was tested using game accessibility guidelines. After the problems identified, the user testing was conducted to investigation how much text chat as an alternative to voice chat and visual

representation of sound activities in OMBRGs helps to improve gaming experience of deaf people.

### **3.1. Content Analysis**

The content analysis used to extract meaning and pattern from unstructured data (Amy, 2019). Generally, to conduct content analysis data were collected as a set of text, video or audio from books, journals, radio programs, websites, photos, music or blogs. To answer the research question “what are the problems deaf people experiencing in OMBRGs related to accessibility and usability?”, feedback and discussion forum of OMBRGs was chosen to collect data where players use to leave feedback as a comment describing their opinions towards game. Video games create feedback and discussion forum in their official websites to know their users’ problems or opinions about the game. Such feedback and discussion forum contain valuable information and wide range of user’s involvement. There was also other discussion platform where players discuss about the video game problems, issues and challenges. So, the first phase of this research involves finding and selecting deaf and hard of hearing players feedback about OMBRGs in different feedback and discussion platform.

### **3.2. Guidelines review**

The guidelines review was performed to gain knowledge about accessibility practice in OMBRGs. To support the finding of previous section, review of at least three OMBRGs were conducted. The purpose of the guidelines review was to find hidden and unexplored issue and problems in OMBRGs. The guidelines review investigates the set of guidelines

with the system to identify whether the system have met the requirements of accessibility or not. Generally, a set of guidelines for accessible were written by the group of experts.

### **3.3. Ethical considerations**

In order to collect data, consent form was provided to all the participants. The data collection procedure doesn't require participants real name and details. Participants were provided questionnaire after the given task completed. Ethical consideration for this research:

- Participants can refuse or withdraw at any time. Participant's comfort and safety were given more importance.
- Consent form was provided as printout hardcopy before the testing was started.
- Participants must agree the consent form to be involve in the research.
- A consent form consists purpose of the research, procedures, risk, benefits and confidentiality of data.
- No personal information was collected intentionally. In order to provide privacy and confidential security to the participants, personal details were removed.
- Data gathered only through the electronically. Hence, all data were kept secure with password protected and removed after the analysis was completed.

## **Chapter 4: Deaf players Feedback review**

In order to find challenges and issues of deaf players, feedback and discussion forum was the best source where numbers of users participated to share their thoughts and opinion about the game they played. Video game designers create feedback forum to know about the customers satisfaction and how well the game was doing. The most important and valuable data was natural impression of user. As designers of developers need feedback from the user for the development and improvement of the system (Mamtani, 2018). There were various ways of collecting data from the users. The ways of data collection effects the nature of the data. The current section involves the investigation into public user feedback of PlayerUnknown's Battlegrounds (PUBG) game. Players who have downloaded and experience the game share their opinion in the feedback section. Feedback sections consist various comments of players. Anyone can view and write the comments in feedback section. Regarding to first research question, user feedback of PUBG game helps to investigate issues and challenges of deaf people in such games. Feedback and Discussion section were created by the game developers whereas user write their comments. Users from different place and with different ability shares their experience in feedback section which is very valuable for the game developers. Hence, such documents cover wide range of users from different places with different ability. Such forum created for the improvement and development of the video game. To analyze the comments, content analysis were chosen for developing a representative description (Lazar, Feng, & Hochheiser, 2017). Content analysis used to extract valuable information from the user comments.

As, user feedback helps to find out the user satisfaction towards the system, program or anything (Ceban, 2018). User write comments and share their experience as a feedback. Generally, video game collects user feedback through website providing feedback forum where user can write comments related to problems, issues, bugs in the game. Collecting user feedback through website results fake data, unstructured data and huge amount of data. Creating feedback section in official video game website offers anyone who visited those websites can share their point of view. There was no validation of user required to write comments in video game website's feedback forum. Most of the video game used this public way of collecting user feedback to find out how well the video game was doing, what are the issues and problems users were facing and what are the changes and improvements users were asking. As mentioned, such data was not worthy enough as many of them might be fake and intentionally created because feedback section was open and public so anyone can write comments. Comparatively, PUBG provide some degree of validity and reliability because user need to create their account to give feedback or write comments in feedback section. PUBG game has more than millions of users in different gaming platforms such as mobile, PC and PlayStation. Players playing in different gaming platform shares their experience in different platform Feedback section. For example, PUBG players in PC platform give feedback in "Game discussion and feedback for PUBG on PC (PUBG)". As user feedback is very important to know about the user satisfaction. Players also share and discuss about issues and barriers of video game. Similarly, feedback section of PUBG also consist valuable information related to issues and problems of specific group of people. There are also other discussion

platforms like steam and reddit where user discussed about accessibility, usability and gameplay topics.

The purpose of investigating user feedback was to find out issues and problems of deaf people in OMBRGs. The PUBG was chosen because it has many user's and popular battle royale game. The investigation was done in selected topic discussed in feedback section. The topics were selected from the three discussion and feedback platform PUBG website, Steam and reddit. During the process of topic selection, only topic relevant to the research were selected. Topics were searched using keyword: "deaf and hard or hearing support", in PUBG website, steam and reddit discussion and feedback platform. Only topic containing more comments and user participation was chosen. The chosen topics consist numbers of participants both hearing and deaf or hard of hearing. The intention of the study was to analyze comments consisting problem, issues and challenges of deaf and hard of hearing players in OMBRGs. The selected topics from each discussion platforms were studied and analyzed individually. The steps conducted to analysis the comments from feedback and discussion forum was as follows;

- a) Select topic only if relevant to the research
- b) Copy forum and paste it in Word
- c) Erase the user identity and save it as word file
- d) Open file in Qualitative analysis software (NVivo)
- e) Use coding if problem, issues and challenges were identified
- f) Skip short and meaningless comments

In the feedback section, comments related to accessibility and usability issues experienced by deaf and hard of hearing players was marked with meaningful code. In

OMBRGs, sound plays very important role along with team coordination while playing in team/squad mode. So, text chat and visual feedback elements as an alternative to voice chat and audio or sound was very important for deaf people to play such games. The study of user feedback and discussion shows that text chat use to inform individual status, their surroundings, asking helps for supplies and kits whereas visual feedback elements helps to indicated gunfire direction, footsteps and vehicles movements. For example, character in the game has been shot from the far distance and sound of shooting was used in the game, visual representation of where and how far shot was came from shown in the game screen. The problems identified in each platform were merged and discussed below.

#### **4.1. Results and findings**

The comments in feedback section shows that deaf players face two main problems in OMBRGs: lack of text chat option and visual information. Most of the PC, Xbox and PS games focuses on providing real world experience in virtual world by using audio and sound mostly. It was found that gameplay was different in OMBRGs where communication among players and audio or sound produce by characters in game was very important. Hence, deaf players in feedback section mostly discussed about the text chat and visual feedback elements as an alternative to voice communication and audio and sound information. The study of feedback comments shows that text and visual feedback elements plays essential role in OMBRGS. The findings show that PUBG in PC version was not accessible for deaf and hard of hearing people. Game Accessibility guidelines also recommended accessible video game must support text chat and visual representation of any sound or audio information for deaf or hard of hearing players



(GameAccessibilityGuidelines). It was also mentioned in the feedback section, Deaf or hard of hearing players use other software in game that support text chat and visual representation. Overall, the study of feedback and discussion section of deaf and hard of hearing players shows problems, solutions and recommendation in PC platform. Problems refers to the primary obstacles that affect the performance in the game, Solutions that are not implemented in game by game developers by adapted by users as an external source to overcome the problems appeared in the game and suggestion of the players that need to be implemented in the game which can make it easy for them to play the game. As far, the content found under the three categories i.e. problems, solution and suggestion were described below;

- **Lack of Text Chat option in the game**

Text chat option was not implemented in the game. Deaf and hard of hearing players mentioned that text chat was not available in the game. “We win most of the game, our squad was very active as we make a plan and used to alert every time through voice chat. No one can beat us because of our coordination and strategy but last game we suffer due to not have proper communication as we have one random guy who didn’t talk and response to us.

*“I strongly think this is very important matter for many players who are Deaf and Hard of Hearing. I grew up playing games since 1980s and the first time I ever played multiplayer was during 1990s. I am Deaf with low vision and I never let it get into my way when it comes to playing online with anyone online. I rely on keyboard to quickly communicate with anyone, which allows me to fully interface*

*with anyone. Same thing for other many players who are Deaf and HOH (Short for Hard of Hearing) who relies on text chat to communicate with anyone.”*

- **Lack of visual representation indicating enemy’s direction**

Audio or sound of character movements, gun fire, vehicle movement was used in the game. But it was found that no visual representation of such audio was provided as alternative which makes it difficult to play for deaf and hard of hearing player. As hearing players can hear footsteps, bullets refill and grenade that gives them advantage over deaf and hard of hearing players. It was difficult to pinpoint if shot coming from back.

*“I was born deaf. However, I received surgery and the Cochlear Implant (google it for details) of which allows me to hear in my left ear. I crank up the volume on my headphones and I use that to play my games. However, one problem I've been noticing while playing PUBG is the inability to detect the direction of sound. Normal people are able to play just fine, because they retain both ears and can track the direction of sounds like gunfire, vehicles, gunshots, etc. Now, when someone is being shot at, it shows blood on your screen to indicate you're taking damage. My problem is, in order for me to track where the shooting is from, i have to look for where the bullets are hitting and track down where that person could be shooting from. Which usually, by the time I've figured that out, I'm either close to death, or I'm dead.”*

*“We have a problem with the blood pattern, it doesn't show where we are getting shot from. We have to look around (360 degrees) to find enemies. It's very difficult for us, because we can't always stand correctly behind cover. Blood pattern needs*

*improvements to indicate where we are getting shot from, then we'd have a better chance locating enemies and fighting them instead of almost hopeless chance to fight back. These 2 things are very important for the deaf community."*

- **Using text chat (steam chat) affect the player's performance in the game**

Players mentioned that text chat was used to inform any dangers around the player but while using text chat they were distracted which affect their performance. The situation when being attacked and need to ask for help by typing message was very difficult. Small font and Typing text create extra work for deaf and hard of hearing players. Additionally, each team members name or id must be mentioned before typing the message otherwise it creates confusion among team members.

*"Now, that this interesting game known as PlayerUnknown's Battleground either totally removed or doesn't implement the text chat, the developer team have totally removed our opportunities to figure out how to communicate with our team / squad / teammates in the game. Because of that, we are forced to use an external chat program (Discord, Steam, other) that takes significantly lot times to switch between them when being in game that even require sounds. I already am well aware that this game is 'sound' based game, but again, ANYONE with any kind of disabilities ALWAYS find the ways to achieve something in game. With the current ongoing situations about this game having no text chat, it forced us into huge, unfair disadvantage situations".*

*"I have to constantly warn my teammate about what's going on around us via text chat, which, as you can imagine, affects our performance."*

*“A text chat would be nice to have, but in harsh situations, it's no help and would distract rather than help.”*

- **Lack of character's movements alert**

The sound or audio produce by characters movement in the game was heard by every player who was nearby. So, hearing players can easily kill deaf and hard of hearing players due to lack of visual indication of character movements.

*“Hi, I'm deaf too. PUBG is good, but yes, the inability to hear sounds interferes very much, and because of this I almost left the game. It's hard to realize that the player who just killed you has heard all your moves around the house, and you do not.”*

- **Using Skype for sign language communication was not worthy enough**

As text chat was not implemented in game and steam chat was really distracting the deaf and hard of hearing players. Deaf and hard of hearing people used skype in the second monitor for sign communication. The problem was it also requires extra resources and split focus from the game while communicating.

*“Currently we are using skype on 2nd monitors, where we can share information over webcam in international sign language. But we still prefer in game chat, it enables us to focus more on the game.”*

- **Sonic radar not reliable and compatible**

Hearing impaired players use sonic radar for the visual representation of sound activities in the game. Players found that it stops working after a while and does not work properly.

- **Visualization plugin was not accurate and difficult to use**

Players mentioned that visualization of sound activities lack accuracy compare to sound. The installation process of visualization plugin was difficult and complex which requires experience and knowledge of using plugin in game. It also requires sound or audio card for better performance which need extra cost. Overall, it was found that using sound does not need extra work in the game while visual representation of sound require focus.

- **Text chat was used to blame and talk unnecessary thing compare to voice chat**

Voice chat was easy and reliable communication option in game based on users' feedback whereas text chat was only used to message unnecessary things and blaming each other after failure. It was found that Players using voice chat seems more active than text chat players. As voice chat players shares valuable information along with other things that leads to victory and progress in the game whereas text chat players feel lazy to type message and cannot focus in game while typing.

*“If text chat or alternate communication becomes available, they will use that. And then you get in-game communication like Overwatch where the only chat that happens is people talking shit on misplays that could have been prevented if there was any sharing of information to begin with.”*

### **Action taken by deaf and hard of hearing players to overcome the challenges in PUBG in PC platform**

- **Use steam chat for the text communication**

As text chat option was not available in the game, deaf and hard of hearing players use steam chat for text communication. Before the game was started players should be connected in steam chat. Steam chat was external chat system that was operated externally. The message was displayed on the top of the game-screen.

*“I will quote my statement from my post Because of that, we are forced to use an external chat program (Discord, Steam, other)”*



Figure 5.1: Using steam for text chat

- **Use sonic radar for visual representation of sound activities**

As an alternate to the sound or audio in the game players used sonic radar. Sonic radar helps to represent the direction of sound activities in the screen of the game. Sonic radar was the external software displayed in pc screen along with game. It



uses shades of color in the circle indicating direction from where sound was coming.

*“I recommend using Sonic Radar, it provides visual cues on screen relative to audio position to help make games more accessible to deaf players”*

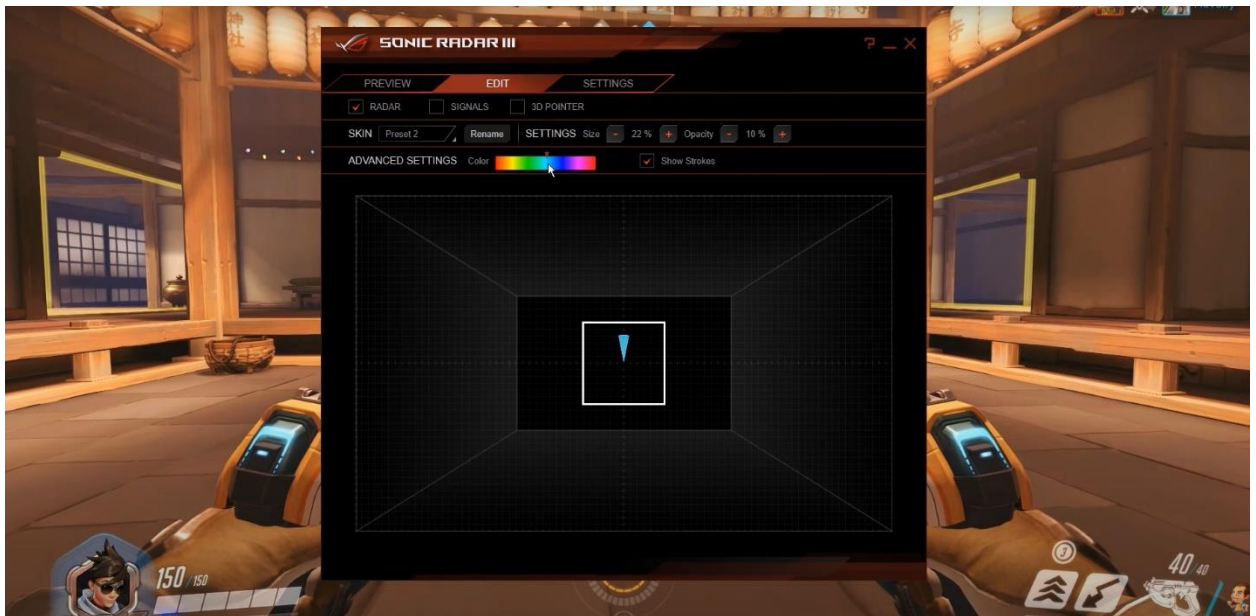


Figure 5.2: Figure: Sonic radar home screen



Figure 5.3: Sonic radar active in the center of the game screen in blue

- **Using skype for sign communication in second monitor**

Deaf players mentioned that they used two monitors where one was used for video call and other was for playing game. They used to communicate using sign language through webcam to other deaf players.

- **Using bone conduction headphones for detecting sound activities**

Some deaf and hard of hearing players use bone conduction headphones for detecting sound activities. Generally, bone conduction headphones use vibration to indicate the sound direction. For example, sound activities occurred from left direction in the game then, it starts to vibrate in the left side ear.

*“If you are able to hear via bone conduction this is definitely an option I would try out. If not, the vibrations from the headset may also help a little.”*

*“Just to say that I picked up a pair of bone conducting earphones also and while I don't hear anything the vibration at least gives me an indication as to where the shooter is.”*





Figure 5.4: Bone conduction headphones

- **Use subpac for physical feedback of sound activities**

Along with visual representation software players use subpac for physical feedback. Subpac used to place in the back of the players which generates vibration or punch in the back when players being attacked or shot by the enemy.

*“I think with the help of someone with good hearing it can be tweaked really well and then displayed on a screen over your gaming screen.*

*edit : you can add a subpac (<http://subpac.com/>), you won't be able to locate sound with it (it's mono), but you will get a punch in the back if someone shoot at close-medium distance, and it will vibrate if a vehicle is near.”*



Figure 5.5: Subpac as physical feedback of sound activities

- **Use Izotope insight for visual representation of sound activities**

As mentioned about Izotope insight for the visual representation of sound activities in game, it also works like sonic radar.

*“Hi, I've just tried to feed my audio visualization plugin (Izotope Insight) with PUBG sounds and it work really well.”*

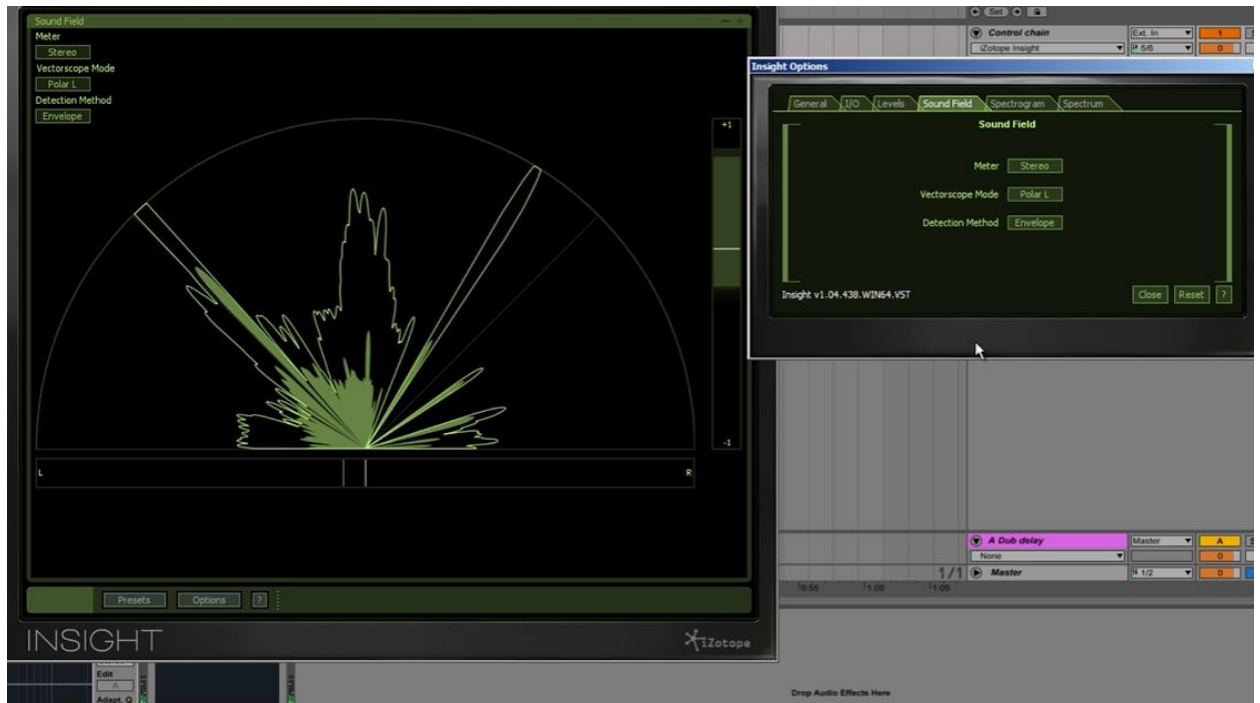


Figure 5.6: Izotope insight (audio visualization plugin) for sound activities

## Suggestion for game developers by Deaf and hard of hearing players of PUBG in PC platform

- **Use appropriate visual cues to indicate enemy's attack direction**

When players were getting shots as sound or audio of gun shots was used which makes difficult for deaf people while players were being attacked or shot, only blood was presented in the screen. It was suggested that instead of presenting too much blood in the screen, mark of the blood in the semi-circle indicating direction from where being attacked would be helpful.

*“As for subs themselves, I think, they should mention sound's type (shot, step, blast, engine sound), loudness, direction and, maybe, a distance (which can be also expressed through mention of loudness, I'm not sure). Color coding can be*

*used along with text, maybe, for character of events of same type (so player could realize that several "shot from far left" messages point out to a fight between two guys with different weapons, not to several shots from one gun). Maybe, to express distance, font size can be used too, I mean, far shot is not just quiet shot, it's echoed, so it's not enough to just describe far event as having low loudness. I can even imagine using place on screen -- it's kind of self-descriptive to understand sound's direction when message "BOOM" is placed on the left/right side.*

*Because of benefits such subs can provide, they should be relative enough, and, maybe, assuming turning sound off, so non-deaf players wouldn't be tempted to use subs."*

- **Use caption as an alternate to audio or sound in the game**

Some players think that presenting as a caption of audio can help. For example, if enemy's attack from the left direction then "Shots from left" can be presented. And toggle option can be provided if hearing people don't want to use it.

*"My suggestion is: why not make a simple sub, describing environmental sounds and its direction? IT doesn't need to be verbose, simple "quiet steps from the left", and "loud shots from 15 hours" (with "quiet" and "loud" describing distance or run/walk, or "with/without silencer") would be enough, and, I think, is not very difficult to implement. Of course, exact description of incoming sound can provide some benefits when compared with relative perception by ears, so option "toggle subs on" can also toggle sound off (so hearing players won't use subs to have any benefits)."*

- **While using caption there must be separate information**

It was mentioned that, game uses sound for footsteps, gunfire, vehicle movements and voice chat. So, using different color for different sound's caption in different place can be helpful.

*"Well, from my standpoint environmental subs definitely should not be mixed with any other text messages, be it chat, commands, or in-game event reports (like "dude1 was killed by dude2"). This is very special feature which should be placed on screen separately to be easily noticed."*

- **Text chat in the game can help deaf and hard of hearing players**

With a lot of practice and experience players can use text chat for quick communication with team members. As recommended by deaf players providing text chat helps them to communicate with other players. Text chat can be toggle on or off, so hearing players won't be bothered.

- **Presentation of text chat in the game**

It was suggested that text chat can be presented in any side of the screen but not in the middle. Also, text can be disappeared after few seconds which can't affect or distract players. Text chat can be mark with players identity that helps other to identify who sends the message.

- **SMS template can be useful for fast communication**

Many players shares how difficult it was to type message and focus in the game at the same time. So, using SMS template like "enemy ahead", "let's go" and "help me" can be useful. Just one click SMS could be useful suggested by deaf players.

*“I especially played many different games that requires quick communication and teamwork, such as Project Reality for Battlefield 2, Squad, Battlefield 3, IL-2 1946 (Simulation), War Thunder, Call of Duty series, and other games. When I used text chat with my teammates, we were able to success because of us practicing together and figuring out the short code names for any situations.”*

- **Use effects on character’s body part to represent bullets hit instead of using blood mark or blood pattern showing direction of shots coming from**  
Indicating sound activities would be cheating and not fair enough stated by players. It takes to learn skills to play any video game so showing direction of sound activities would not be fair. Using visual effects to mark on character’s body part when getting shots from enemy provide real gaming experience without giving any advantage to any players.

*“Rather the blobs of blood, make it more like a semi-circle. Somehow, put in a way that we can tell where we’re being shot from. If this could be added in, it would improve my gameplay, and would allow me to play the game along with others without having to depend on others,”*

The reason for investigating user feedback was to find problems in OMBRGs of deaf and hard of hearing players. The collected data shows feedback section consists three major contents; problem, solution and suggestion. Where some problems were solved using external sources like visual representation plugin and sound plugin in the game. Those plugins used by deaf players were not accurate and reliable. They may crash after using for a while and not responding, as it shows that it supports only by high speed processor.

They also mentioned some recommendation for the improving their gaming experience. The finding of this section suggests that lack of text chat and visual representation of sound activities. Players who use to play PUBG in PC platform support external text chat software and visualization plugin that allows deaf and hard of hearing people to play this game. But using external plugins makes more difficult to play game. The usability problems found using external plugins for text chat and visual feedback in PUBG was listed below:

Title	Problem	Comments
Steam text chat plugin	Distract and difficult to use in game.	<p>“We (deaf) always use in-game team chat for information in other games like CSGO, but it's not possible in PUBG. We dislike using the steam chat, since it takes extra time to open the steam overlay and write information to 1, 2 or even 3 people, and steam group chat pop up in-game, and obviously we can't hear if someone writes to us in group chat.</p> <p>We really hope that you add team chat one day. Of course, it's not a top priority for PUBG developers.”</p>
Sonic Radar Visualization plugin	Not accurate and reliable	<p>“still use blood patterns plenty in most games, really screws with me on PUBG because I'll flip around to where it says the bullet came from and I'll get shot from the other direction”</p>

Table 5.1: Usability issue using steam and sonic radar in PUBG

## **Chapter 5: Game Testing**

The purpose of the game evaluation was to find out of accessible and usability in current OMBRGs. This section tries to find out the requirements of accessibility guidelines and usability in the context of deaf and hard of hearing people in OMBRGs. The guidelines review inspect the Game accessibility guideline (Guidelines & n.d.), a set of principles ensuring accessibility in video game for disable people. Guidelines review was the investigation of any system based on the sets of rules (Lazar et al., 2017). Game heuristics for the usability evaluation in the OMBRGs. The game testing was carried out using accessibility guidelines for hearing impaired. The problems and issues found in user feedback analysis of PUBG was also reviewed in the game testing process. Major problems identified in user feedback analysis of PUBG was lack of text chat and visual feedback. As game accessibility guidelines prefer text chat, sign language communication and visual representation of sound activities should be implemented in game (Guidelines & n.d.).

The playtesting was performed in OMBRGs in mobile platform. The findings from user feedback analysis shows that external text chat and visualization plugins was used in PC, Xbox by deaf and hard of hearing people to improve gaming experience. Implementation of text chat and visual feedback elements in PC version game was not found. Mobile version of OMBRGs were tested because most of the to get the unbiased result. In PC version of OMBRGs, external visualization plugin and sound plugin was used. Similarly, Xbox and PS version of OMBRGs was also found not implementing text chat and visual feedback. As a result, mobile version of OMBRGs was very popular and becoming the profession of gamers. As smartphone became most popular gaming platform from recent



years. In 2018, smartphones become most popular gaming platform in Germany (Puppe, 2019). Smartphones gaining popularity worldwide (WePC, 2020). All the new games were released in smartphones as well along with PC, Xbox and PS platforms. The reasons for choosing smartphones for evaluating OMBRGs were, most of the games were released in smartphone platform, first choice for gaming, very importantly most of the population in the world used smartphone. The very big reason was numbers, almost half of the world's population use smartphone. According to Statista, over three billion people uses smartphone worldwide (Statista, 2020). PC, Xbox and PS were household gaming consoles, that holds same number of users altogether as smartphone users. Hence, providing accessibility for large population matters than small group of people. Observation was used to collect data during the analysis of feedback elements in video game. As its name itself provide clear meaning, Observation to observe something (Methodology). As observation can be conducted either structured or unstructured. The game accessibility guidelines, game heuristic evaluation and problem identified in user feedback review were tested. The process of conducting evaluation was based on playthrough procedure (Gareth, 2014):

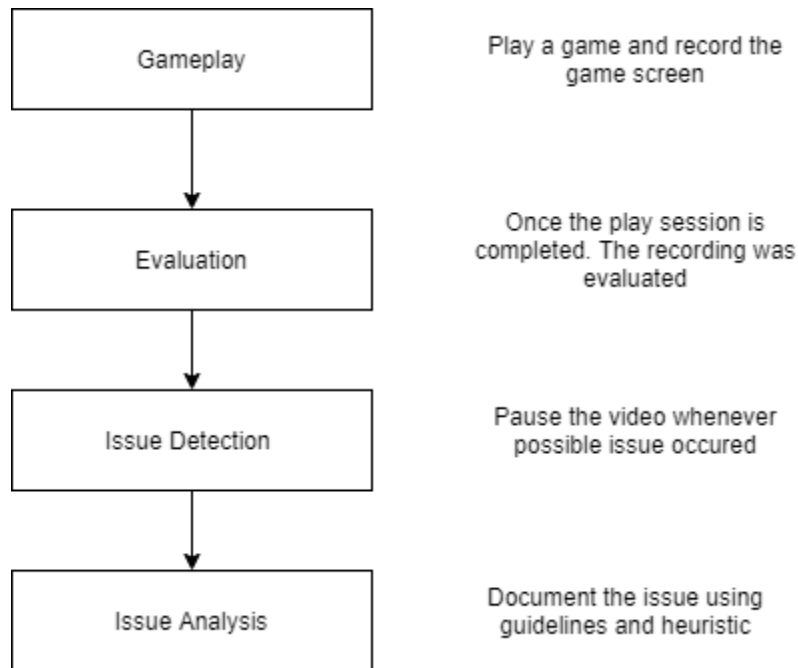


Figure 6.1: Playthrough procedure (Gareth, 2014)

The device used to play game was Smartphone Huawei P20 pro. The selected device has its own screen recoding function which was used to record the gameplay secession. And the analysis was conducted based on game accessibility guidelines and heuristic for game evaluation.

### **Selected Games**

The games in smartphone platform; popular and most downloaded games were selected. Google play store and app store were combined for studying games popularity and downloads. The followings were the selected OMBRGs in mobile:

- Playerunknown’s Battleground (PUBG) mobile (Tencent)
- Garena Free Fire: Kalahari (GArena)
- Call of Duty Mobile (AcTiViSion)

## 5.1. Game Accessibility Guidelines

The accessibility guidelines chosen in this section was available in website. It was still present as a living document contained only accessibility guidelines. The guidelines chosen was awarded for advancement in Accessibility and “Finalist 2016” TIGA games industry awards (Guidelines & n.d.). These guidelines were designed for all genre of game and applicable based on the disability group. There are motor, cognitive, vision, hearing, Speech and general category guidelines. The guidelines presented for disable group was categorized into three section: basic, intermediate and advanced. The reason for selecting these guidelines was it covers overall requirement of deaf people. The following were the set of principles in game accessibility guidelines (Guidelines & n.d.).

- **Provide subtitles for all important speech, provide subtitles for supplementary speech and Ensure subtitles/captions are or can be turned on before any sound in played**

Three guidelines were merged because all of them refers to the enabling subtitle in the game.

In game, various dialogue and audio were used which might be difficult for hearing impaired people. So, subtitle must be presented for all the dialogue and audio used in the game.

- **Provide separate volume controls or mutes for effects, speech and background/music and keep background noise to minimum during speech**

Hearing loss affect certain frequencies more than other group of people, so allow players to control the volume independently was essential.

- **Ensure no essential information is conveyed by sounds alone**

Game developers must provide visual representation of any audio information that directly affect the gaming experience. Provide subtitle for all important speech and must be default in setting. For instance, if subtitle can be turned on and off then opening scene will be played without subtitle.

- **Provide separate presentation of effect, speech and background noise**

Presentation of subtitle/caption convey only each type of information separately. For instance, if dialogue scene starts and background noise then present dialogue must be presented separately and background noise present separately.

- **Text use to provide essential information must be clear, easy to read**

Use of text chat in game must be clear and easy to read. For example, Clear white subtitle text on letterboxed black background, which can be visible and readable in any background.

- **Provide a visual indication of who is currently speaking**

The speaker in the game must be identified to reduce conflict or confusion in the game. If played in multiplayer mode, then each player conversation should be tag with their own name which make it easy to understand who is speaking.

- **Allow subtitle/caption presentation to be customized**

As subtitle/caption were designed by game developers and presented where it was fixed. So, only the assign position was used to represent subtitle/caption. But sometimes it makes players to distracted or difficult to see. So, allowing players to change the position of the subtitle/caption in game setting can be helpful.

- **Support text chat as well as voice for multiplayer**

In multiplayer, communication among player was very important to achieve better results. So, along with voice chat game must support text chat to facilitate players who cannot speak or cannot hear.

- **Provide visual means of communicating in multiplayer**

The game must provide different means of communication. For example, allowing the interactive map where players can mark and informs other players to move in marked location.

- **Allow a preference to be set for playing online multiplayer with players who will only play with/are willing to play without voice chat**

The very important principles of this guidelines that ensure human rights. If hearing impaired player do not want to be play with players who can hear then this decision can be taken by them. It means allowing them to choose to play with hearing impaired or players who can hear.

- **Ensure that all important supplementary information (e.g. The direction you are being shot from) conveyed by audio is replicated in text/ visuals and provide captions or visuals for significant background sounds**

As the title of the guidelines provide clear meaning. There must be visual representation of information that is conveyed by audio. For example. If player being attacked with grenade and it can be heard, then it must be visual. For ex. If footstep conveyed by audio, then it must be presented visually either using caption or visual cues.

- **Ensure the subtitle/caption present at an appropriate words-per-minute.**

Text must be present in natural way with normal speed which can be readable by players. If presentation speed was fast, then it may be difficult to read and understand.

- **Use symbol-based chat**

It refers to allowing players to use symbol chat such as smileys, face icon or body language of characters in game.

## **5.2. Results**

The result of game accessibility guidelines review shows that, the OMBRGs have offered more accessible gaming environment than other gaming platform. And, it shows that not every game follows the guidelines of accessibility some games still lack text chat option and proper visual feedback in game. The accessibility issues found in the selected games were listed and described below:

### **PUBG mobile**

The results show that PUBG mobile has both audio and text chat option. The use of audio in this game was minimum but while playing in team, players use voice which subtitle was not presented. The results of the game accessibility guidelines review of PUBG mobile was listed below:

#### **Provide subtitles for all important speech**

- In PUBG mobile, no special audio or dialogue were used. But, Aeroplane sounds used in the game which has no visual presentation. Aeroplane brings airdrops in every minute with full of special equipment.

## Provide separate volume controls or mutes for effects, speech and background/music

- PUBG allows players to adjust every audio used in the game

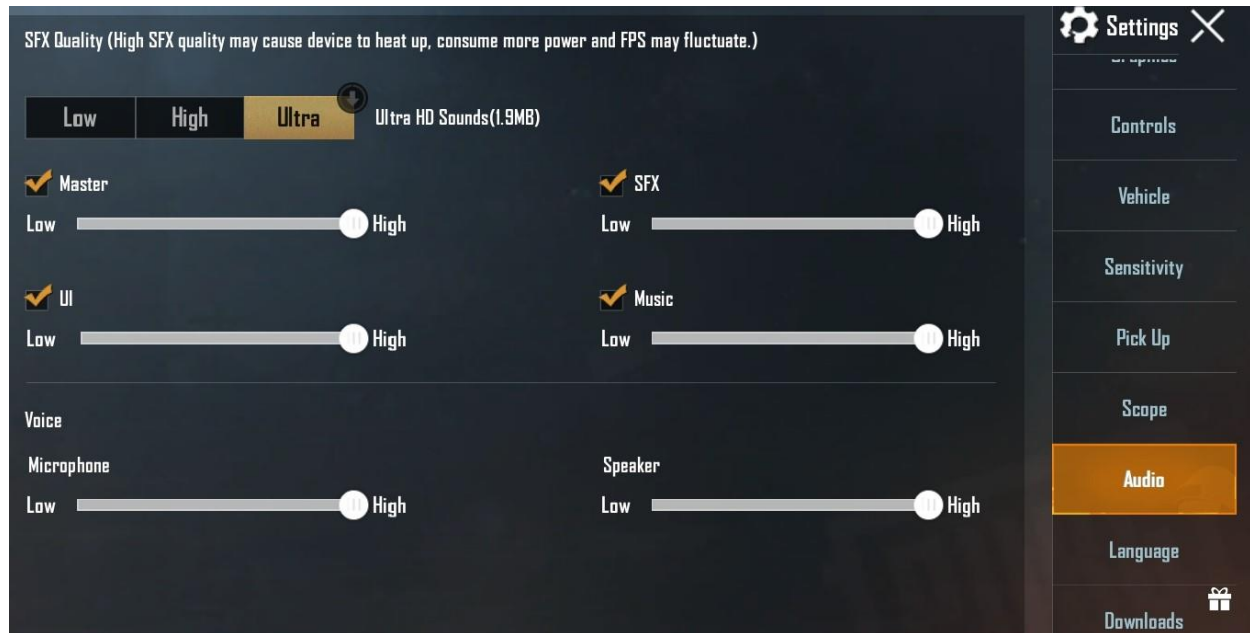


Figure 6.2: Volume settings in PUBG

## Ensure no essential information is conveyed by sounds alone

- The air drops were landed every couple of minutes which contains special weapons and gadgets. The weapons and gadgets of airdrops gives advantage to the player over others. When the airdrops arrive, the information conveyed using sound of plane, but no any visual cues were used.
- And when player being attacked by grenade, then the grenade throw sound and grenade switch sound was used which was heard by player who can hear but no any visual cues was used. This major sound activities directly affect the gaming experience of players who cannot hear.

**If any subtitles/captions are used, present them in a clear, easy to read way**

- Text used in PUBG mobile presents in clear and easy to read way

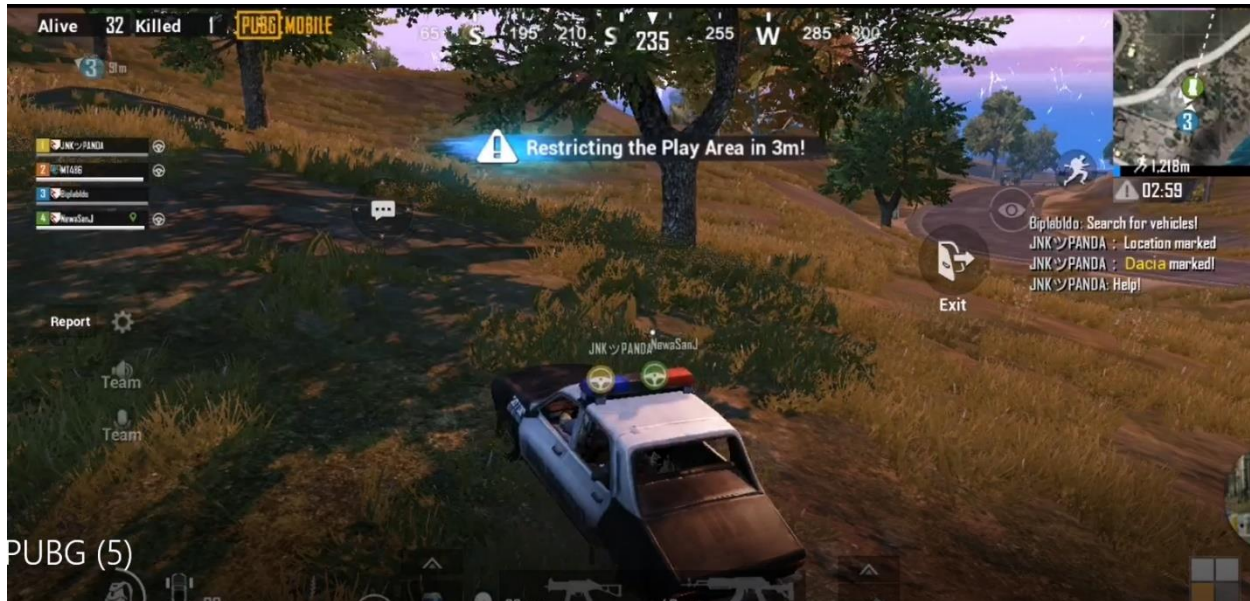


Figure 6.3: Text presentation in PUBG

**Provide a visual indication of who is currently speaking**

- If players send text to the teammates, then the sender name tag was also displayed to identify who sends the text message. And important features in PUBG mobile was each player small icon presented in different color in the list and mini map as well. So, if any place were marked by players then mini map show who marked and where.





Figure 6.4: Identification of sender in the text message

### Allow subtitle/caption presentation to be customized

- This game does not allow player to customize position and size subtitle, caption and text message in the game. It's very important for deaf players to customize the position of subtitle, caption and text message presentation position because text or visual cues was the only input for them. The customization of text presentation position allow user to place where they feel comfort to read and interpret quickly. As shown in the figure below, all the text presentation position was fixed. The kill update was presented in left-mid overlapping the side view buttons, important remainder displayed in the middle of the screen and message in the right-mid game screen behind the text chat button.



Figure 6.5: Caption and text message presentation.

### Support text chat as well as voice for multiplayer

- Both voice and text chat option available in the game. If player wants to type random message, then press “Tap to Type” it allows player to type otherwise list and wheel option of predefined voice phrase can be used as shown in the figure below.



Figure 6.6: Text chat option in PUBG

### Provide visual means of communicating in multiplayer and Use symbol-based chat

- The map appears in the right corner of the game screen, it allows players to mark the location where to go or gather around, danger zone with red circle and safe zone with big with circle. The map shows the location of team members and where team members dies as shown in the figure below player number 4 died near to Shooting Range.

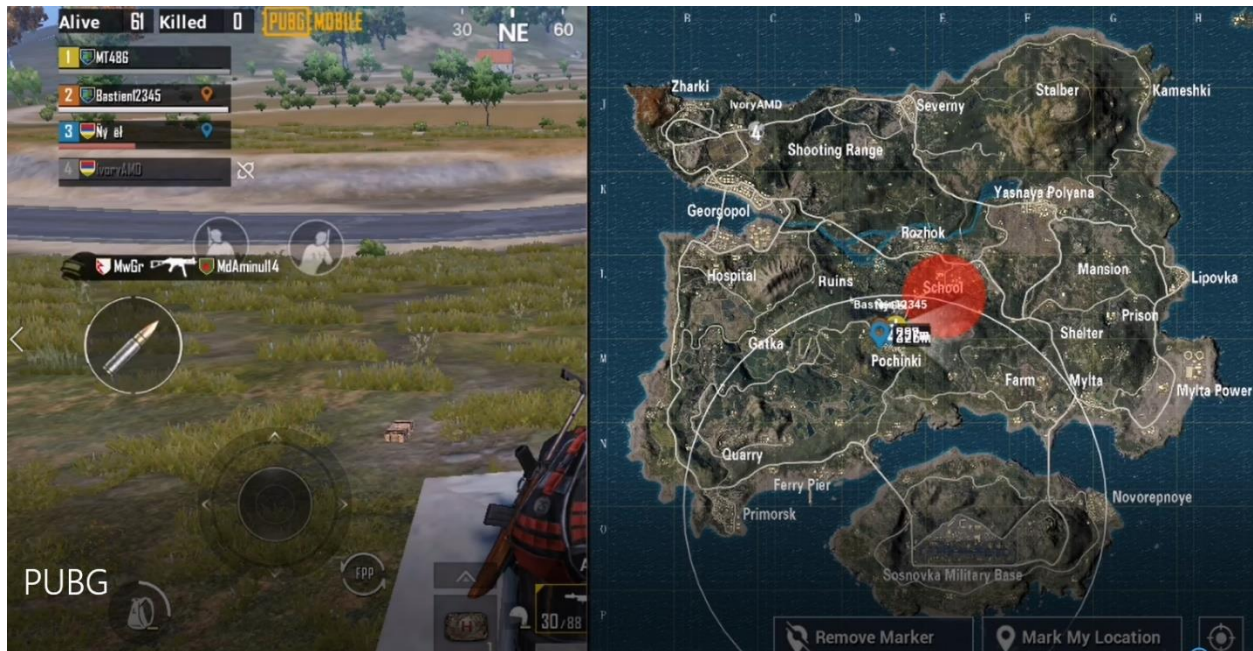


Figure 6.7: Interactive map in PUBG mobile

➤ Option of emotes and predefined voice phrases

If player was unable to speak, emotes and predefined voice phrase can be used. The list of predefined voice phrase speaks out loud as well display in the game screen as message. The emotes allow players to communicate using body language of character. As shown in the figure below, hi/hello there, love/thank you, clap/excellent work, hurt/breakdown, victory sure, victory and Bow emotes were available to use.





Figure 6.8: Option for emotes and list of predefined voice phrases

- Another option allows for making fast communication in rush situation was wheel predefined voice phrases which will be triggered if the text chat button was clicked and held. It will provide an option of predefined voice phrases same as the list but in a wheel option in the center of the screen.



Figure 6.9: Predefined voice phrases in wheel option

**Allow a preference to be set for playing online multiplayer with players who will only play with/are willing to play without voice chat**

- PUBG mobile offers players to choose the server option such as North America, Europe, Asia, South America, Middle east and KRJP. Also, they can select the language which they prefer, and game will match the language in selected server to assign the team. If player do not want to be in any team, they can clear the check box in auto matching. But the game do not offer voice or silent matchmaking preference.



Figure 6.10: Matchmaking preference in PUBG

**Ensure that all important supplementary information (e.g. The direction you are being shot from) conveyed by audio is replicated in text/ visuals**

- The direction of gun shot from where player being attack was presented with red bullet icon in the top right map and blood in the screen will be displayed. If the

player hit the opponent, then it shows white hit icon in the opponent body. And, if enemy and vehicle come near then presentation of footsteps and wheel in red icon displayed in the mini map like the bullets shown in the figure below. The game has used similar icon that matches the real-world scenario and present different icon for different sound. The teammates health status was also displayed which shows statues of players reducing health bar, blur and transparent if player died and full white line if player alive in the top left corner of game screen in the figure below.



Figure 6.11: Visual feedback indicating gun shot and hit direction

### **Garena Free Fire: Kalahari**

In this game, team players can communicate only through voice chat. Text chat was not implemented in this game which was the major issues for the players who cannot speak and hear in this game. The results of game accessibility guidelines review of Garena Free Fire was listed below:

**Provide subtitles for all important speech**



- In the figure below, essential audio and in-game update was presented as subtitle. In every 2 minutes zone was shrinking which was presented in red text in the top center of the screen, little below airdrop approaching was presented that informs the players, box with special weapons and equipment arrive and kill information that show which players kill whom in the game.



Figure 6.12: Subtitles of essential information in Free Fire

**Provide separate volume controls or mutes for effects, speech and background/music**

- Volume can be adjusted of music, sound effects and voice by the players. It allows players to control each volume independently.



Figure 6.13: Volume controls option in Free Fire

- **Ensure no essential information is conveyed by sounds alone**
  - In Free fire audio was presented as subtitle. Subtitles was pretty good enough for players to read but visual cues were not presented well. Visual representation of footsteps and gun shot displayed in mini map as arrow indicating from which direction it is happening. But, as shown in the figure below enemy used vehicle to rush out and no any visual representation was appeared in the map only small red circle was indicated top of the enemy. In, most of the cases visual representation of essential information was not presented.



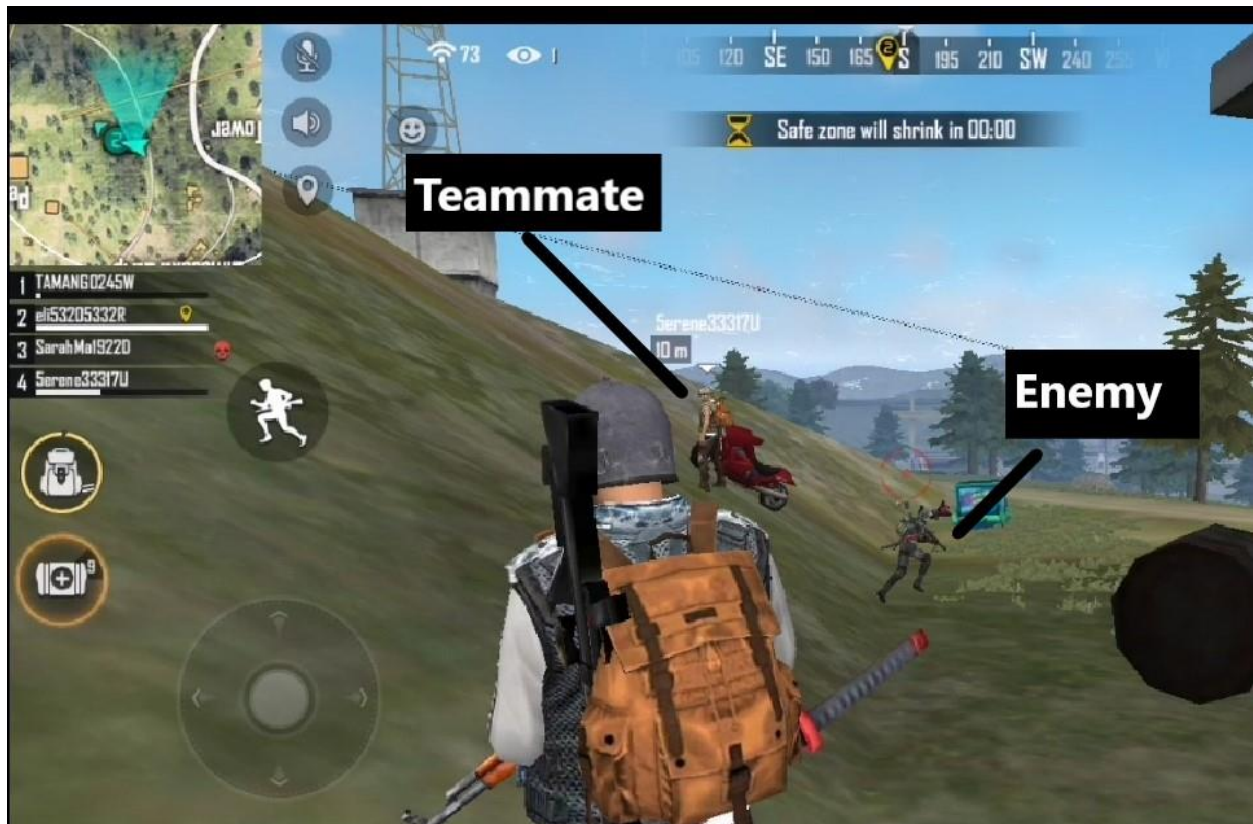


Figure 6.14: No visual representation of enemy in map

**If any subtitles/captions are used, present them in a clear, easy to read way**

- The text used in the game was clear and easy to read. Also, presentation of subtitle position can be moved anywhere in the game screen.

**Provide a visual indication of who is currently speaking**

- Players only use voice chat to communicate each other in this game. But the marking in map and marking supplies was possible in the game. As shown in the figure below, player2 mark the location in map which can be seen by all team members yellow mark in map and identify who mark that location.



Figure 6.15: Player marking location in Free fire

### **Allow subtitle/caption presentation to be customized**

- Players can customize the presentation of subtitle. The figure below shows that “Airship is approaching” position can be moved anywhere and “Player A kills Player B” can also move.

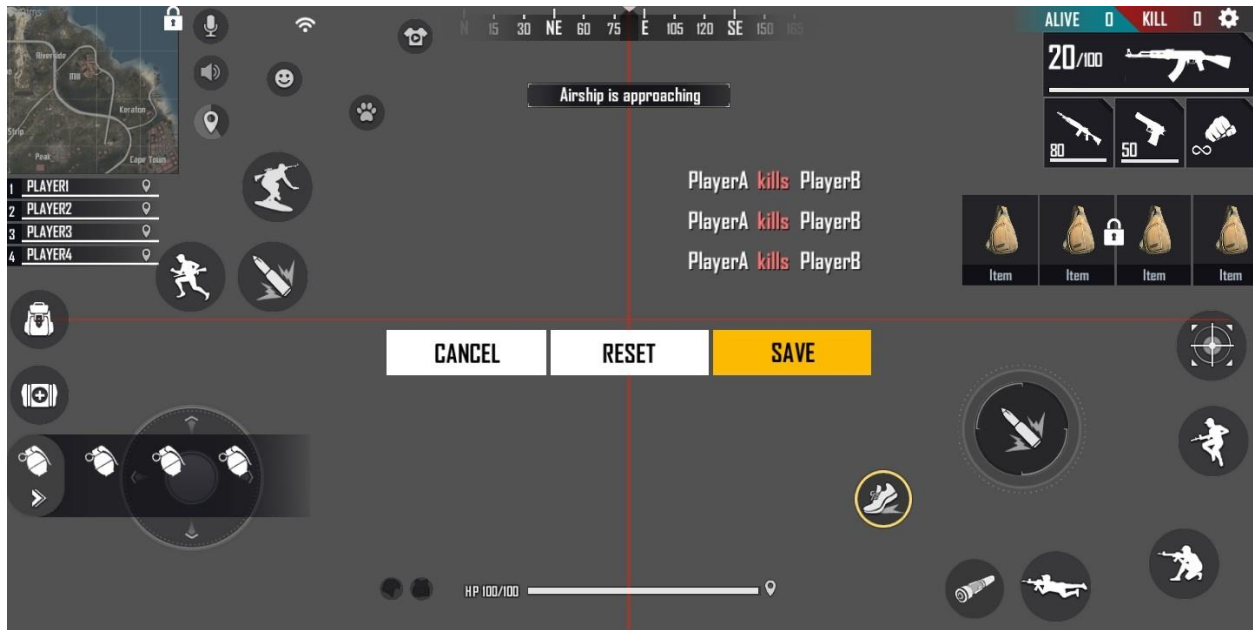


Figure 6.16: Subtitle presentation position setting in Free fire

### Support text chat as well as voice for multiplayer

- As game accessibility guidelines has suggested that multiplayer game must support text chat as well as voice chat. This game was found lack of text chat option, but voice chat was available in the game. This game only allows voice chat which means it may cause problem to deaf players while playing.



Figure 6.17: Voice chat pointing in Free Fire's screenshot

### Provide visual means of communicating in multiplayer

- In Free Fire, players can mark the location in map where they want to go but need to open every time to know about how far the location was. Mini map shows the location of teammates and where teammates dies. The orange circle with drone icon indicate the danger zone where player being attack by the drones and white small circle indicates next safe zone when the size of the zone shrinks.





Figure 6.18: Map zoomed in Free Fire

**Allow a preference to be set for playing online multiplayer with players who will only play with/are willing to play without voice chat**

- The matchmaking preference shows in figure below only allow players to click the auto-match or not. It means that auto-match formed team with random players using auto matchmaking process and if not, then player must play alone against squad or team. So, there was no available option for players to choose rather than auto-match.

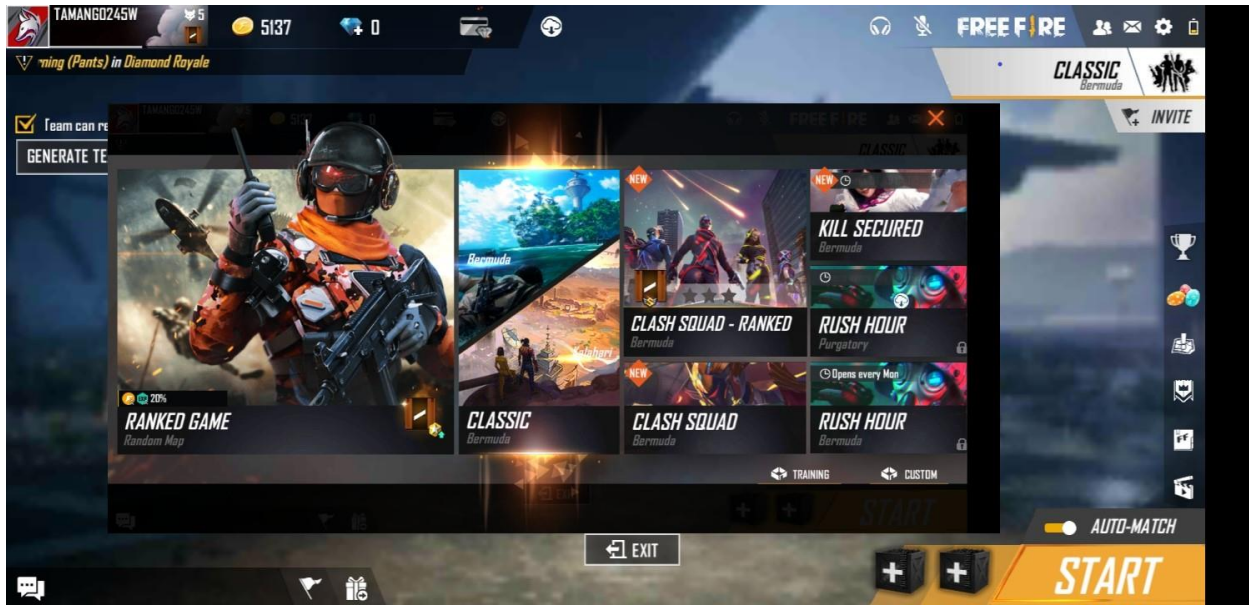


Figure 6.19: Matchmaking preference in Free Fire game

Ensure that all important supplementary information (e.g. The direction you are being shot from) conveyed by audio is replicated in text/ visuals

- As shown in the figure below, when players being shot the blood displayed in the screen and red arrow in mini map which indicates the direction from where opponent firing. And the hit indication pointing enemy with red circle shows if enemy get damaged to provide feedback that players shot hit the enemy or not. The numbers in the middle of the screen indicates how much enemy gets damaged and player as well. The red arrow in the mini map in the top left corner use to indicate for different sound activities such as footsteps, gun shot and vehicle movement.



Figure 6.20: Visual representation of being shot and hit to the opponent

### Use symbol-based chat

- This game offers players to use emote but players must buy the emote to be able to use in the game. It shows that this feature was not implemented to provide alternated choice of communication for people who cannot speak or listen.



Figure 6.21: Emote option in Free Fire

## Call of Duty Mobile

The results show that, this game allows players to communicate using voice chat, text chat and other means of communication. The results of game accessibility guidelines review of Call of Duty mobile was listed below:

### Provide subtitles for all important speech

- In this game, audio and dialogue was use frequently. But, subtitles of every audio and dialogue was presented in the game.





Figure 6.22: Subtitle presentation of essential information in Call of Duty mobile

**Provide separate volume controls or mutes for effects, speech and background/music**

- Volume controller offer players to adjust every audio used in the game such as voice chat, UI, SGX and music.



Figure 6.23: Volume controller in Call of Duty

**Ensure no essential information is conveyed by the sounds alone**

- While played without sound, players get every piece of information either as message, notice or warnings. Overall, game provide all the necessary or essential information through subtitles, message and visual icons.

**If any subtitles/caption are used, present them in a clear, easy to read way**

- Text used in text message presentation was not readable. As text appears for a second in the game screen where text was not visible. Players who relies on the text find it difficult to play this game.



Figure 6.24: No contrast between text and background color in Call of duty mobile

**Provide visual indication of who is currently speaking**

- In the figure below, it shows that every activities of players was presented visually in the list of the team members and players name tag was used when they send test message.





Figure 6.25: Visual indication of players in Call of Duty

### Allow subtitle/caption presentation to be customized

- The option menu does not provide any setting to customize subtitle and message presentation position in this game.

### Support text chat as well as voice for multiplayer

- The figure below shows that players can use both text and voice chat in the game. For the voice communication, players can choose option to listen all voice chat or only team members and mic to allow communicate to all or within a team. But text chat has no option to go all or team, it will be used only within the team members.



Figure 6.26: Call of Duty with voice and chat option for communication

### Provide visual means of communicating in Multiplayer

- Emote option, players can communicate using emote in the game
- Predefined voice phrases, players can use voice phrases to ask for help, weapon also to mark the enemy location and supplies

- Mini map, it allows players to set or mark the location



Figure 6.27: Visual means of communication in Call of duty

**Allow a preference to be set for playing online multiplayer with players who will only play with/ are willing to play without voice chat**

- Player can create custom room for playing in squad and matchmaking preference was only auto.

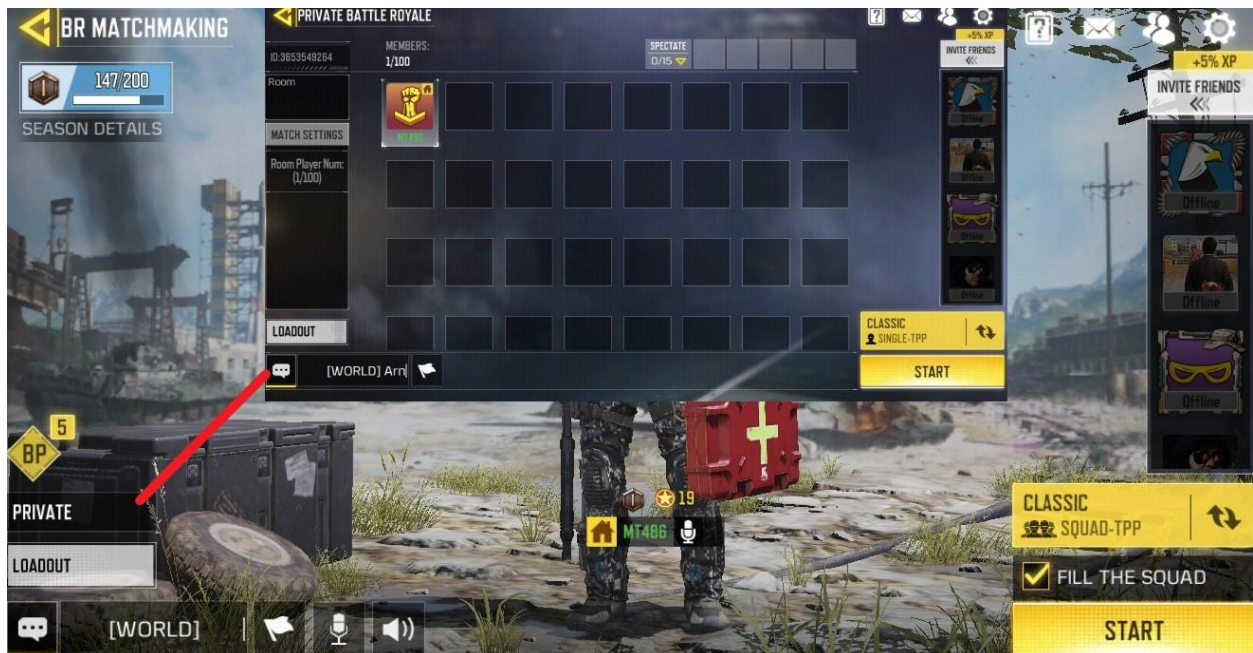


Figure 6.28: Match making option in Call of duty

**Ensure that all important supplementary information (e.g. The direction you are being shot from) conveyed by audio is replicated in text/visuals**

- This game has provided visual presentation of all the audio information very well.
- Footstep as a red feet icon and gun shot as a yellow bullet icon in the mini map represent if character in game hear footstep and gunshot sound.
- Also, if players hit the enemy red target icon displayed in screen.





Figure 6.29: Visual representation of audio information in Call of duty

### Summary of guidelines review

Guidelines	PUBG mobile	Free Fire	Call of Duty mobile
Provide subtitles for all important speech	Pass	Pass	Pass
Provide separate volume controls or mutes for effects, speech and background/music	Pass	Pass	Pass
Ensure no essential information is conveyed by sounds alone	Fail	Fail	Pass
If any subtitles/caption are used, present them in a clear, easy to read way	Pass	Pass	Fail
Provide a visual indication of who is currently speaking	Pass	Pass	Pass
Allow subtitle/caption presentation to be customized	Fail	Pass	Fail

Support text chat as well as voice for multiplayer	Pass	Fail	Pass
Provide visual means of communicating in multiplayer	Pass	Fail	Pass
Allow a preference to be set for playing online multiplayer with players who will only play with/are willing to play without voice chat	Fail	Fail	Fail
Ensure that all important supplementary information (e.g. The direction you are being shot from) conveyed by audio is replicated in text/ visuals	Pass	Fail	Pass
Use symbol-based chat	Pass	Fail	Pass

Table 6. 1: Game accessibility guidelines review of PUBG mobile, Free Fire and Call of Duty mobile

The results of guidelines review show that PUBG and CoD provides text chat and visual representation of sound activities where Free fire lack text chat option. The different games used different ways to represent the visual cues of sound activities. Overall, PUBG mobile and CoD mobile allow deaf people to experience game without any assistive tools or features.



## **Chapter 6: User Testing**

In OMBRGs, the role of audio and voice communication was very important. The implementation of audio and voice communication features creates challenges for hearing impaired people. According to the guidelines of accessible video game both voice chat and text chat should be implemented in the multiplayer game and visual representation of sound activities. The purpose of user testing section was to find out does implementation of text chat and visual feedback in MOBRGs help to increase gaming experience. In order to conduct this testing, PUBG in mobile platform was chosen. The PUBG in mobile platform allow to change or modify its controls and interfaces. So, two different setting were designed where participants performed some task using two different setting in PUBG mobile. The first setting allows participants to use wheel predefined voice phrases and visual feedback of sound activities of gunshot, footstep and vehicle movement where second setting allow participants to use only normal text chat which required to type, and no visual feedback elements were presented.

Text chat in OMBRGs aims to help players who cannot hear and speak as an alternative to voice chat but was it helpful if text chat where players must type all the time in the game. As OMBRGs was all tactics and strategy based where everything visible both by players and characters in the game. So does visual feedback of footstep, gun shot and vehicle sound in the OMBRGs helps to improve gaming experience if they can visually see the enemy around.

The analysis deaf players feedback shows that typing text message may distract players and affect the gaming experience where visual feedback may not be helpful in rush situation. This testing helps to address the second research question “does the text chat

and visual representation of sound activities helps to improve gaming experience of deaf people in OMBRGs”. The experiment was designed to find effect of text chat and visual representation of sound activities in OMBRGs. To conduct the experiment, a concrete hypothesis needed which can be statically interpret (Lazar et al., 2017). Generally, experiment takes two hypotheses null and alternative which was also resemble by the current scenario of study. Two hypothesis were created where Null hypothesis refers to help to improve gaming experience whereas alternative hypothesis refers to have no any improvement in gaming experience (Lazar et al., 2017). So, the hypothesis was listed below:

- Does predefined voice phrases appear as wheel and list option in the game screen helps to make effective and efficient communication in OMBRGs?
  - H<sub>0</sub>: Wheel option of predefined voice phrases help to make effective and efficient communication in OMBRGs
  - H<sub>1</sub>: Wheel option of predefined voice phrases does not help to make effective and efficient communication in OMBRGs
- Does visual representation of footsteps, gunshot and vehicle help to improve gaming experience in OMBRGs?
  - H<sub>0</sub>: Visual feedback of footsteps, gunshot and vehicle helps to improve gaming experience in OMBRGs
  - H<sub>1</sub>: Visual feedback of footsteps, gunshot and vehicle does not make any differences in the OMBRGs

### **Participants selection**

The participants were selected based on the gaming experience of OMBRGs. The nature of the testing was flexible where two different sample were created. The focus group of this research was deaf or hard of hearing people who have played battle royale game. So, the random ten players who have experience of OMBRGs were selected but the testing was conducted without sound or silent mode. The reason was beginner or novice player must learn the game strategy first and to play as a team which can affect the results of the testing. Where players who have already played battle royale game and have good knowledge about teamwork in the game can contribute how these features can help them to improve their gaming experience. All the selected players were friendly with battle royale game in mobile version.

The selected participants age group were from 20 to 29. Four of them was studying and six of them were working. All of them had played battle royale game in mobile device and frequently played in squad/team.

Participants	Age	Game	Playing times ( in a week)
P1	24	PUBG mobile	More than 20 hours
P2	22	Call of Duty	10-20 hours
P3	25	Free Fire	Below 10 hours
P4	26	PUBG mobile	10-20 hours
P5	18	Free Fire	10-20 hours
P6	20	Call of Duty	More than 20 hours
P7	19	Call of Duty	10-20 hours

P8	25	Free Fire	Below 10 hours
P9	21	Free Fire	10-20 hours
P10	22	PUBG mobile	More than 20 hours

Table 7.1: Demographic information of Participants

**Setup of game samples**

User testing performed in Huawei P20 pro. PUBG mobile was downloaded in P20 pro and set up the two different game setting. First setting, where map size increases in the game screen where visual feedback represented, and wheel and list option presentation in game screen of predefined voice phrases allowed to be used in the game. The voice phrases

**Sample 1**



Figure 7. 1: Sample 1 game screen

Second layout where map size was reduced, and players need to type manually to communicate in the game.

## Sample 2



Figure 7. 2: Sample 2 game screen

## Procedure

Before the testing started, participants were greeted and informed about the purpose of the study. The involvement of participants was accepted after the signature in consent form. The consent form consists purpose, benefit, risk and confidentiality of the collected data. Also, participants were aware about the right to leave from the experiment if they do not want to continue. The personal data were not published or mentioned in anywhere but only used for the study purpose. The testing process requires participants to play the PUBG mobile in two different setting and perform the given task. The participants were

asked to perform a task in the game. The task to be performed in the game were listed below:

- Play matches in two different setting.
- During the gameplay:
  - Try to mark the location of enemy
  - Try to mark supplies to the teammates
  - Try to engage in battle and kill at least 2 enemies

The participants were also informed about the follow up questionnaire after the task completed. During the testing, participants were observed how they interact with the interfaces and difficulties they have faced in the game.

### **Data collection and Analysis**

The data were collected through set of questionnaires after the testing completed. The questions were designed to collected numeric data for the quantitative analysis. The reason for collected data using quantitative method was to prove and support the research statically. The collected data analyzed and interpreted using statistical tool. In scientific study, t-tests and the ANOVA were widely used as a analysis tool to measure or compare the means of groups (Lazar et al., 2017). ANOVA was used for comparing the means of the two or more groups whereas t-test used to compare means of not more than two groups. In the current study, two different independent variables were tested to measure the difference in results as a dependent variable. The SUS analysis was also chosen to find the usability of two different samples.

## **ANOVA**

Analysis of variance was commonly used to find the difference of variables when two or more independent variables were involved (Statistics, 2020). Similarly, wheel option of predefined voice phrases and visual feedback supposed as an independent variable and the study was to find the difference in gaming experience with or without the supposed independent variables. ANOVA helps to find the difference or impacts of variables but unable to find which one was the best when there was more than two groups (Gurchetan, 2018). In simple term, the purpose of this testing was to find effect of wheel option of predefined voice phrases and visual feedback elements on the gaming experience of deaf people. In order to do that, Null and alternative hypothesis was generated. Where null hypothesis represents no any significant difference and having no relationship between variables (Gurchetan, 2018). And alternative hypothesis accepted when null hypothesis rejected. Its vice versa situation where acceptance of one hypothesis cause the direct rejection of another hypothesis. The ANOVA test can be conduct in three different ways, One-Way ANOVA, Two-Way ANOVA and N-Way ANOVA. One-Way ANOVA was selected that helps to determine any statically difference between the means of independent groups.

## **SUS Analysis**

The purpose of the using system usability scale (SUS) analysis was to measure usability in game with or without the wheel option of predefined voice phrases and visual feedback. As, SUS was highly recommended and reliable tool for measuring usability of any systems “fast and easy” (Usability.gov, 2020). Basically, system usability scale consists

of 10 questions related to usability with five responses from “strongly disagree” to “strongly agree”. The modified questions were listed below:

<b>SN.</b>	<b>Original Question</b>
1	I think that I would like to use this system frequently
2	I found the system unnecessarily complex
3	I thought the system was easy to use
4	I think that I would need the support of a technical person to be able to use this system
5	I found the various functions in this system were well integrated
6	I thought there was too much inconsistency in this system
7	I would imagine that most people would learn to use this game very quickly
8	I found the system very cumbersome to use
9	I felt very confident using the system
10	I needed to learn a lot of things before I could get going with this system

Table 7. 2: SUS questionnaire original and modified

Each question has Likert scale option from “strongly disagree” to “strongly agree” where 1 to 5 numbers were assigned to each like, strongly disagree = 1 and strongly agree = 5.

The overall process of calculating and analyzing SUS score was described below:

- All odd question was subtracted by 1
- All even question value subtracted from 5
- And the new value was multiplied by 2.5.



- The final value total was graded from A to F

SUS final score	Grade	Adjective Rating
>80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
<51	F	Awful

Table 7. 3: SUS Grade scale table

### 6.1. Result and finding

The participants interaction in both samples were observed. The testing results was presented below:

### 6.2. ANOVA test result

The One-way ANOVA analysis tools was used to test the hypothesis.

Does predefined voice phrases appear as wheel and list option in the game screen helps to make effective and efficient communication in OMBRGs?

- H<sub>0</sub>: Wheel option of predefined voice phrases does not help to make effective and efficient communication in OMBRGs
- H<sub>1</sub>: Wheel option of predefined voice phrases help to make effective and efficient communication in OMBRGs

Groups	Count	Sum	Average	Variance
Sample1	10	116	11.6	2.04444
Sample2	10	88	8.8	1.95556

Table 7. 4: Summary table for text chat

Source of Variation	SS (Sum of squares)	df (degree of freedom)	MS (mean square)	F	P-value	F crit
Between Groups	39.2	1	39.2	19.6	0.0003	4.41387341
Within Groups	36	18	2		3	9
Total	75.2	19				

Table 7. 5: ANOVA table for quick text chat

As shown in the table,  $F = 19.6$ ,  $F_{crit} = 4.41$  and  $p\text{-value} = 0.00033$ . Since  $F > F_{crit}$  and  $P\text{-value} < 0.05$  which suggest that  $H_0$  was rejected. So, It was proved that wheel predefined voice phrases in OMBRGs help to make effective communication.

**RQ3.** Does visual feedback of footsteps, gunshot and vehicle help to improve gaming experience in OMBRGs?

- $H_0$ : Visual feedback of footsteps, gunshot and vehicle does not help to improve gaming experience in OMBRGs
- $H_1$ : Visual feedback of footsteps, gunshot and vehicle helps to improve gaming experience in OMBRGs

Groups	Count	Sum	Average	Variance
Sample 1	10	88	8.8	1.288888889
Sample 2	10	73	7.3	0.233333333

Table 7. 6: Summary table for visual feedback

Source of Variation	SS (Sum of squares)	df (degree of freedom)	MS (mean square)	F	P-value	F crit
Between Groups	11.25	1	11.25	14.7810219	0.001187291	4.413873419
Within Groups	13.7	18	0.761111			
Total	24.95	19				

Table 7. 7: ANOVA table for visual feedback

As shown in the table above,  $F = 14.78$ ,  $F_{crit} = 4.41$  and  $P\text{-value} = 0.0011$ . Since,  $F > F_{crit}$  and  $P\text{-value} < 0.05$  which suggest the  $H_0$  hypothesis rejected. So, it proves that visual feedback of footstep and gunshot in OMBRGs helps to play even without sound.

The result of ANOVA analysis shows that wheel predefined voice phrases helps to make effective communication in game and visual feedback helps to improve gaming experience.

### 6.3. SUS analysis result

Generally, SUS analysis tool was used to evaluate wide variety of products and services where video game was rarely chosen. But the purpose of the evaluating video game using SUS analysis was to compare between the two samples to identify the difference and where players found easy and better gaming environment without sound. The result of the SUS analysis listed below:

Participants	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
User1	4	2	3	2	4	2	4	2	3	2
User2	3	3	2	1	5	1	3	1	3	2
User3	4	2	4	2	4	2	4	3	4	2
User4	3	1	3	1	3	1	3	1	3	3
User5	4	2	4	2	4	2	4	2	3	1
User6	3	3	4	1	2	1	3	2	2	2
User7	4	2	3	2	4	2	4	1	3	1
User8	3	1	4	2	3	3	3	3	3	2
User9	4	2	3	3	3	1	3	3	4	1
User10	3	3	4	2	4	2	4	2	3	2

Table 7. 8: SUS score for Sample 1 (with Wheel and list option of predefined voice phrase as text chat and visual feedback)

<b>Participants</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>	<b>Q5</b>	<b>Q6</b>	<b>Q7</b>	<b>Q8</b>	<b>Q9</b>	<b>Q10</b>
User1	2	1	4	2	2	2	3	3	2	3
User2	3	3	1	3	3	3	4	3	4	1
User3	2	2	2	1	2	1	2	2	2	3
User4	1	1	4	2	4	2	4	2	4	2
User5	2	3	2	1	2	2	2	3	4	2
User6	1	1	1	3	3	3	4	1	3	1
User7	2	2	2	2	2	1	3	3	2	2
User8	2	2	3	3	4	2	4	3	2	3
User9	2	2	2	2	2	3	4	2	3	2
User10	3	1	3	1	3	1	3	1	2	3

Table 7. 9: SUS score for Sample 2 (with manual typing text chat option and no visual feedback)

<b>Sample 1</b>		<b>Sample 2</b>	
<b>SUS score</b>	<b>Grades</b>	<b>SUS score (/100)</b>	<b>Grades</b>
70	B	55	D
70	B	55	D
72.5	B	52.5	D
70	B	70	B
75	B	52.5	D
62.5	D	57.5	D
75	B	52.5	D
62.5	D	55	D
67.5	D	55	D
67.5	D	67.5	D
<b>Average score</b>			
<b>69.25</b>	<b>B</b>	<b>57.25</b>	<b>D</b>

Table 7. 10: SUS analysis grade table of sample 1 and sample 2

The SUS analysis grade table shows that participants found usable game with visual feedback of footstep and gunshots and wheel predefined voice phrases for communication. As the sample 1 which was game with visual feedback of footsteps and gunshots and wheel and list option of predefined voice phrases for text communication score 69.25 equivalent to grade “B” shows that good usability.

## **Chapter 7: Discussion**

This chapter explains the finding of the current research. The importance and contribution of the current finding to accommodate better gaming environment for deaf people. The engagement of deaf players in OMBRGs was increasing and still looking forward to experience other games. Most of the previous research for accessible video game focused on subtitle and caption which results implementation of accessible subtitle and caption in current video games. But the analysis of deaf players feedback shows OMBRGs lack accessibility for deaf people.

The analysis of deaf players feedback showed that the increasing popularity of OMBRGs among deaf and hard of hearing people. As subtitle and caption was only studied and preferred to make accessible video game for deaf people. But, growing use of voice chat and several character playing at same server in OMBRGs causing problems and challenges that affect the gaming experience of deaf people. The current study shows that subtitle and caption was not enough to increase accessibility in OMBRGs for deaf people. The Online multiplayer gaming nature allows several players to play at same server and the sound produced by each player's character in the game lack visual presentation in game screen. The caption and subtitles were used for scripted dialogues or sound which was already implemented in game by game developers. It was found that the implementation of subtitle and caption in OMBRGs for sound or audio activities was not found. The other major challenges for deaf players in OMBRGs was the use of voice chat in duo and squad match. The use of voice chat in duo and squad match provides advantages and support among players. But the current findings show that lack of text chat or any visual communication in OMBRGs.

Accessibility guidelines of video game for deaf people also shows that text chat and visual representation of sound activities must be implemented in video game. But most of the OMBRGs in PC platform lack text chat option and visual representation of sound activities. APX also suggest that video game must provide secondary channel for communication and interpretation. The results of guidelines review in mobile platform shows that accessibility features were not implemented properly by all OMBRGs. Some, OMBRGs in mobile platform found only voice chat implemented and no any other means of communication was implemented. The results show that growing popularity of OMBRGs need to be studied for accessible text used in text message presentation and accessible visual cues used for visual representation of sound activities.

The user testing results shows that the predefined voice phrases help to make effective and efficient communication than typing manually text chat in OMBRGs. In OMBRGs, voice chat was easy and effective communication which only require players to speak. For instance, to ask for help and provide some additional information like I am surrounded by enemies to teammates then using voice chat players only need to speak but same communication require additional effort using text chat. So, many deaf players had mentioned that they found distracting while typing text chat to teammates in rush situation. But the predefined voice phrases like “help”, “I am surrounded by enemies”, “enemies ahead or danger ahead”, “I need a supplies”, “Cover me”, “I got supplies”, “stay low”, “stay alert” and “I will cover you” help to make easy and effective communication with team players. Such voice phrases displayed in the game screen as wheel and list option. To use it players only need to choose which one to send and click it. The selected predefined voice phrases appeared and speak out loud in game.



The visual representation of footsteps, gunshot and vehicle movements represented in map of the game screen. The players found it very easy to understand what was displayed in the map. If the enemy come nearby, the footsteps icon displayed in map, if player get shot from enemy then the red small bullet icon displayed in map, if car or any vehicle comes nearby then small wheel icon displayed in map indicating the direction of footsteps, gunshot and vehicle. This results also suggest the solution for PC platform to increase accessibility for deaf players.

Overall, the finding of this research shows that major problems in OMBRGs for deaf people was lack of text chat and visual representation. Also, the usability problems occurred using text chat and visual representation in OMBRGs. But, the use of predefined voice phrases allowed players to make effective communication even in rush situation. The visual representation of sound activities as small icon show positive impact on deaf player gaming experience.

### **7.1. Limitation**

As every research or project suffers from the limitations which taught to make changes and improve the research. The first limitation was studying in two different platforms, PC and mobile to identify problems in OMBRGs. As the game screen interfaces and controllers was totally different in PC and mobile platform where testing required before evaluating game to get the data about accessibility and usability in both platforms.

The lack of real deaf user involvement in user testing. The problem was finding the real deaf player who have played OMBRGs was difficult to find. The deaf users engaged in discussion and feedback section of OMBRGs was hard to convinced. They were only

ready to participant in online survey, but the research focuses on engagement of user for the observation. But If content analysis followed by online survey could be the best methods that generate more reliable and concrete problems of deaf people in OMBRGs.

The choice of methods was also the limitation of this research. If the research was conducted using content analysis of deaf people feedback and identifying real deaf user for the feedback section and conduct the online survey generate better results to find the accessibility issues in OMBRGs. The number of participants was limited, if more participants was involved and interview was conducted then the result might show more valid and concrete effects of text chat and visual feedback in OMBRGs.

The most important things to be concerned in this section was the lack of involvement of real deaf user. After the analysis of deaf people feedback, the planning of this project was to conduct online survey involving real deaf players. But when the deaf players found online was tried to convince to participant in research, most of them did not replied and some of them ignore the message. So, I think if online survey after analysis of deaf people feedback was conducted then this research gets much better.

## **Chapter 8: Conclusion**

The purpose of this research was to identify and investigate the problems experienced by deaf people in OMBRGs. Two research questions were prepared where, first research question focuses on identifying the problems and issues of deaf people in OMBRGs and second research question focuses on finding the effect of text chat and visual feedback in deaf player gaming experience in OMBRGs.

The analysis of deaf people feedback and guidelines review was conducted to address the first research question. The results show that two major issues found in OMBRGs related to accessibility, lack of text chat and visual representation of sound activities. Most of the deaf players use additional plugins that support text chat and visualization of sound activities that helped to play OMBRGs. Using text chat in OMBRGs affects gaming experience of deaf people and visualization plugins was not accurate and reliable for representation of sound activities in game screen. The game accessibility guidelines review shows that among three only two OMBRGs provide text chat and visual representation.

The results of user testing address the second research question. It shows that text chat and visual representation in OMBRGs can help to increase deaf people gaming experience. The use of predefined voice phrases helped to make effective and efficient text communication without distracting players while playing. This research highlighted the problems of deaf people along with the importance of text chat and visual representation of sound activities in OMBRGs.

As previous research on accessible video game for deaf people focused on subtitle and caption. This research shows that visual icons help deaf people more than caption in

OMBRGs. But the accessible visual icons need be investigated to provide better gaming experience. The text chat only show that predefined voice phrases helps deaf people because it reduces the problem of typing manually message. But the presentation of text chat still needs to be investigated.

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## Appendices

### Appendix 1: Consent form

#### The Consent Form

#### An investigation into Online Multiplayer Battle Royale Game to help deaf people

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**Purpose of the Study:** The goal of the study is to understand how quick text chat and visual feedback in online multiplayer battle royale game can help deaf people to improve their gaming experience. The participants will be asked to play the battle royale game and need to answer the questionnaire after the match completed.

**Procedures:** Participants in the study will be asked to play battle royale game with and without quick text chat and visual feedback option, it means two matches and need to perform given task while playing. The testing will be observed by the researcher and questionnaire will be provided after the match finished.

**Risks/Discomfort:** The only risk involved in participating in this research is fatigue during the task performance. But participants can take rest after the match completed or stop

the testing if participants do not willing to play the game. Also, during the questionnaire participants have right to fill the form freely without any pressure or stress.

**Benefits:** Your participants and data will be useful for the improvement of online multiplayer battle royale game for deaf and hard of hearing people.

**Confidentiality:** Participants personal information and collected data will be used for study purpose and will not published in any way.

If you are ready to participant in this research, please sign your name below.

\_\_\_\_\_ I have read, understand and agree with the consent form.

**Supervisor of this research:**

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**Appendix 2: Questionnaire for ANOVA and SUS**

## Questionnaire for text chat

I can ask for help or supplies with my teammates in rush situation

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

I can aware my teammates about danger or anything easily without distraction

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

I found using text chat option was enough to play this game without voice chat

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

## Questionnaire for visual feedback

I am always aware if anything happens around me in the game

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

I can fight effectively even without sound in the game

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

I can track the direction of gunshots in the game

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

## **Questionnaire for SUS analysis**

I think that I would like to play this game frequently

1 2 3 4 5  
Strongly disagree      Strongly agree

I found this game unnecessarily complex

1 2 3 4 5  
Strongly disagree      Strongly agree

I thought the game was easy to play

1 2 3 4 5  
Strongly disagree      Strongly agree

I think that I would need the additional support to be able to play this game

1 2 3 4 5  
Strongly disagree      Strongly agree

I found the various functions in this game were well integrated

1 2 3 4 5  
Strongly disagree      Strongly agree

I thought there was too much inconsistency in this game

1 2 3 4 5  
Strongly disagree      Strongly agree

I would imagine that most people would learn to use this game very quickly

1 2 3 4 5  
Strongly disagree      Strongly agree

I found the game very complicated to play

1 2 3 4 5  
Strongly disagree      Strongly agree

I felt very confident playing the game

1 2 3 4 5  
Strongly disagree      Strongly agree

I needed to learn a lot of things before I could get going with this game

1 2 3 4 5  
Strongly disagree      Strongly agree