Toward a Supplemental Haptic Interface to Aid Novice Gameplay

by

Sara Czerwonka

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Sara Czerwonka
Abstract

As the video game industry grows and becomes more popular, new players with limited experience may be joining the video game community and learning to play for the first time. This thesis study investigates how the experience and mental models of novice players differ from experienced players, and how this information can be utilized to design more effective tutorials for these new players, particularly with multimodal interfaces as a possible technique in mind. To do this, an exploratory survey study about experiences and preferences related to difficulty and tutorials was presented. The results indicated support for hands on tutorials with gradual onboarding techniques. Participants also identified unfamiliar control schemes, game complexity, and assumed knowledge about video games as major barriers to entry for new players. To address this, a pilot user study was conducted to test the effectiveness of finger-based haptic cues in addition to the user interface as a novel technique to alleviate difficulty and aid learning for novice players in a first-person shooter game. Results indicated that the system produced somewhat positive effects on player performance, and the system was generally supported by players as a potential solution. However, there were several limitations impacting this study and the significance of its results.
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Chapter 1

Introduction

As the video game industry grows and matures, so does the primary audience, who have developed an second-nature understanding of how games work and how players are meant to interact with games. But what about those who may not have grown up playing games, but are interested in picking up gaming as a hobby as an adult? This group of people, who I refer to as beginner or novice gamers throughout this thesis, are very interesting to consider through the lens of video game user experience design. These players present unique challenges for designers who want to ensure that their games are accessible to all players without risking frustrating and alienating the intermediate and expert players who have a wide breadth of contextual knowledge informing their gaming habits. Video game companies have used various techniques in order to adjust their game to better suit new players, including dynamic difficulty which adjusts according to player performance [19, 5], and extensive accessibility options [29] . In this thesis, I propose the novel concept of utilizing haptic vibrational cues as a tool to help players with learning the controls of a new and unfamiliar video game. Although previous research does exist on the topic of haptic feed-forward as a
technique for aiding novice gameplay [34, 35], there has not to my knowledge been an exploration of this haptic cues as a technique to help players with learning in addition to performance prior to this study. According to Jagoda [19], there are three types of difficulty present in video games; mechanical, interpretive, and affective difficulty. Mechanical difficulty refers to difficulty associated with participatory action dependent on physical skill, whereas interpretive difficulty requires the player to exercise analytical skills to respond to stimuli. Affective difficulty refers to difficulty associated with emotions or feelings that are brought on by playing the game [19]. These difficulties may be heightened for novice players who do not have previous experience with video games. Overall, the novice gameplay experience is relatively under-researched, with most game-based research focusing on the players with some level of previous experience. This lack of focus on novice gamers may also be prevalent in the video game industry, as White [39] argues that often times these players are overlooked in the design of video game tutorials, which assume some level of previous knowledge about video games and tend to skip over crucial basic information that new players need to be able to play the game effectively. Research from Alexander et al. [5] and White [39] compares the feedback from different groups of users, including casual and novice gamers, with regards to difficulty and tutorial design, respectively. It was found that casual gamers, which can be but are not necessarily novice gamers, tended to choose lower difficulties and enjoyed them significantly, even if their chosen difficulty was too easy according to their skill level [5]. Novice gamers in particular responded well to a tutorial design that incorporated scaffolded instructions that were presented variably according to the player’s performance, rather than traditional text pop-ups at set intervals throughout a tutorial [39]. These studies outline the varied perspectives that inexperienced gamers
have on video games, and how difficulty and tutorial design can be manipulated to provide them with the best experience possible.

The user interface (UI) of a video game as an incredibly important aspect of the design as it provides the player with crucial information throughout the experience that affects the way that they make decisions and interact with the game. The user interface is very important for the new player experience as well, as a poorly designed interface could have detrimental effects on a new player’s understanding of how the game works [23]. Blogger Doctor Professor [31] advocates for difficulty scaling in the context of the user interface as well as the gameplay by only giving novice players access to UI elements that are pertinent to them at the time, while allowing experts to access more information. This can help to ensure that new players are not overwhelmed with too much complex information that they don’t know how to use yet, while ensuring that experienced players are able to make use of their contextual video game knowledge to interact with the UI as they like. In accordance with the notion that novice gamers are unique in their needs, these sources advocate for a special focus on the novice user when designing the user interface.

Haptic feedback is a technology that has been utilized in the video game industry in various ways in order to enhance the user experience. Haptics in video games refer to the use of force or tactile feedback to provide a touch sensation to the player, usually to provide information or a sense of immersion that enhances the gameplay experience [28]. Haptic feedback has been used to aid visually impaired gamers by shifting information from the visual channel to the haptic channel [28], as well as to provide feed-forward information about upcoming hazards to novice players in Mario Kart Wii [34], with varying results. Additionally, haptic feedback has been coupled with audio cues in various studies with the goal of impacting working memory [36], reducing
visual distractions in a virtual environment [24], and building wayfinding skills in visually impaired participants. The findings of these studies and many more have impacted the design and testing of the novel haptic glove interface that is presented in this thesis study.

1.1 Research Goals

As previously mentioned, novice gamers are a largely under-researched group whose experience is likely vastly different from those with more experience due to a lack of previous contextual knowledge about certain games or genres. In order to examine this experience in-depth, I proposed an exploratory survey meant to examine the thoughts and opinions of players of various levels of skill with regards to game difficulty and tutorials. Following this, I used the results of the survey study to inform the design of a novel haptic glove design for aiding novice gamers with learning unfamiliar control schemes. I conducted a pilot user study of this system in order to determine its effectiveness at addressing barriers that prevent new players from engaging with video games.

The primary questions guiding this research are as follows:

- **RQ1**: How do the experiences and mentalities of novice and experienced gamers differ on the topic of video game tutorials and difficulty?

- **RQ2**: How can haptic cues be utilized in addition to the user interface to alleviate mechanical and interpretive difficulty for novice players in a first-person shooter game?

The implications of this research include an understanding of the barriers to entry for new gamers, which can be used to make educated decisions regarding the difficulty
of games and the techniques for developing tutorials that cater to a wide range of players with varying levels of skill and game-related knowledge. Additionally, this research provides insight into the practicality and applicability of haptic cues as an interface element in games, particularly in the context of difficulty adjustment. This is important, as there is potential for haptic elements to serve as a technique for decreasing the cognitive load required in gaming and providing novice users with extra support to learn those mechanics which are unfamiliar to them, but commonplace in the video game industry.

1.2 Thesis Structure

The structure of the document is outlined in this section, along with a brief description of what each section includes.

1.2.1 Chapter 1: Introduction

This chapter provides a brief overview of the unique experience of novices in the gaming community, as well as the role that haptic feedback plays in the design of video games. Additionally, this chapter covers the objectives of the research as well as the structure of this document.

1.2.2 Chapter 2: Literature Review

This chapter provides a comprehensive overview of three major topics as they relate to this research; video game difficulty, instructional design in video games, and user interface design in video games. This chapter examines these topics through the lens of the current research and provides the reader with an understanding of how various
techniques have been used in the past to augment and address video game difficulty, as well as how players’ varying levels of skill affect the user experience of a game. Papers discussed in this section provide the theoretical background and precedent for this thesis research.

1.2.3 Chapter 3: Survey Study

This chapter outlines the methodology and results of an exploratory survey study that aimed to understand the differences in experience and preferences between players of novice, intermediate, and expert skill when it comes to video game onboarding and tutorial design. Additionally, this study aimed to identify any barriers that currently exist in the gaming industry and community which may hinder novice gamers from being able to effectively participate in gaming as a hobby. This chapter presents the qualitative and quantitative results of the survey, including a thematic analysis identifying themes and sentiments in the short-answer portion of the survey. The results indicated a strong preference for hands-on tutorials that require contextual use of mechanics to solidify understanding in the player, among other design choices. Additionally, barriers identified by participants included unfamiliar control schemes, assumed knowledge that is not present in the player, and social stigma surrounding being an unskilled player. Lastly, this chapter discusses these results in detail in order to provide context for research presented in Chapter 4.

1.2.4 Chapter 4: User Study

This chapter presents the design, development, and testing of a novel technique for incorporating haptic feedback into video games by utilizing vibrational cues to aid novice players with learning to use unfamiliar control schemes in first-person shooter
video game. In this chapter, I outline the design of a system that includes a set of prototype haptic gloves developed using Arduino and other electrical components, a custom first-person shooter developed in Unity, and a control system that allows the researcher to control the haptic gloves in accordance with the player’s actions in the video game in user study that employs the Wizard of Oz technique for usability testing. This study presents the results of a 10-participant pilot user study that aimed to understand the effectiveness of this novel system as a technique for aiding beginner video game players with learning how to play a first-person shooter for the first time using keyboard and mouse controls. The results indicate that this technique may be effective in addressing barriers that are present to new players by providing extra support through the haptic channel, although due to a low participant account the results cannot be deemed statistically significant.

1.2.5 Chapter 5: Conclusion

This chapter outlines the major findings of both the survey study and user study and how they can be applied to the video game industry as a whole. As well, it outlines the contributions of the paper, limitations associated with the research, and proposes future work.
Chapter 2

Literature Review

Research related to adaptive user interfaces for the purpose of enhancing and augmenting novice video game play has not to my knowledge been explored fully in published research. Significant work, however, has been conducted in similar and related topics across the fields of user interface design, learning, and game design research. This literature review is focused primarily on three overarching themes that guide this research; video game difficulty, instructional design/game-based learning, and user interface (UI) design, particularly in the context of haptic interfaces.

This section begins by providing an overview of difficulty in video games, as well as the impact of these difficulty ranges on players of various skill and experience levels. This includes a thorough examination of the so-called "new player experience" that is present in modern video games. Next, I discuss prominent instructional design techniques present in video games such as tutorial sections and onboarding. The theory of experiential learning is also discussed as a grounding principle for the design of various game-based learning devices. This research influenced my understanding of how novice gamers learn new video game mechanics effectively. Lastly, I discuss a wide
range of research regarding UI design in video games. Primarily, this section covers
the use of haptic and audio-based UI to augment or enhance the player experience
in some way, whether it be to aide in accessibility for those with disabilities or to
decrease cognitive load engaging in complicated tasks. Additionally, this section
includes discussion of visual presentation of UI elements, as this is the most prominent
technique for presenting game UI at the present moment. This thesis research is
primarily concerned with the combination of these various types of UI presentation as
a way to alleviate the struggles that new players face when engaging with unfamiliar
games or game genres.

2.1 Video Game Difficulty

According to Jagoda [19], there are three types of difficulty present in video games;
mechanical, interpretive, and affective difficulty. Mechanical difficulty is based in par-
ticipatory interaction by the player and primarily depends on skill, whereas interpretive
and affective difficulties are primarily based in one’s ability to understand and respond
to stimulus either analytically or emotionally [19]. In the context of this research,
mechanical difficulty is the primary topic which I intend to study, although affective
difficulty and the evoking of different emotions such as frustration or excitement as
they correspond to mechanical difficulty is a peripherally important topic as well.
While some video games, such as the Dark Souls franchise [1], provide one level of
difficulty with no room for adjustment according to player skill, many games provide
various modes that adjust mechanical difficulty in order to make a game easier or
harder depending on the player’s desired experience. Additionally, some games even
incorporate dynamic difficulty adjustment that adapts to player performance during a
session by raising or lowering mechanical difficulty [19, 5]. Mechanical difficulty, and particularly the subset of games that offer little in the realm of customizable difficulty can cause gaming culture to be exclusionary to novices and new players, making it extremely difficult for these players to feel as though they belong in a gaming space [19].

As a result of an industry debate on whether static or dynamic difficulty is the most optimal implementation for video games geared towards specific target audiences, Alexander et al. [5] conducted a study to determine how game difficulty affects player enjoyment at various levels of skill and experience. It was found that players who identified themselves as "casual gamers" tended to choose lower difficulties and enjoyed them more, even if the difficulty did not match their actual level of skill. Comparatively, experienced gamers related their enjoyment and the difficulty of the game. This is to say that experienced players enjoyed the game less when they found that the difficulty was outside of their skill range. This research supports the use of multiple difficulty levels in order to appeal to a wide range of players, but also sheds light on the possibility that players choosing the wrong difficulty for their play style may cause a negative experience [5].

Although the previous research supports the inclusion of easier difficulties to accommodate novice players, this belief does not necessarily extend to the gaming community as a whole. A sub-community of gamers that enjoy extremely difficult games argue that the majority of twenty-first century titles offer too much hand-holding in the form of tutorials and lighter difficulties. This can lead to exclusion in the cultural space according to a certain level of prestige related to skill and dedication, and may cause novice players to feel intimidated and unwelcome in gaming communities [19]. A series of blog posts by Doctor Professor on their website titled "PixelPoppers" discuss
this phenomenon and how it impacts the gaming industry’s ability to welcome a new and diverse player base [31, 29, 30]. They argue that "signaling", a behaviour that aims to show off some aspect of one’s character in order to gain status, is a central aspect of why some gamers resist the presence of easier difficulty modes in games. It is argued that this status is perceived to be less meaningful when barriers are removed and the game becomes more widely playable by individuals of varying skill levels, therefore compromising the elite social status that hardcore gamers place on themselves [30]. The author argues that this is a result of a lack of empathy for individuals who may not possess the necessary skills or knowledge to play games at what may be considered to be a "normal" difficulty [29].

Although it is evident that the gaming community has contributed to this notion that many games are only to be experienced by those who have "earned their fun", game developers undoubtedly have a part to play in the stigma surrounding easy modes. The concept of locking in-game content behind harder difficulties is a common practice in late 20th and early 21st century games, so as to reinforce the notion that only skilled players are deserving of experiencing gaming to the fullest [29]. Additionally, the alienation of novice gamers goes even further in the direct mockery of players who choose easy modes in those games which do provide them. This may take the form of the naming of easy modes, such as in Wolfenstein 3D’s "Please Don’t Hurt Me" and "Can I Play Daddy?" modes [29].

These various factors combine in such a way that may lead novice players to feel excluded and unwanted in the cultural spaces surrounding video games, and may be discouraged to play games at all. This is not to say that the entire gaming industry is inaccessible to novice players, however. Games such as Bayonetta 2 [22] and The Last of Us Part II [16] have utilized customizable aspects of difficulty to allow for the
largest possible range of players to be able to experience their stories. This ranges from able-bodied new players, who may benefit from a bit of extra assistance while they familiarize themselves with the controls, to gamers with disabilities impacting their motor function, hearing, or sight. This is a step in the right direction towards an industry that is welcoming to all, regardless of ability or experience. In considering how important easy modes and customizable difficulty are in games, Doctor Professor states that "It doesn’t matter if we ourselves would never, ever touch that [automatic] win button. We would still want it to be there" [29].

2.2 Instructional Design in Games

Beyond the premise of difficulty in games, there are many things that can be done to ensure that a video game is as accessible as possible for individuals with a varying level of gaming experience. Whether this be through explicit tutorial sections or subtle onboarding techniques throughout the game’s story, there are many ways that games can facilitate learning. Additionally, there has been research in the field of education related to using video games to teach external topics, therefore reinforcing the notion that playing games can be a learning experience [27]. The following section is primarily concerned with how players learn through gameplay and what specific techniques can be used to ensure comprehension of game mechanics.

2.2.1 Learning Through Play

The intersection between education and play is one that has been studied extensively, as the use of games to facilitate learning in the classroom has become increasingly more commonplace with the release of modifiable platforms such as Minecraft Education
Edition [4]. Additionally, the use of moddable games such as Sid Meier’s Civilization 4 to teach historical topics in the classroom has also been documented [27]. Expanding upon previous research regarding educational theory and game design as they intersect with one another, Kiili [20] proposes a model based on experiential learning theory and flow theory that provides a baseline for what specific elements are required to facilitate learning in a game. According to this model, it is important to provide immediate feedback, clear goals, and challenges that are matched to the player’s skill level. When these requirements are met, players can experience “flow”; a state of absorption and engagement in an activity in which the player loses track of time and their surroundings, and focuses solely on the game [20]. This is thought to be a valuable and enjoyable experience for players, which may lead to more experimentation, improved skill development, and reflective observation as a result of the challenges presented in the game. When used as a link between education and game design, Kiili argues that this model can provide a richer experience for users and a stronger retention of educational materials present in the game.

In addition to the previously mentioned studies surrounding the use of games as a tool to facilitate learning in the classroom, it is also valuable to consider how the inherent participatory nature of games facilitates contextual learning of game mechanics and techniques. Mitgutsch [26] explores this concept thoroughly and argues that the nature of video games facilitate recursive learning through experiences present in the gameplay including irritations, confrontations, and failure. The author argues that these experiences lead the player to react by anticipating what to do next, and the immediate feedback that they receive of whether they are right or wrong translates into learning that they can utilize moving forward [26]. Through this cyclical process of experience, reaction, and feedback, players are able to acquire new knowledge, as
well as expand upon and restructure their current knowledge about the game. Because of this, Mitgutsch argues that games are a powerful technique for teaching higher-order thinking skills that can be utilized in other aspects of one’s life. An example of this can be seen in the massively-multiplayer online role-playing game (MMORPG) World of Warcraft, which creates motivation to play and learn by experience through offering in-game goals that can only be achieved through community involvement and problem solving, as opposed to explaining all aspects of the game through tutorials [40].

2.2.1.1 Onboarding

The onboarding aspects of video game design are incredibly valuable when it comes to ensuring that players have the knowledge and skill required to meaningfully interact with a game of any specific genre. In this paper, I utilize Bycer’s [8] definition of onboarding as the process of training someone to complete tasks. Bycer states that ”it’s all about getting the player acclimated to new concepts as quickly as possible” [8]. Onboarding can often take the form of tutorials, which are defined sections of a game which are solely meant to teach new mechanics, often providing an extremely forgiving space for players to experiment and familiarize themselves with new mechanics. Tutorials could be mandatory or optional, and may be accessed through menus or as part of the first level of the game. Onboarding may include tutorials, but is not only limited to explicit sections and may also include mechanics such as decision-making support [13] and intermittent flashcard reminders [39] that take place throughout the game, rather than exclusively at the beginning.

Although there has been significant research into learning in the context of video games, there is seemingly a lack of research into the onboarding process as a whole. A literature survey conducted by Endresen and Nathan-Roberts [13] in 2018 found
only 14 studies published within five years that met their criteria, which required that studies be focused on helping players through decision-making through defined decision support protocols, a subset of video game onboarding [13]. Although I was able to find some research focused on tutorial design and onboarding as it relates to motivational mechanisms [40], it seems that this area is still somewhat under-researched.

According to a 2018 blog post by Sandro Cantante [10], there are three general approaches to onboarding that are often seen in games; walkthrough, hands-on, and mixed. These techniques are used to teach the player about new mechanics before showing all of the possibilities of the aforementioned mechanics [10]. The walkthrough approach consists of pausing gameplay to provide information, typically through text or graphics. This can be an effective method for providing large amounts of information, but there is no opportunity for players to practice and ensure that they understand the new information in context. The hands-on approach places the player in a situation in which they must use a new mechanic in context to bypass an obstacle. This method requires the player to learn through experience and experimentation, similar to what is recommended in Kiili’s proposed model [20]. However, there are potential issues for more complicated mechanics which may not be intuitive to the player [10]. A mixed approach aims to combine both of these approaches in order to maintain flow while ensuring that players understand concepts fully. Cantante states that none of these are perfect solutions, and different games will require a different approach in order to ensure a positive experience for new players [10].

While studies involving onboarding in console and computer games are seemingly lacking in the field, a study by Thomsen et al. [38] ventured into the free-to-play mobile game space in order to identify heuristics for increasing player retention through onboarding. The heuristics identified by this study are as follows; identify a clear
goal, give players autonomy, match the player’s skill level, ensure that the game is relatable, provide clear feedback and progression, allow for varying contexts of play, ensure learnability, use music to support the environment, provide a rewards system, and combine all previous heuristics to ensure that the experience is immersive for the player [38]. Further, multiple community blog posts by Josh Bycer [8, 7] argue that the replayability of tutorial sections is a valuable aspect of onboarding as it allows players to revisit mechanics at their leisure and ensure a comprehensive understanding of how to play the game [8, 7].

2.2.1.2 Designing for the Novice Gamer

Paying particular attention to the elements of onboarding such as tutorial sections is incredibly valuable in the video game industry, as there may be players with a vast range of previous experience, knowledge, and skill hoping to play a game for the first time. Because of this, it is important to ensure that games are designed with novice players in mind. Bycer [9] states that there are three types of new players that should be considered when designing the instructional elements of a game. The first are those players who are new to the game in question, but are familiar with gaming conventions in this genre. Second, there are players who may have some previous experience playing video games, but have never played a game in this genre. Third, there are those players who have never played a video game before, and happen to choose this specific game as their starting point. Often, these players, particularly those with no prior experience, are overlooked in the design of tutorials, which may assume that the player has more knowledge about the game or genre than they actually do [39].

In order to better understand how game tutorials can accommodate new players, White [39] designed and studied the effects of three tutorial modalities in World of
Warcraft on player motivation and learning. Inexperienced players were exposed to both the Flashcard Instructional Strategy, which provided traditional text "pop-ups" to display information on how to use mechanics in-game, and a Just-In-Time Scaffolded Instructional Strategy, which adjusted the presence of instructional material on-screen according to the perceived player mastery of certain skills. In this condition, players who make frequent errors using a specific mechanic can expect more frequent reminders and help, whereas those who have demonstrated their mastery will not receive unnecessary help [39]. New players preferred and performed better under the Just-In-Time Scaffolded strategy, indicating that this level of adaptability in the game’s presentation of instructional material is valuable in allowing players to better understand mechanics, while also achieving a state of flow due to a lack of interruptions once mechanics were mastered [39]. Interestingly, participants also responded well to instructional design strategies which utilized audio modalities in place of visual cues (i.e. verbal audio as opposed to visual representation of text), calling into question whether the use of multimodal interface elements may lead to better comprehension of game mechanics in novice players [39]. This finding provided inspiration for the concept of my study, which aims to build upon previous research to understand the impact of haptic cues in addition to the traditionally visual user interface on mastery of mechanics by novice players.

2.3 User Interface Design in Games

A large part of a game’s presentation is the user interface, which is any feature which provides information or assists the player with interacting with the game [21]. This often takes the form of a heads-up display (HUD). The HUD typically presents itself
as an overlay on top of the game-world which provides the player with information that they need to understand in order to effectively play the game [6]. Most often, HUD elements are presented non-diegetically, in that they are overlaid on the game world and do not exist as part of the fictional world. However, some games have presented these elements diegetically so that they exist as part of the world in an effort to increase player immersion [6, 23]. Contrary to expectations, research has found that the integration of UI elements into the world does not necessarily provide a higher sense of immersion or involvement, and it is more important to ensure that information is presented clearly and effectively, regardless of whether it is presented as part of the game world [21, 6].

The design of the user interface has a large part to play in the novice experience, as the information that is presented is integral to being able to effectively interact with the game world. An interface that is poorly designed can lead to issues with players allocating their attention to the wrong elements of the game, therefore affecting performance and potentially leading a new player to become frustrated or discouraged [23]. A study by Marre et al. [23] found that presenting information diegetically in VR improved novice performance, as all of the required information was integrated into the scene and attention was kept in one place, making it easier for the player to engage with both the game world and the UI. This is an interesting finding, as it implies different requirements for UI presentation between novice and expert players [23]. Because of this, online blogger Doctor Professor [31] proposes that there should be easy and hard modes for the UI, which adjust what information is presented according to the player’s skill and experience. They reference Animal Crossing: New Horizons and its presentation of the tool selection UI, which begins with a simple interface and allows the player to opt-in to a more complicated interface later on in the game’s
This allows the UI to exist as less of a barrier to new players, while also allowing expert players to use an interface that is more suited to their game knowledge and experience [31]. Additionally, this acts as an onboarding technique by delaying complex mechanics and scaffolding information to aid novice players in learning the simple mechanics first and moving on to complex mechanics later [31].

### 2.3.1 Audio Interfaces

As previously mentioned, the user interface consists of all elements of a game that provide the player with information or assists the player with engaging with the game [21]. Audio cues have an important part to play in this, as they can provide important environmental cues that can influence how the player responds in gameplay [15]. Typically, audio interface elements are used to supplement a visual UI and may accompany visual elements to call attention to important aspects of the game, although there are some cases where audio cues are used alone and require the player to recognize and respond to them in-game (i.e. alarm systems in stealth games). While most research into video game UI is focused on visual and haptic modalities, a study by Gaina and Stephenson [15] further expanded on the use of audio cues by presenting an experiment wherein players learned to play a game using only audio cues and no visual interface. They presented a proof-of-concept for an entirely audio-focused game, which must balance the amount of feedback and opportunities for player input in order to allow players to effectively learn how the game works without overloading their capacity to process audio information [15]. While no formal results were presented, this study provides insight into the considerations that must be taken into account when designing games that focus on audio, as well as the implications for individuals with accessibility limitations such as visual impairment, who often require modifications to
the audio in traditional games in order to enable effective play [15].

2.3.2 Haptic Interfaces

Video games have evolved and changed over time in many ways, notably by incorporating haptic devices to enhance the gameplay experience and provide the player with new ways to interact with the software. Haptic devices that are utilized in games typically take two forms; force feedback devices and tactile devices. Force feedback devices use mechanical parts to simulate force, friction, and roughness, whereas tactile devices provide vibration, temperature, and pressure [28]. These can be used to give the player valuable information about the environment to help them make gameplay decisions. Additionally, haptic feedback can provide players with a higher sense of immersion by engaging multiple senses in the game. Similarly to audio cues, haptics can be used to help visually impaired individuals engage with traditional video games through substituting information that would regularly be communicated visually into the haptic channel [28]. This study involves the use of tactile devices to substitute visual information into the haptic channel in order to enhance novice gameplay, similarly to the way gameplay is augmented through haptics for visually impaired players.

Haptics are also increasingly being integrated into serious games. Serious games are those games which are utilized for more than entertainment. This can take the form of training simulations, visualization and simulation software, and educational tools, which may use game principles to enhance the learning of various information in professional and educational contexts [28]. A study by Menelas and Benaoudia [25] identified three learning outcomes for these serious games which can be influenced by haptics; engage the user with the learning content, develop technical skills, and develop cognitive skills. They argue that in order to engage the player with the game
content, tactile feedback can be used to translate emotions and evoke a response in the player. Technical skills can be developed using force feedback to guide movement, and cognitive skills can be developed using a variety of haptic techniques to help players develop skills relating to selection, location, connection, and arrangement tasks in the context of the learning outcomes. While haptics are typically utilized to enhance the depiction of real-life scenarios, the connection between the visual and haptic channel can be valuable as a way to enhance learning [25].

While haptics can be used to facilitate the learning of new tasks, they can also be used to guide and assist with the performance of dynamic tasks. A study by Forsyth and MacLean [14] tested haptic feedback along with a predictive algorithm to help guide users through a path-following tasks in a simulation, with implications for driving [14]. This could also have application in the video game space, as much of the gameplay in modern video games centres around movement and completing dynamic tasks. By using an algorithm that was able to provide guidance in real-time through force feedback in a steering wheel-like apparatus, participants were able to more accurately follow a path than when using non-haptic counterparts. Additionally, haptic guidance was well received by participants, indicating that this method may be effective when applied to leisure-based activities such as gaming.

A similar technique for providing users with haptic guidance specifically in novice gameplay can be seen in work by Seaborn [35, 34]. In this work, a wearable vibrotactile device was outfitted to be worn on both of the player’s forearms in order to transmit information about upcoming turns to novice gamers playing a round of Mario Kart on the Nintendo Wii [35]. Similarly to Forsyth and MacLean’s [14] study, novice players preferred using the haptic device when compared to a visual feedback condition or no feedback condition. However, no significant difference was found in performance
between the haptic feedback condition and no feedback condition, whereas there was a significant improvement when using the visual feedback technique [34]. This raises questions about the conditions required for haptic guidance to be effective in improving performance. Although it is unclear the reason for this discrepancy, I question whether the participants’ lack of previous experience with the task may have led to difficulty in perceiving haptic cues in addition to visual stimuli in Seaborn’s [34] study. Despite inconclusive results on the validity of haptic feedforward for novice gameplay, Seaborn presents design guidelines for the use of haptic devices to improve accessibility for novice players. These include "coupling the haptic cues to the means of control" and "gradual introduction of cues" among others [34].

2.3.3 Multimodal Interfaces

While it is possible for a video game interface to only engage the player through the visual, audio, or haptic channel exclusively, most interfaces have some element of multimodality in the way that they combine visual, haptic, and audio information to further engage the player. According to Menelas and Benaoudia, transferring information to the haptic channel can be helpful to unload the visual channel and maximize the amount of information that a player can perceive using multiple modalities. Additionally, rendering information haptically can supplement and strengthen information that is already presented to the player visually [25]. I can hypothesize that this is also true for audio cues, which could be used in similar ways. This section provides an overview of various studies into how haptic, audio, and visual interfaces can be utilized in tandem to improve the experience for players.

Research into the interplay between visual and haptic modalities has not been limited to gaming contexts. A 2005 paper by Brederson et al. [18] presented this
concept in the context of a virtual workbench, which provides an opportunity for more immersive visualization of scientific data using head/hand tracking, haptic feedback, and supplemental audio cues [18]. Discussion of the system primarily consists of development and software/hardware requirements, as well as design goals that were identified to ensure that the system was effective in use. These included calibration between tracked position of the head/hands and the rendered scientific data in order to ensure that haptic feedback mirrored real-world interaction [18]. While no experimental data was presented, it is evident that this type of development has been ongoing in industries other than gaming for at least the last 15 years.

More directly related to this research, studies by Seaborn et al. [36] and Menelas et al. [24] utilized haptic and audio interfaces to help users perform individual tasks. Seaborn et al.’s work focuses on how the coupling of visual and haptic presentation of information can impact working memory. Using a fingertip interface outfitted with haptic motors and lights for visual cues, participants were tasked with identifying patterns presented to them visually, haptically, and dual-coded visually/haptically. Results found that the visual and visual/haptic presentations were most effective compared to the haptic presentation, and coupling of visual and haptic modalities to present the same information in multiple ways improved performance. Additionally, the visual/haptic format was preferred by participants. One reason why the haptic mode did not perform well could be that participants became gradually less sensitive to haptic sensations, making it difficult to distinguish between discrete cues [36]. This phenomenon, referred to in this study as haptic adaptation [36], was important to consider in my study.

Menelas et al. [24] conducted a similar study in which audio and haptic channels were used in order to reduce the amount of visual cues for a user to pay attention to
in a virtual environment. Participants were tasked with locating a target in a virtual environment with multiple distractions using either audio, haptic, or simultaneous audio and haptic cues. Results found that haptic and haptic/audio conditions led to better performance in users when compared to the audio condition, although the haptic condition was noted to be difficult to use when identifying and recognizing patterns that provide necessary information to the user. Similarly to Seaborn et al. [36], the authors state that adopting a multimodal approach by combining audio and haptic cues has potential to aid users, as the use of audio and haptic cues together elicited a positive response from participants while also enabling them to perform well in the task [24].

On the topic of aiding task completion through the use of multimodal interfaces, a new video game called Audiopolis has been designed and studied by Sanchez et al. [37]. This game uses audio and haptic feedback to help people with visual impairments to develop wayfinding skills by practicing cognitively demanding navigation tasks in a virtual environment. This study, similar to Menelas et al.’s [24] previously mentioned work, tested haptic, audio, and a combination of the two modalities in order to understand whether these techniques are effective for teaching blind players to navigate a virtual space. Interestingly, the audio-only condition performed best among the three groups in the majority of cognitive tasks that were required of the users, although all three conditions exhibited a high degree of success overall. This could perhaps be due to the increased complexity required when using the haptic interface, although there is no data to support this conclusion [37]. This study is valuable to us as it addresses the cognitively demanding task of navigating through an unfamiliar place for individuals with visual impairments and demonstrates how audio and haptics can be used to supplement this interaction.
While significant research has taken place surrounding the use of multimodal interfaces to aid in task completion, research directly related to playing video games for entertainment remains somewhat limited in comparison. In one study, Eid et al. [12] propose Slingshot 3D: A multiplayer video game that incorporates both tactile and force feedback along with visual UI elements and verbal communication through the audio channel. Participants found that combining the three modalities was a valuable way to enhance the experience, although it was noted that the use of too many modalities at once could reduce task performance, as it may lead to distraction [12]. It is worthy to note that participants in this study were all familiar with computer games, therefore separating this research from the present study, which only intends to focus on novice gamers.
Chapter 3

Survey Study

To begin identifying the particular aspects of video game tutorials and onboarding materials that create barriers for new players, I administered an exploratory survey to individuals of varying levels of skill and experience to gauge their experience with video game tutorials that they have played through in the past. In particular, this study aimed to shed light on what can be done to aid new/novice gamers to bridge the gap of difficulty and game-related knowledge when playing a specific game for the first time. Additionally, the results of this study informed the game genre that I chose to explore when developing the prototype in the second study.

3.1 Participants

29 participants were recruited through social media posting to the Canada HCI Slack Channel and Carleton Research Participants Facebook group. In order to be eligible to participate, participants were required to have at least some recent experience playing video games. We chose not to restrict responses to novice players, as I believed there may be valuable insights from intermediate and expert players on what they perceive to
be barriers to newcomers in the video game space. The median age of the participants was 23, with the youngest being 22 and the oldest being 36. 14 participants identified as men, 16 identified as women, and two identified as gender-fluid. 16 participants indicated that they play video games upwards of five hours per week, whereas the other 13 played less than five hours per week. The majority of participants were expert or intermediate gamers, with 14 and 11 participants identifying as each, respectively. 6 participants self-identified as novice gamers who are actively learning to play games in one or more genres.

3.2 Methodology

Our survey totaled 16 questions and consisted of multiple questions that were conditionally presented to the participant depending on their self-identification of gaming skill/experience (i.e. novice, intermediate, expert). The survey consisted of both multiple choice and short answer questions regarding participants’ self-reported gaming behaviours, skill, and experience with tutorials in varying game genres. Participants were required to share their experience with tutorials according to their level of skill and knowledge of gaming conventions. Additionally, I gathered data on how game difficulty impacts participants’ choice to play specific games, as this may provide insight into how game difficulty may be connected to enjoyment for players of differing skill levels. In order to gather a wide range of perspectives on ways to improve the tutorial experience for new players, I asked those participants who self-identified as intermediate or expert players to describe any barriers that they perceive that would make it difficult for new players to engage with video games. Additionally, we asked novice players three additional questions about what influenced them to become
interested in gaming, the ways in which tutorials can help them feel comfortable engaging in a game, and what they believe to be the most significant barrier to their ability to play video games comfortably. The full survey can be viewed in Appendix A.1.

Responses were collected from November 18, 2021 to November 25, 2021 using Qualtrics XM software. Upon completion of data collection, I conducted an analysis of quantitative results using the built-in Qualtrics XM Results analysis tool to understand the results as they related to individuals of each level of gaming skill. A thematic analysis of the qualitative results was conducted using NVivo Software, wherein themes and sentiments were identified using an inductive coding approach. These codes were utilized to identify themes and sentiments regarding the gaming tutorial experience across responses by all participants. The full code book can be viewed in Appendix A.3.

3.3 Results

Of the responses received, the most popular game genre that participants were familiar with was puzzle, with 25 of 29 participants indicating that they had some experience playing a game in the genre. This was followed closely by action-adventure games, with 23 familiar participants, as well as shooters (third-person or first-person) and role-playing games (RPGs), with 22 participants indicating familiarity. The least popular genres for participants to have experienced before were real-time strategy (RTS) and turn-based strategy (TBS) games, with only 14 participants having played them before. This may be due to a higher level of perceived difficulty in these genres, which are commonly understood as being more complicated and having a steeper
learning curve than other genres such as shooters.

When asked about how game difficulty impacts the choice to play specific games, 22 participants indicated that they prefer a balance of difficulty. These participants play games with the goal of overcoming challenges, but not at the expense of enjoyment. 6 participants prefer games that do not provide too much of a challenge and would rather focus on the story, and 2 participants prefer to play the most difficult games which challenge them to perform at the best of their ability. Of the 6 individuals who identified as novice gamers, half indicated their preference for non-challenging games, and the other half stated that they prefer balanced difficulty. Comparatively, of those participants who self-identify as intermediate or expert gamers, the majority indicated that they prefer balanced difficulty, with only two individuals each preferring very difficult or non-difficult games. This data indicates that although there are some individuals who prefer to experience games on either end of the spectrum of difficulty, the majority prefer an experience somewhere in the middle, which challenges them effectively according to their skill level. As each player’s individual skill level is different, there is a clear need for effective tutorials to help bridge the gap of difficulty and ensure that all players are able to have a balanced experience resulting in enjoyment.

When asked about how likely participants were to play through an optional tutorial, regardless of whether they are familiar with the game/genre in question, 38% of participants indicated that they were somewhat likely, while 28% were somewhat unlikely. 17% of participants indicated that they were very likely, and another 17% were very unlikely. Of the six novice participants, only three indicated that they were at least somewhat likely to play through an optional tutorial. This is surprising, as we have come to expect individuals with little or no experience playing a game in a
certain genre to seek out tutorials and onboarding materials as a way to become more familiar with the mechanics of the game and be able to learn and play more effectively. While the sample size is too small to be able to develop any concrete conclusions about whether this is truly the case, we may hypothesize that a lack of effective tutorials that cater to novice players as well as those with more extensive gaming experience may lead new players to resort to simply learning through experimentation in the context of the game. In this case, those tutorials which assume that players have more contextual game-related knowledge than they actually have could be serving as a barrier to entry for players, who may get discouraged by their experience playing through a tutorial that is not necessarily designed with their needs in mind.

On the topic of barriers to entry for new players, I asked those participants who identified as intermediate or expert gamers whether they perceive any barriers that may make it difficult for new players to engage with video games. Of the 22 respondents, 15 stated that they did perceive some barriers, five stated that they did not, and two were unsure. Those participants who stated that they do recognize barriers to entry in the video game world were asked to expand on them in a short answer question shortly after. The barriers that they have listed and explained are presented in the thematic analysis section below.

3.3.1 Thematic Analysis

As part of the survey, participants were required to share their thoughts and opinions on those features and design choices which make for a positive tutorial experience, as well as those which make for a negative experience. A primary theme that was derived from these questions is the value of utilizing a hands-on approach to tutorial instruction, requiring the player to demonstrate understanding by utilizing a skill in
order to bypass obstacles. Participants indicated their preference for these tutorials which are built into the gameplay rather than separated into a defined tutorial section. One participant stated that "having the tutorial as part of the first level/scene and demonstrating a rule/mechanic in a real in-game scenario is good". Additionally, multiple participants stated a preference for these hands-on tutorials to be connected to the plot, as this provides a more engaging experience that motivates the player to learn the mechanics. The vast majority of participants indicated their preference for optional tutorials, as well as the ability to skip certain sections of a tutorial if a mechanic is already familiar. Participants who identified as expert or intermediate gamers indicated a preference for basic mechanics being taught through optional tutorials, but higher level mechanics and strategy being left to the player to explore and experiment with. One participant referred to this concept in their discussion of the 2011 fantasy RPG "Skyrim", stating that "ancillary mechanics (enchancing, alchemy, buy/sell, etc.) are more up to players to learn/explore on their own, which I like. I prefer simpler tutorials for games/genres I already know well".

In terms of those mechanics which created a negative experience for players, among the most prominent were excessive length and over-reliance on text and audio-based explanations. Participants found that tutorials which were too long could be boring and frustrating to complete, especially for those individuals with previous experience playing games in the genre. Additionally, using solely text-based descriptions of mechanics did not seem to provide a positive experience for most users, as one participant stated that "having to read a lot of text, which I probably won’t remember anyway by the time I get to playing" contributes to a negative experience. Interestingly, the only mentions of audio-based cues were with a negative connotation, perhaps indicating that audio cues and instructions in games may be better utilized as a
supplementary tutorial technique rather than a primary mode of information delivery. Additionally, participants indicated their dislike of tutorials which provide too much information, instead preferring those which introduce mechanics gradually and provide the opportunity for the player to practice and demonstrate their understanding. While gradual onboarding is clearly an effective technique for teaching new players, this also increases the risk of leaving more experienced players feeling frustrated with the slow pace of introduction of mechanics that they may already know. As stated by one participant; "There is a right balance, but sometimes the developers either think their audience is stupid and over explains, or way more advanced and makes the tutorials useless because [they are] so complicated". From the data provided, I can hypothesize that providing the option for players to skip certain parts of the tutorial or the tutorial entirely if they are already familiar with certain mechanics will help alleviate frustration while ensuring that new players are taken care of.

All participants regardless of gaming skill and experience were asked to provide insight into their perceived barriers that may exist for novice gamers. Among the barriers mentioned, one of the most prominent was game complexity. Participants noted that the perceived complexity of a game, particularly in genres with multiple high-level mechanics and strategies that are necessary to grasp, may be intimidating for new players. In this case, game complexity may be related to the perceived difficulty of a game, even if the basic mechanics are fairly simple to grasp. One participant stated that complexity is a very important aspect of the games that they choose to play, saying that "if I can’t play a game out of the gate, the game is too complicated and I can’t be bothered". Game complexity can vary greatly across genres, and an effective tutorial can be invaluable to ensure that these high level mechanics are effectively communicated to the player to prevent them from acting as barriers to
entry. Despite the overwhelming support for optional tutorials, one participant argued that mandatory tutorials may be required for those games with very complicated mechanics, arguing that "people skipping tutorials may mean they drop out later due to a poor user experience [due to a lack of understanding of high-level mechanics]."

Many of the barriers identified by participants were related to control schemes and controller familiarity. Because games rely on button presses as the primary interaction mode, understanding of the control schemes of different controllers and keyboard/mouse set-ups is essential in order to be able to effectively interact with the material. Becoming familiar with a controller is only one piece of the puzzle however, as each individual game within a genre may vary when it comes to specific button mappings. One participant stated that "most games have different button mappings, and I tend to always mis-click and do the wrong action". This can be a difficult barrier for new players to overcome, as it means that experience with another game in the same genre does not necessarily equate to the ability to grasp the controls of a game to play it effectively upon beginning. Additionally, the ability to remember which buttons correspond to which action after prolonged time away from the game may cause frustration for new players. One participant explained this by saying that "I found remembering what buttons to do what really confusing as an extremely infrequent gamer". Because of this, another participant argued the positive impact of tutorials that can be revisited later on in the gaming experience, explaining that "if I leave the game for a week I will need to get a refresher from the optional tutorial/practice mode". Those games which provide access to the tutorial at any time can mitigate this barrier by providing players with space to practice and familiarize themselves with the controls at any time.

Many video game tutorials are designed with the assumption that the player has
at least some basic knowledge of gaming, such as how to use a controller to move/look around in a 3D space. This assumed knowledge can prove to be detrimental for new players who may not be aware of popular gaming conventions such as using the W,A,S, and D keys to move using a keyboard. Additionally, required hand-eye coordination to interact with the controller was mentioned by multiple participants as a barrier for new players, with one participant describing a situation where it may be difficult "for people who want time to think or look at the controller for the right button, but they are too slow [and] then it is too late". Another participant argued that "games make certain assumptions of hand-eye coordination and knowledge of basic mechanics". Additionally, these games often assume some level of physical ability, and therefore do not provide adequate accessibility options for those with disabilities, particularly related to hearing and vision, that impact their ability to engage with interactive media. This assumed knowledge does not always only apply to basic game mechanics, however. In one participant’s description of the tutorial for the Massively-Multiplayer Online RPG (MMORPG) Final Fantasy XIV (FFXIV), they stated that "it was a good way of teaching the player the basic buttons and tasks, but without having prior knowledge of MMORPGs, it would be quite difficult for newer players to understand the [higher level mechanics]". In this case, it is assumed that players who pick up FFXIV already have experience playing similar games and therefore do not need to be instructed on how to engage with high level mechanics and strategies that are present in these more complex multiplayer games.

The last prominent theme that was detailed by participants throughout the survey is the stigma surrounding being a new or unskilled gamer. With multiplayer games becoming incredibly popular as a way to connect with others, the social impact of one’s video game skills and abilities is heightened. As argued by Jagoda [19], discourse
surrounding game difficulty can create a social dynamic that emphasizes prestige and excludes those who do not possess the skills deemed necessary to be part of the community. On this topic, one participant shared that "I think generally people can be over-protective of games when it comes to new players". This protectiveness may manifest as toxicity in a gaming community, which could intimidate new players and deter them from learning to play a game for fear of being ridiculed or made fun of. In particular, multiplayer games may exacerbate this issue by pairing highly skilled players with novice players in competitive atmospheres, further contributing to feelings of intimidation and embarrassment in novices. One participant stated that "competing with experts and players with more experience often discourages me from playing and makes it less enjoyable". In order to limit these instances and lessen the barrier to entry for new players, multiplayer games can utilize skill-based matchmaking to pair novice players with other novice players and encourage a positive learning experience with less chance of discouragement due to ridicule when mistakes are inevitably made.

### 3.4 Discussion

This survey study aimed to provide an overview of the experience of players with various levels of gaming skill and experience in relation to tutorials and onboarding in games. This study explored the positive and negative experiences that players have had when learning to play new games, as well as the barriers that exist for new players to learn the necessary skills to effectively play video games and engage with the greater video game community. The questionnaire results provided insight into how skill and experience impact player tendencies related to tutorials, as well as their general beliefs about what can be done to make the best tutorial possible. These insights include
the notion that novice players were more likely to choose easier games than other participant groups, although they were similarly as likely to skip an optional tutorial as those with more gaming experience. Additionally, insights related to tutorial design uncovered techniques such as building hands-on tutorials into the context of the game as positive design choices that create a more effective learning experience for players. From this data, I identified multiple themes in the participant responses that provide guidance for the development of a novel system for augmenting tutorials for novice players.

One of the most notable findings in relation to this research is the overwhelming preference for hands-on tutorials. Overall, participants indicated their belief that those tutorials which require the user to demonstrate understanding of skills in order to bypass obstacles are more effective in teaching players to not only remember the controls, but also use them in context to solve a problem. This is seen as a more effective technique than explaining through text and audio responses, as it can be difficult for players to translate this information into action effectively. Additionally, not requiring players to demonstrate their understanding of a concept before moving on to the next may lead players to feel overwhelmed with the amount of interaction options. By designing hands-on tutorials and limiting text-based onboarding, we can ensure that information is effectively communicated in a way that allows players to practice and experiment with various gaming mechanics. Another valuable finding is the prominence of control schemes and controller familiarity as barriers to entry for new players. As the primary way for players to interact with the game, the effectiveness of the communication of controller schemes and button inputs is extremely important. This barrier is becoming increasingly difficult to overcome due to the various controller and keyboard layouts prominently used in the game industry, which must each be
learned and comprehended fully in order to play the corresponding game effectively. Additionally, one participant even stated that games within the same series may not share the same control scheme, which adds further confusion and difficulty. By constructing tutorials that focus primarily on ingraining controls into the player’s memory, we can lessen this barrier and ensure that new players are not intimidated by control schemes that they are not already familiar with. It is worth noting however that this may not entirely reduce the barrier of interaction via keyboard and mouse or controller configurations, as much of the difficulty that players may have with learning new controls is the speed and efficiency with which they need to respond to stimuli in the game. Once a player has understood which button triggers which action, they still must spend time understanding how these actions relate to each other, and how to use them in combination to effectively play the game. Aiding players with learning unfamiliar control schemes may reduce some friction, but there are likely still significant barriers related to effective use of the controller or keyboard and mouse that are experienced by novice players.

Another finding was impact of the social stigma surrounding being a new or unskilled player. It is evident from the responses that this is a prominent aspect of the new player experience, especially in multiplayer gaming communities. Many players mentioned some aspect of feeling embarrassed or intimidated when playing multiplayer games due to the likelihood of interaction with players who have a high level of skill and experience, who may prefer to play with someone at a similar level. By forcing new players to engage with players at a much higher skill level, the possibility for toxic interactions may be heightened due to each party expecting to play with someone more closely matched to their own level. These toxic interactions can provide a negative experience for new players, which may further discourage them
from engaging in the video game community as a whole. Above all else, these issues are related to the assumption that the video game industry and community makes about each player’s previous knowledge and experience with gaming mechanics and social rules. I can hypothesize that as the video game industry has matured, there has been an expectation that players have also matured in their skills and understanding of common video game mechanics, which influences the design of tutorials. While this is often true, as individuals who have played games for years and have honed their skills require less involved tutorials, novice players may be getting left behind by the video game industry’s assumption that all players have at least some level of experience. Based on this finding, I recommend the implementation of optional tutorials that cover basic mechanics, as well as an option to tailor the tutorial’s length and depth according to the player’s needs. By providing opportunity for tutorials to be customized according to the player’s self-reported skill/experience level, rather than assumed, video game developers may be able to bridge the gap of difficulty between players of different skills by providing them with necessary direction without overwhelming new players and frustrating experienced players.

These findings have influenced the development of a multimodal FPS tutorial that incorporates haptic feedback to address issues surrounding the learnability of control schemes for new players, as well as to address the need for hands-on tutorials. I hypothesize that by assuming minimal previous knowledge in players, this tutorial will be effective in teaching novice players important basic mechanics such as camera controls, movement, and actions such as jumping and shooting a gun. Additionally, the multimodal nature of information delivery through both visual and haptic cues may address apathy associated with overuse of text-based instructions as mentioned by multiple participants. For further information about the design and development
of this system, see Chapter 4.
Chapter 4

User Study

In order to address the barriers to entry into video games identified in the previous survey study, I developed a multimodal first-person shooter tutorial that incorporates the use of a custom-built set of prototype haptic gloves that provide the player with vibrational cues to guide them in learning unfamiliar control schemes. The design and implementation of this system in a pilot user study is described below.

4.1 System Design

The goal of this study was to develop a wearable vibrotactile interface to be used when playing a first-person shooter video game to explore the viability and the user experience of employing haptic guidance as a technique for helping novice players learn to play video games with unfamiliar control schemes. The system developed for this pilot study consists of three major components: the set of haptic glove prototypes, the first-person shooter game and hardware including display, mouse, and keyboard, and the control system, which was utilized by the researcher in a Wizard of Oz-style user study. The system was designed in order to test the effectiveness of two tutorial
modalities, visual and haptic/visual, on novice player performance and user experience. The decision to develop this system came through extensive research presented in Section 2, as well as through analysis of the data gathered as part of the survey study outlined in Section 3. Additionally, the decision to develop this system with a keyboard and mouse configuration as opposed to a controller configuration came from the player’s precise use of multiple fingers when interacting with a game with keyboard and mouse controls rather than with only the thumbs and index fingers when using a controller. This allowed for haptic leads to be used more precisely to guide player action. Based on the results of the previous study, I hypothesized that the use of vibrational cues to guide players through learning to use various keys and mouse clicks as required throughout the game would provide a positive user experience for novice players due to the use of both the haptic and visual channel in tandem. Due to the haptic interface’s ability to offload the visual channel, I predicted that participants would exhibit less tension and commit less effort when playing the game with the haptic gloves as opposed to without. Additionally, I expected participants who used the haptic gloves to perform better when playing through the tutorial when compared to those who only received information visually. The full list of hypotheses can be found below:

- **H1:** The experimental group will exhibit a higher task completion rate than the control group.

- **H2:** The experimental group will score higher in interest/enjoyment and competence metrics than the control group.

- **H3:** The experimental group will score lower in pressure/tension and effort/importance metrics compared to the control group.
• **H4**: The experimental group will rate the difficulty of their experiences lower than the control group.

### 4.1.1 Haptic Gloves

![Image of haptic glove interface](image)

**Figure 4.1**: The prototype haptic glove interface.

#### 4.1.1.1 Hardware

The prototype of the wearable haptic interface was developed using an Arduino Nano microcontroller connected to a breadboard. Six coin-type vibration motors were fastened to the knuckles of two fingerless cotton gloves and connected to the breadboard via jumper wires. Additional components included two 8 NPN Darlington 50V 500mA transistors and two 56 ohm resistors. Each vibrational motor had a
diameter of 10mm and carried a voltage of 2V-5V. The motors were fastened to the left ring (LR), left middle (LM), left index (LI), left thumb (LT), right index (RI), and right middle (RM) fingers, as these are the fingers that are used to play the game using a keyboard and mouse (See Figure 4.1). The prototype was powered via a USB connection to the researcher’s laptop computer, from which commands were sent to the system during the study sessions. When the researcher issued a command to the system to trigger a specific finger’s motor, that motor would vibrate for 350 milliseconds in order to signal to the participant that they were to use that finger to follow the commands on the screen.

4.1.1.2 Software

The software component of the haptic glove interface was developed using Arduino IDE. The control system was developed using Processing to allow the researcher to use their own keyboard to send haptic cues to the participant in real time. For more detailed information on the development of the control system, please see Section 4.1.3.

4.1.1.3 Inspiration

The development of the haptic glove prototype was inspired by David Schneider’s DIY Muscle Memory Programmer, as featured in the September 2014 edition of IEEE Spectrum [32, 17]. This project used a similar technique of haptic motor vibration on the knuckle of each finger to teach users to type correctly and therefore increase typing speed and efficiency. The Arduino IDE code and schematic diagram provided in the public GitHub repository for this project [33] were used to generate a baseline prototype which was then modified to suit the needs of this project. Specific design
choices such as the placement of the haptic motors on each finger and the choice to use fingerless gloves were influenced by Schneider’s work.

4.1.2 Video Game

For the purpose of the study measuring the effectiveness of a haptic interface as a tool to supplement a standard video game tutorial, a custom-built first-person shooter game was developed in order to meet the specific needs of this study. The details of this game are outlined below. I chose to develop a first-person shooter game as the genre is among the most popular in the gaming industry, as evidenced by the results of the survey study presented in Section 3.3. Additionally, the vast amount of resources available to support the development of FPS games in Unity impacted my choice to design this pilot study around a first-person shooter, as I have had no previous experience with video game development and was able to utilize pre-designed resources to assist with developing a functional game.

4.1.2.1 Hardware

The game was played using a desktop PC running Windows 10 with an i5-6500 3.2 GHz CPU, GeForce GTX 970 and 8GB RAM, and was displayed on a 24” widescreen 1080p monitor in the Human-Computer Interaction building at Carleton University. Participants interacted with the game using a wired Verbatim keyboard and wired Microsoft Vanilla 2 button mouse with a scroll wheel. Supplemental audio feedback of gunfire and movement in-game was presented to the player using the monitor’s built-in speaker system.
4.1.2.2 Software

The development of the game was completed in Unity version 2020.3.22f1. Due to a lack of previous experience in game development, I utilized the assets and code provided in Unity’s ”FPS Microgame” template, available via Unity Learn [2].

This package provided ready-made assets pre-coded to include movement, physics, and shooting mechanics. Using these building blocks, I developed a custom level meant to gradually teach players the basics of first-person shooters including movement, jumping, aiming/shooting, crouching, and switching weapons. The layout of the level can be seen in Figure 4.2. The level included various obstacles for the player to navigate through including stairs, ramps, and barriers. 15 common enemies were placed in the level with varying levels of activity to provide the player with a gradual learning experience (i.e. the first enemy the player encounters is docile and will not fight back, whereas later enemies will move toward the player and continuously shoot until they are eliminated). The final enemy in the game is categorized as a mini-boss, which carries a higher amount of health and more dangerous projectiles that have the capability of damaging the player more than common enemies. The game was exported as an executable file and played through a desktop application, rather than through a web browser.

4.1.3 Control System

The control system was developed using a combination of Arduino IDE, the open-source software used to upload simple code to the Arduino Nano microcontroller, and Processing, an open-source programming language that allows for simple graphical user interfaces (GUI) and integration with Arduino in real-time. Code samples for
Figure 4.2: Overview of the custom FPS level design.

each program can be found in Figures 4.3 and 4.4. The control system ran on the researcher’s Dell XPS 15 9570 laptop PC through a USB connection to the Arduino Nano. In order to operate the system, the researcher was required to press the key or keys associated with the command being presented to the participant. For example, in order to send the haptic cue associated with the instruction to crouch using the ’C’ key, the researcher would also press the ’C’ key which is programmed to trigger the left index (LI) vibration motor. This design choice allowed for the researcher to operate the system easily without having to focus on their own screen or keyboard, therefore allowing for full attention to be paid to the participant’s screen. The researcher could use this system to follow along with the participant’s progress throughout the level by providing the associated haptic cue when the participant reached each section of the tutorial, so that the participant would experience a visual description of how to complete a task and a haptic cue at the same time.

Additionally, both the researcher and participant’s computers were running a
Figure 4.3: Sample of Arduino IDE code used to program each haptic motor.

keylogger program developed using Javascript. This program ran in the background and tracked each key pressed along with the time stamp. For more information on the use of this software, see Section 4.1.4.4

Figure 4.4: Sample of Processing code to allow the researcher to send commands to the Arduino Nano using their keyboard.

4.1.4 Methodology

The study employed a between-subjects design meant to test the efficacy of a supplemental haptic interface to aid novice gameplay in a first-person shooter on PC using keyboard and mouse. Participants were assigned to either the experimental or
control group and were instructed to complete the same task either with or without the addition of the haptic gloves prototype.

4.1.4.1 Study Design

I chose to utilize a between-subjects design to ensure that participants could not learn to play the game and improve from session to session. A between-subjects design was particularly important due to the nature of the participant demographics, as it was required that each participant had very minimal previous experience with first-person shooter video games. Because of the nature of the study, there was a possibility that a participant could develop a strong understanding of how to play the game effectively after just one session, which could impact their data in subsequent sessions.

This study utilized a Wizard of Oz technique to test the efficacy of the prototype haptic device. The Wizard of Oz approach consists of a human operator who controls the system while the participant is interacting with it. It is especially important to ensure that the participant does not know that the system is being operated by another person, as this may cause them to interact differently. Similarly to Seaborn’s "Gauntlet Guide" [34], the prototype haptic glove that I developed did not interface automatically with the PC video game at the time of studying, therefore making the Wizard of Oz approach ideal to test the system while remaining in scope. Due to my experience developing the system and restrictions related to COVID-19 that prevented more individuals from being present for the in-person study sessions, I operated the system and acted as the Wizard during all study sessions. At all times throughout the study, I was seated in a chair approximately 6’ behind the participant using a laptop computer. By using a 10’ long USB cord to connect the laptop computer to the Arduino microcontroller, I was able to hide the connection and ensure that the
participants did not suspect that I was controlling the system.

4.1.4.2 Participants

Thirteen participants were recruited to take part in the study through social media posting to the Carleton University Research Participants Facebook group, the Carleton University discord page, and the r/CarletonU reddit community, as well as through posters in various places throughout campus. Upon data analysis, three participants had to be excluded from the data set due to inconsistencies in data logging. Of the ten remaining participants, eight identified as women, one identified as a man, and one identified as something else. The age of the participants ranged from 18-53. In order to be eligible to participate, participants had to be 18 years or older, speak and read the English language fluently, and have no limitations or disability related to motor function. Participants were also required to have minimal experience playing first-person shooters. Consent was obtained via a signed consent form that was distributed to the participants by email prior to the study session. The consent form provided an overview of what the participant could expect when coming to the study session, how their data would be treated and stored, and any inherent risks related to COVID-19 exposure. Risk mitigation strategies were outlined to ensure that participants were comfortable and could make an educated decision about their participation. Each participant was compensated with a $10 Amazon Gift Card after completing the study. This study was approved by the Carleton University Research Ethics Board.

Although this study considers the experience of novice video game players as a whole, I chose not to restrict this study to people with minimal experience playing any genre of video game before. This decision was made to ensure an adequate participant count and to identify any differences in player performance and experience of those
individuals with experience in other genres such as strategy and puzzle games. As a result, eight of ten participants indicated that they were beginners playing video games as a whole, or that they had never played a video game before. One participant indicated that they were an intermediate video game player, and one participant indicated that they were an expert video game player, although this participant stated that their experience was primarily in real-time strategy and city-builder games. All ten participants indicated that they were either a beginner first-person shooter player, or that they had never played a first-person shooter before.

4.1.4.3 Tasks

In playing through the tutorial of the game, participants were required to complete seven tasks. These tasks were determined based on the various mechanics that are taught to the player throughout the tutorial. In the experimental group, each of the first six tasks were coupled with a haptic vibrational cue to the finger required to complete the task. A visualization of each task and the associated vibrational cue can be viewed in Figures 4.5 and 4.6. The seven tasks are outlined below.

1. Use the mouse and ‘W’, ‘A’, ‘S’, and ‘D’ keys to move to the illuminated area.

2. Use the ‘SPACE’ key to jump and reach higher areas.

3. Use the left mouse button to shoot an enemy.

4. Use the right mouse button to aim down sights at an enemy.

5. Use the ‘C’ key to crouch behind obstacles and protect yourself from enemy fire.

6. Use the ‘Q’ key to switch weapons to the newly acquired shotgun.

7. Successfully complete the level.
Figure 4.5: Visual representations for each of the first six tasks to be completed by the participant.

4.1.4.4 Data Collection

When choosing the data collection methods that I would employ for this project, I aimed to address not only the performance effectiveness of the haptic glove prototype, but also the impact of the prototype on enjoyment of the game as a whole. Performance data was gathered through various methods. I chose primarily to utilize validated scales akin to Seaborn’s work [34] to measure enjoyment, pressure/tension, perceived
competence, effort, and ease of use, as the two studies shared similarities in goals and study design. Additionally, I developed my own questions to measure the difficulty of various mechanics throughout the game. A further expansion of each measure is presented below.
4.1.4.5 Performance

Performance data was measured using task completion rate, which was determined using the comparison of .log files generated from both the researcher’s and participant’s computers. A task was deemed to be completed if the first key that the participant pressed after being prompted by the haptic or visual interface was correct. A task was deemed incomplete if the first key that the participant pressed after being prompted to try out a new mechanic was not correct. The final task, “successfully complete the game”, was determined complete if the participant was able to defeat all enemies including the final boss without taking enough damage to lose the game. The task was deemed incomplete if the player lost all their health at any point throughout the level. In the event that a participant lost the game prior to being prompted to complete a specific task, the task was not deemed incomplete and was instead removed from the participant record.

All performance data was collected in real-time and was later analyzed via .log files and video recordings by the researcher to determine task completion and note any findings deemed worthy of further discussion and exploration beyond the quantitative data. For more information on how these findings were noted, see Section 4.1.4.12.

4.1.4.6 Enjoyment

I collected data on participants’ enjoyment of the gameplay experience through the post-test questionnaire. I used 7 likert-scale questions from the Intrinsic Motivation Inventory (IMI) [3], a validated scale previously utilized by Seaborn [34] in a similar study to this one. The enjoyment questions were taken from the Interest/Enjoyment set in the IMI, with small modifications to the wording to better represent the study.
4.1.4.7 Pressure/Tension

To measure the participant’s feeling of pressure and tension, I used 5 questions from the IMI [3] similarly to the enjoyment data in the post-test questionnaire. The pressure/tension questions presented in the IMI are believed to be a negative predictor of intrinsic motivation [3], therefore making pressure and tension a valuable measure to consider in the context of this study, as there may be a possibility of increased or decreased tension due to the addition of a haptic interface. Similarly to the enjoyment section, wording was slightly altered to align with the study goals.

4.1.4.8 Perceived Effort and Competence

To measure the participant’s perceived competence, I used 5 of the 6 questions provided in the IMI [3] in the post-test questionnaire. I chose to omit the question associated with the statement ”I think I did pretty well at this activity, compared to other students”, as it did not align with the study design and may have induced some confusion due to the participant’s understanding of their involvement as a solo interaction between only the participant, the researcher, and the system. Additionally, I used the 5 IMI [3] questions associated with effort and importance to determine whether the use of the haptic interface had any effect on how much effort participants felt they needed to use to complete the tasks required. As above, questions were slightly modified as needed to suit the activity.

4.1.4.9 Ease of Use

In order to understand the effectiveness of the haptic interface, I utilized 8 likert-scale questions that were previously used by Seaborn [34] in the post-test questionnaire. These questions were originally adapted from Davis’ Perceived Ease of Use question-
naire [11] and were adapted by Seaborn [34] to allow participants to self-report their experience with using the technology through the lens of usefulness and ease of use. Similar to Seaborn, I also provided participants with an open-ended question following this section to allow for them to further expand on their thoughts with regards to the haptic interface. These questions were only presented to the experimental group.

4.1.4.10 Difficulty

Perceived difficulty of each mechanic as well as the game as a whole was collected using the post-test questionnaire. The questions were presented in the format of "How difficult did you find jumping?" with each question referring to one of the mechanics that were taught throughout the level. Answers to the question were part of a 4 point likert scale with the option to choose "Very difficult", "Somewhat difficult", "Somewhat easy", and "Very easy".

4.1.4.11 Qualitative Feedback

Participants were provided with five open ended questions as part of the post-test questionnaire, in addition to the one open ended question that was provided to the experimental group with regards to ease of use (See Section 4.1.4.9). These questions were chosen to allow the participants to vocalize any distinct positive or negative experiences that they had playing through the game. This data was reviewed by the researcher in order to pull out common sentiments and develop a further understanding of the novice gameplay experience. The open ended questions that were used in the post-test questionnaire are presented below.

1. What did you enjoy most about playing this game?
2. What did you dislike the most about playing the game?

3. How effective did you think the tutorial was in teaching you to play the game?
   Please be as specific as possible.

4. If you could change one thing about the tutorial to make it more effective for you, what would it be?

5. Do you have any other comments?

4.1.4.12 Observational Data

In addition to the data provided by the participant through performance metrics and the post-test questionnaire, the researcher also recorded their own observations based on any interesting behaviour that participants exhibited throughout the study sessions. This observational data was noted either immediately after the session or later in the analysis period when video recordings were being analyzed. This data was recorded for the corresponding participant and may be used in tandem with the quantitative and qualitative results to generate an understanding of player behaviour as it relates to the study of the effectiveness of the haptic glove prototype.

4.1.5 Procedure

Each study session took place in a Human-Computer Interaction lab at Carleton University. The room contained various desktop PCs equipped with keyboards and mice, as well as various adjustable desk chairs on wheels to allow free movement. Prior to each study session, participants were required to confirm their COVID-19 vaccination and symptom status using the Carleton University cuScreen tool and the Ontario COVID-19 Screening tool. Participants then confirmed their eligibility and
signed the consent form to ensure that they were aware of the risks and potential benefits associated with participating in the study.

Figure 4.7: Example study setup and participant interaction.

The study setup involved a desktop PC, keyboard and mouse with a scroll wheel, as well as a desk chair that could be adjusted according to the participant’s height to ensure comfort. For the experimental group, the haptic glove prototype was placed on the desk with the Arduino board placed to the left of the user to allow for the researcher to connect via USB and maintain a safe distance. The study setup can be viewed in Figure 4.7. After confirming eligibility and ensuring that the participant was fully aware of what the study entailed, the researcher explained whether the participant would be part of the control group or the experimental group. For participants in the experimental group, the researcher provided verbal instructions for putting on the gloves and conducted a short test to ensure that all motors were working. At this point, participants were instructed to begin recording their screen using the Xbox Game Bar software already installed on the PC, and begin playing the game. Participants were instructed to play the game at their own pace and take as much as time as needed to
master each mechanic presented to them.

As the participants played through the game, the researcher observed from a distance and controlled the system through a personal laptop computer, under the guise of taking notes. For the experimental group, the researcher controlled the system by providing haptic cues to each corresponding figure according to the instructions provided to the participant on screen, as seen in Figures 4.5 and 4.6. Once each visual prompt was given to the participant during the session, the researcher responded immediately by providing a haptic cue associated with the visual prompt. Each haptic cue was provided only once in tandem with the UI pop-up explaining how to complete a task. While the control group did not utilize the haptic glove prototype, the researcher completed the same task of pressing keys that correspond to the instructions provided to the participant to complete each task (i.e. the researcher still pressed the 'C' key on their personal computer when the participant was tasked to do so in order to crouch and avoid enemy fire). This was done to ensure that the keylogger software that is described in Section 4.1.4.4 was able to gather accurate data about the participant’s actions associated with each task that they are presented with, regardless of whether they received haptic cues.

Once each participant either completed the game or lost due to taking too much damage, they were instructed to end the screen recording and complete an online survey about their experience playing through the game using the online platform Qualtrics XM. Once the survey was completed, the session was deemed complete and the researcher extracted the video recordings and .log file generated by the keylogger from the participant computer onto a USB drive. The participant’s .log file was then combined with the researcher’s .log file using a simple Java program to create a chronological log of all key presses on both computers during the course of the
session. This allowed the researcher to see what keys the participant pressed after being prompted by either the visual channel or the visual-haptic channel to press a certain key to complete a specific task, along with the time it took to press the key after being prompted. This data was used to determine task completion and generate insights into unusual participant behaviour.

4.2 Results

In this section, I present the quantitative and qualitative results and offer high-level insights into their meaning in the context of the evaluation of the haptic glove prototype. A deeper discussion of my interpretation of these results is presented in Section 4.3.

4.2.1 Performance

Table 4.1: Individual task completion data for both the control and experimental group. "N/A" denotes an instance where the participant lost the game prior to reaching the task.

<table>
<thead>
<tr>
<th>Control</th>
<th>Task1</th>
<th>Task2</th>
<th>Task3</th>
<th>Task4</th>
<th>Task5</th>
<th>Task6</th>
<th>Task7</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>P5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>P12</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Success Rate 80% 100% 100% 60% 80% 66% 40%

<table>
<thead>
<tr>
<th>Experimental</th>
<th>Task1</th>
<th>Task2</th>
<th>Task3</th>
<th>Task4</th>
<th>Task5</th>
<th>Task6</th>
<th>Task7</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>P7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P13</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Success Rate 100% 100% 100% 40% 60% 80% 100%
Individual task completion data is presented for both the control and experimental groups in Table 4.1. The experimental group performed better than the control group on three tasks (movement and navigation, switch weapons, complete game), while the control group performed better on two tasks (aim down sights, crouch). Tasks 2 and 3, jumping and shooting respectively, were completed by every participant. Additionally, two participants in the control group were unable to complete task 6 (switch weapons), as they lost the game before reaching that point in the level. Due to a low participant count, statistical analyses of these results was not possible and therefore it is difficult to understand whether the haptic glove prototype had a significant impact on participant performance. Due to this, the hypothesis H1 cannot be accepted. However, the fact that all 5 participants were able to complete the game using the haptic gloves compared to only 2/5 participants who were not using the gloves may indicate some level of benefit from using the haptic interface.

4.2.2 Enjoyment

When asked to rate their enjoyment and interest in the game using the Intrinsic Motivation Inventory (IMI) [3] sub scale, both groups indicated a mean score above 5, indicating that they had been interested in the game and enjoyed playing it to some extent. Both groups reported very similar scores and due to the low participant count, statistical significance cannot be determined. The scores for all four IMI subscales can be found in Figure 4.8.

4.2.3 Pressure/Tension

When asked to indicate their perceived feelings of pressure and tension while playing the game, the control group produced a mean score of 4.04, while the experimental
4.2.4 Perceived Competence

When asked about their perceived level of competence when playing the game, the control group produced a score below the median (3.52), while the experimental group produced a much higher score of 5.24. This may indicate that the addition of the haptic glove interface could have contributed to helping players to feel more competent in their own abilities due to the subtle cues that were provided to them seamlessly during gameplay. As before, more research is required to determine if this
finding is applicable to a larger participant group. Although the experimental group posted higher scores in both perceived competence and interest/enjoyment, H2 must be rejected due to lack of statistical significance.

4.2.5 Effort/Importance

When asked about the effort that they put in when playing the game, as well as how important they felt it was to do well when playing the game, the control group scored slightly higher with a mean of 5.68, compared to the experimental group’s score of 5.00. It is worth noting that both these scores are indicative of a fairly high level of effort. Given the relative closeness of the scores, it is difficult to predict whether the haptic glove interface had an effect on the amount of effort that players put in to the game. Although the experimental group scored lower on pressure/tension and effort/importance metrics as predicted in H3, the hypothesis cannot be accepted due to the inability to test for statistical significance.

4.2.6 Difficulty

In the post-test questionnaire, participants were required to rate their perceived difficulty of each of the mechanics that were taught to them throughout the tutorial, as well as the overall difficulty of the game, on a scale of 1-4. Overall, both the control and experimental group found the game to be somewhere between "Somewhat Easy" and "Somewhat Difficult", with a mean score of 2.4 for both groups. Overall, participants found navigation, jumping, aiming and shooting to be fairly easy with minimal differences between either group. Crouching was found to be slightly more difficult for the control group as compared to the experimental group, who rated it 2.0 as opposed to the control group’s rating of 2.4. Switching weapons, the final
mechanic that is taught to the player before they must complete the level without any
guidance, was found to be the most difficult mechanic for both the control group and
experimental group. The control group seemed to have a more difficult time than the
experimental group, rating the difficulty to be 3.25 as compared to 2.4. The reason
for this disparity is currently unknown and requires further research to understand
whether this was impacted by the haptic gloves. Due to the variability of these results,
H4 must be rejected. For more information about the perceived difficulty of the
various mechanics in the game, please refer to Figure 4.9.

### 4.2.7 Ease of Use of the Haptic Glove Prototype

In order to assess the experience of the experimental group as related to their use
of the haptic glove prototype device, I asked participants to indicate how strongly
Table 4.2: Individual and mean self-reported scores for each item in the Perceived Ease of Use scale [11]. (1 - Disagree, 3 - Neutral, 5 - Agree).

<table>
<thead>
<tr>
<th>Davis Scale Item</th>
<th>P2</th>
<th>P7</th>
<th>P8</th>
<th>P10</th>
<th>P13</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigating the world would be difficult without haptics.</td>
<td>2.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.0</td>
<td>4.0</td>
<td>2.8</td>
</tr>
<tr>
<td>The haptic cues made it easier to navigate.</td>
<td>2.0</td>
<td>4.0</td>
<td>5.0</td>
<td>5.0</td>
<td>3.0</td>
<td>3.8</td>
</tr>
<tr>
<td>I was confused by the haptic cues.</td>
<td>4.0</td>
<td>2.0</td>
<td>2.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>The haptic cues caused my performance to suffer.</td>
<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.8</td>
</tr>
<tr>
<td>I found the haptic cues frustrating.</td>
<td>3.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.6</td>
</tr>
<tr>
<td>I found it easy to recover from mistakes while receiving haptic cues.</td>
<td>2.0</td>
<td>4.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.2</td>
</tr>
<tr>
<td>The haptic cues often behaved in unexpected ways.</td>
<td>4.0</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Overall, I found the haptic cues useful.</td>
<td>3.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.6</td>
</tr>
</tbody>
</table>

they agree with various statements from Davis’ scale of Perceived Ease of Use [11], as previously used by Seaborn [34] in a similar study. The individual and mean scores for each item in this scale are presented in Table 4.2. Overall, participants found the vibrational cues somewhat useful, with all participants either responding to the statement with ”Somewhat Agree (4.0)” or ”Neutral (3.0)”. Participants seemed to generally disagree with negative statements regarding the haptic cues, although the low participant count makes it difficult to understand whether this finding is applicable to a larger community of novice gamers.

In addition to the scalar results, participants were also provided with space to share their thoughts on the design and functionality of the haptic glove prototype. In response to this question, P2 stated that ”I think the thumb cue was the most useful and distinctive, as it reminded me to press the space bar to jump”, later also mentioning that ”I like the idea of haptic cues as I think it could intuitively reinforce the objectives of the game”. Similarly, P10 stated that ”the haptic gloves definitely helped me to learn the initial responses! The design worked well”. P7 shared their
experience on the haptic cues, saying that "they were useful to learn which finger to move, though sometimes it was hard to tell which was the right key to press". P2 also shared a similar sentiment, stating that "I don’t think I always remembered what hand I was using to do what, since I was new to the game and just reacting, but most of the time I seemed to be accomplishing what I was trying to do, even as the game was slowly getting harder".

Both P2 and P8 mentioned that they believed that the vibrations were strong enough to be easily noticed, although both had suggestions for improvement of the glove design. P2 suggested "I wonder if the haptic leads were instead attached to the bottom of the fingers that I would notice the cues more and mentally connect it to using that particular finger". Additionally, they shared another suggestion influenced by their lack of gaming experience: "as a non-gamer, having to use both hands to play a new game with visual and haptic cues was somewhat overwhelming. Possibly having more of a demo at the beginning to map and reinforce the haptic reminders with the visual versions of the commands would make them easier to learn". P8 also suggested that developing a wireless version of the gloves in the future may be more effective to eliminate any stress related to ensuring that cables are connected and not risking damage by the player moving their hands around.

4.2.8 Participant Feedback

All participants in both groups were provided with five short-answer questions to allow them to share their thoughts on the experience of playing the game, either with or without the haptic gloves. The responses to these questions are detailed below and are separated according to each question.
4.2.8.1 What did you enjoy most about playing the game?

Participants in the control group shared their enjoyment of the sound effects and simple graphics present in the game. P9 noted that they enjoyed the simple layout and clear objective of the level. P5 stated that they enjoyed that "the graphics were simple and easy to read; the game did not have distracting visual/audio elements". Similarly, P6 shared that "I enjoyed the design of the game, it seemed straightforward and not confusing which was helpful for both my enjoyment and comfort playing the game".

Participants in the experimental group shared similar sentiments, mentioning the simplicity of the game and graphics as a positive element of the game. Additionally, multiple participants noted their enjoyment of navigating around the rooms and finding obstacles to use. P10 shared "I really enjoyed the spatial layout of the game! It was interesting trying to figure out when to crouch, etc".

4.2.8.2 What did you dislike the most about playing the game?

Four of the five participants in the control group indicated their struggle with reading the instructions during the gameplay, which added stress to the experience. P5 shared "instructions were a little stressful to read over the graphics and the physical controls involved moving between multiple keys per finger", while P9 echoed a similar statement about their experience being "slightly stressful once more was happening and I needed to remember the control keys faster". Additionally, both P6 and P12 found that the instructions disappeared too quickly, making them difficult to read.

Comparatively, the experimental group did not echo similar statements aside from P7, who stated that reading the instructions was their least favourite aspect of the game. Instead, P8 and P13 mentioned brief issues with the game freezing that may
have detracted from their experience. P2 stated that "since I’m not a gamer, there were more buttons to learn to press than I’m used to", which was taken to be a negative aspect of the game.

4.2.8.3 How effective did you think the tutorial was in teaching you to play the game?

The control group, which experienced the tutorial without any supplemental haptic feedback, shared generally positive feedback on the effectiveness of the tutorial. P6 indicated their belief that the tutorial was well-paced, stating that "it was very effective in that all the information I needed or wanted to know was provided to me as I needed it". Similarly, P5 stated that "The tutorial was effective in telling me what I needed to do; it took practice beyond strictly the tutorial to properly learn the functions". This finding demonstrates the need for player involvement in tutorial sections to ensure effective information retention.

The experimental group shared similar positive feedback about the effectiveness of the tutorial, with three of five participants also mentioning the use of the haptic gloves as a supplemental interface. P8 shared their enjoyment of the haptic interface, sharing that "instead of checking the controls, I could simply receive the signal from the haptic interface. Made the tutorial go by quickly whilst still maintaining efficiency". P7 also shared their thoughts on the haptic interface, also mentioning some difficulties associated with memorizing controls; "It was helpful for introducing the keys used for different functions though it was sometimes hard to remember which key was used for what function". P10 shared that they thought the haptic cues allowed them to learn the initial responses to stimuli in the game quickly. They also shared their thoughts on the individual mechanics in the game, stating that "aiming felt intuitive
and moving was quite easy. The shotgun/changing weapons was the only thing I
didn’t feel super comfortable with by the end”. This response mirrors the previous
self-reported results for perceived difficulty, which found switching weapons to be the
most difficult mechanic for both the control and experimental groups.

4.2.8.4 If you could change one thing about the tutorial to make it more
effective for you, what would it be?

In the control group, a common request to improve the tutorial was to have the
text-based instructions stay on screen longer, or allow for the player to indicate with
an action when they have completed reading them, with three of five participants
making this suggestion. Additionally, P5 requested the addition of a supplemental
guide prior to starting the game. They said ”I like to know what I’m doing ahead
of time. A visual guide independent of the active game would have been good, and
would have prepared me for the physical controls to be practiced during the tutorial”.

In the experimental group, one participant also echoed the request for more time
to read instructions. Additionally, P7 suggested that ”It may be helpful if there were a
visual element showing where to place your hand on the keyboard”. Interestingly, P10
suggested more time spent using the shotgun in game, as they did not feel comfortable
using it by the end. Comparatively, P8 suggested an addition of new mechanics
such as ”a reload button or a lie down button, or a non-combat interaction button”. These two responses demonstrate the vast differences in experience and appetite for complicated mechanics, even in a group of novices.
4.2.8.5 Additional comments

The additional comments section allowed participants to share any other thoughts that they felt may be relevant related to their experience playing the game. This question was entirely optional and only four of ten participants answered it. In the control group, P5 and P9 both shared their enjoyment of the gaming experience overall, with P5 stating that the game was "very calming to play". P6 shared their confusion about the lack of direction on how to reload in the game, stating that "I didn’t notice any instruction on how many rounds each weapon had... It was a surprise when I ran out of ammo and had to reload". This confusion may have been due to the decision to include a cool-down effect of the weapons in game, which will replenish ammunition over a few seconds automatically, rather than explicitly require the participants to reload with another button press. In the experimental group, only P2 shared additional comments, stating that "It was fun to play, maybe I would play again if the levels don’t progress too quickly. The game seemed to acknowledge new skills which is validating". After the session, P8 verbally noted that they believed that the gloves could be valuable, especially for older adults who have no experience in a three-dimensional virtual space.

4.2.9 Researcher Observations

After the sessions and during further analysis of the video recordings, any observations that I felt were noteworthy that may contribute to the understanding of the player experience with or without the haptic gloves were documented. In particular, I took notes on the behaviour of the three players in the control group who were unable to complete the level, in order to better understand what difficulties caused them to fail.
These observations are outlined below.

In the control group, three participants failed to complete the level before losing all of their health. Of these, it was noted that P4 did not use the W, A, S, and D keys as instructed, and instead used the arrow keys on the keyboard. Throughout the level, the participant only used one hand, and switched between the arrow keys and mouse to perform activities. It seemed that this greatly contributed to their struggles. Additionally, both P9 and P12 demonstrated some level of panic once enemies in the level were able to shoot back at them. Both participants began moving through the level in an attempt to evade enemy attacks, rather than shooting the enemies back. This behaviour led both participants to lose all their health. P12 also struggled with using multiple keys to move and jump at the same time in order to get past stair obstacles.

In the experimental group, P2 took at least 5 seconds between receiving the vibrational cue and carrying out the action in the early stages of the level. Additionally, this participant took extra time to practice each mechanic after learning it in order to ensure full comprehension. Multiple participants in this group (P2, P10, P13) and the control group (P4, P6) did not make use of the ability to aim down sights for more accurate aiming, although it is unclear whether this is due to a lack of understanding of the mechanic or not feeling that it was necessary to play the game effectively. Throughout the level, P7 demonstrated multiple instances of contextual learning that helped them to better perform. While they failed initially to crouch behind obstacles, they were able to practice and figure out the technique shortly after and then continually made use of the crouch mechanic to take cover behind obstacles throughout the level. Additionally, they first attempted to use the shotgun weapon at long range, contrary to the instruction, which stated that the weapon was especially
effective at close range. After learning from this experience, the participant switched
to the previous weapon to shoot long-range targets. The participant continued to
switch weapons throughout the level according to the situation.

Additionally, it was noted that P2 and P13, both in the experimental group only
used two fingers on their left hand to carry out commands, contrary to the three (left
ring, left middle, left index) fingers which were receiving haptic cues. Although it
is unclear why this may have occurred, I do speculate on the reason behind this in
Section 4.3.1.

4.3 Discussion

The goal of this user study was to understand whether the addition of a haptic glove
prototype to assist with learning the controls of a first-person shooter would provide
a positive user experience for players learning a game for the first time. The design
and development of this prototype was guided by a comprehensive literature review
found in Chapter , as well as the findings related to tutorial design and the novice
gameplay experience that were gathered through a survey study in Chapter 3. In
considering the variability of both quantitative and qualitative results as presented
in the previous results section, as well as the relatively small participant count, it is
difficult to come to a conclusion about the effectiveness of using vibrotactile cues on
the player’s fingers as a supplementary technique to aid novice gameplay. Although
not enough conclusive evidence is present in this study to confidently recommend or
not recommend the use of a haptic glove interface for novice gamers, the multifaceted
nature of the results bring up interesting topics for further evaluation in future studies.
This section provides commentary on the study and results as they relate to the novice
gameplay experience, as well as details the major contributions of this study.

4.3.1 Performance and Observations

In looking at the performance and observational data gathered by the researcher, the results are inconclusive regarding the impact of the haptic gloves on novice gameplay. However, there are some aspects of the results that suggest that perhaps the use of vibrotactile cues may provide some benefit to the user experience. Perhaps the most notable of the findings related to performance is that all five participants in the experimental group were able to complete the game fully, whereas only two participants in the control group were able to complete the game. While observing the participants playing the game in each condition, I noticed that it seemed that participants in the control group struggled more with getting their bearings and learning how to interact with the game using basic mechanics such as moving, jumping, and shooting. Additionally, those players who lost the game seemed to be under a heavier amount of stress due to enemies shooting at them, causing them to abandon their objectives and instead run away from the enemies. Unfortunately, due to the lack of an adequate participant count it is not possible to come to a definitive conclusion about whether the addition of haptic cues may have prevent this from happening in other participants due to a stronger understanding of the game mechanics as they relate to specific player actions.

One finding worth noting is the way that both P2 and P13 used only two fingers to complete all tasks that required the use of the left hand, contrary to the typical three-fingered approach commonly seen in video games that control using a ”WASD” control scheme. This raises the question of whether these participants interacted with the game in such a way due to a lack of understanding of gaming norms, which has
been previously reported by Bycer [9], and why the vibrotactile cues on all three fingers did not adequately teach the player to use their fingers in the most efficient manner possible. A potential solution for this was provided by P7, who suggested a visual representation of ideal hand placement. Adding this visual to the beginning of the level or coupled with each mechanic’s tutorial may provide participants with an additional cue to further strengthen their understanding of the mechanic. Another suggestion from P2 could be applied, as they mentioned the possibility of moving the vibrational motors to the fingertips rather than the knuckles, which they believed may allow them to notice the cues more. Further research is necessary to determine whether this is a viable approach, as there may be risk of the haptic motors interfering with the motor function of the player due to a barrier between the fingertip and the keyboard, therefore undermining the touch sensation related to pressing a key on a keyboard or a button on a mouse.

Additionally, it is worth noting that P4, who used the arrow keys and mouse with one hand rather than the W,A,S,D keys with the left hand and the mouse with the right hand, may not have made this crucial error if they were wearing the haptic gloves, as the individual cues on the fingers of the left and right hands would provide clues as to which hand should be used for each action. It is possible that this may have improved their performance significantly and contributed to a more positive experience, perhaps with the player able to fully complete the level rather than lose part way through.

Another positive finding that is not directly related to the use of haptic cues, but instead encompasses tutorial design as a whole was the way in which P7 demonstrated contextual learning as a result of the implementation of hands-on tutorial design as described by Cantante [10] and advocated for by participants in the previous survey.
study in Chapter 3. By implementing the hands-on approach and requiring players to demonstrate their understanding of a concept in order to move on, the tutorial encouraged participants to experiment with their newly learned skills in order to become more comfortable with playing the game and understand the best strategies for success. This was noted in multiple instances during P7’s session, notably when they used the shotgun weapon at long range, then learned that it was less effective and switched back to the blaster weapon for long range targets and only used the shotgun when in close range. Additionally, P2 spent a considerable amount of time between each section of the tutorial practicing new mechanics in order to gain comfort and confidence. While these findings do not explicitly support the use of haptic cues to facilitate learning, they do support the use of hands-on tutorial design as a way to ensure that new players have the freedom and agency to learn new mechanics on their own terms and ensure that they have fully grasped the concept before moving on.

Overall, although there is a lack of statistically significant data to support the use of both haptic cues and hands-on tutorials when teaching novice players how to play new games, the combination of previous research and anecdotal data gathered through this study provisionally supports these techniques as a possible option for video game developers hoping to provide a positive novice player experience.

4.3.2 Questionnaire Results

The various qualitative and quantitative results that were gathered through the post-test questionnaire paint an interesting picture about the experience of players in both the control group and experimental group. Firstly, although the IMI [3] scalar results were not able to be analyzed for statistical significance, we can make tentative hypotheses about the reason for scores, with the caveat that more research must be
done in order to come to a full understanding of the effectiveness of the haptic gloves. Among the most prominent of the findings related to these scores is the disparity between the control and experimental group’s scores related to perceived competence. On a scale of 1 to 7, the control group scored under 4, whereas the experimental group scored above 5 (See Figure 4.8). This difference is notable, if not significant, and may be used to influence hypotheses about the impact of the haptic gloves on players’ perceived competence. I hypothesize that the addition of haptic-enabled gloves providing cues that align with the game’s tutorial sections may have caused players to feel more comfortable in their own abilities due to a stronger ability to retain information that was provided in multiple channels. This may have allowed participants to begin each task with an added layer of understanding provided by the haptic cue guiding their finger to press the necessary key. However, it was also noted that multiple participants in the experimental group took extra time to practice each mechanic prior to continuing on, which may have contributed to an increased feeling of competence. Evidently, it will take further research to determine the reason for this discrepancy in perceived competence between the groups, as well as to develop guidelines for how to ensure that new players feel as competent and confident as possible when playing a new game for the first time.

Another finding related to the IMI scores was that the control group scored higher in both pressure/tension and effort/importance. The difference between the scores in these categories between the groups is less than in the previously mentioned “perceived competence” category, but combined with some observational data related to participant behaviour, we may be able to hypothesize the reason for these scores. In general, it was perceived that participants in the control group experienced more stress when playing the game, as multiple participants exhibited signs of panic once
the enemies in the level were active and able to shoot at the player. It seemed that both P9 and P12 in the control group became overwhelmed at this stage in the game, which caused them to try to run away rather than utilize their newly learned skills of aiming and shooting to eliminate the enemies. This may have caused participants to feel more pressure and commit more effort to playing the game in order to avoid failure when compared to participants in the experimental group who did not exhibit these behaviours. These findings raise questions about the validity of the haptic glove interface as a technique for stress relief as well as learning when playing video games or conducting other motor tasks, although more research is required to explore these possibilities.

With regards to participant-reported difficulty, it was found that the primary mechanics of navigation, jumping, and aiming/shooting were found to be less difficult than the secondary mechanics of crouching and switching weapons for participants in both groups. This finding demonstrates that relatively simple mechanics which may be perceived as simple and basic to veteran or intermediate players may still be more difficult by new players. Because of this, it is important to ensure that mechanics are fully understood and placed in context during the tutorial to ensure that players are able to understand these mechanics on the same level that they understand the most basic mechanics such as movement. Placing more focus on these mechanics may also encourage players to use them more freely in later gameplay, as it was noted that few participants took advantage of the ability to crouch and switch weapons after being taught how when playing through the level. This further raises the question of how to tailor video game tutorials to new players without risking slowing things down too much for experienced players, as the survey study in Chapter 3 found that intermediate and expert players do not enjoy being forced to play through long
tutorials for mechanics that they already understand due to previous experience with games in the genre.

The comments provided by participants in the short answer portion of the questionnaire provide us with an opportunity to examine the opinions and experiences of new players playing a game for the very first time. These findings may allow us to further understand the unique mental models of novice players in order to better account for their experience when designing tutorials, and when designing games in general. Participants in this study seemed to value simplicity and straightforward design in the games that they play. Additionally, it seemed that keeping the visual and audio channels fairly simple and quiet may have contributed to a positive experience. This may support the use of haptic cues as opposed to visual or audio cues to transmit information in order not to overwhelm the player, although this may vary according to the information being transmitted. Similarly, some participants indicated that they disliked having to quickly read instructions on the screen while other things were happening on screen, especially when textual information was provided for a set amount of time, which made it hard for them to read and fully comprehend the information in the time given. This findings supports the use of text pop-ups that pause the gameplay and require a confirmation from the player that they have read and understood the information prior to continuing on with the tutorial. This can be used in tandem with a hands-on tutorial approach in order to minimize stress in players and ensure that they do not feel rushed to complete any activities in a set amount of time.
4.3.3 Design of the Haptic Glove

Overall, it seemed that the haptic gloves were received positively by participants. According to the Perceived Ease of Use [11] scores, participants indicated that they generally agreed with the statement "Overall, I found the haptic cues useful". Additionally, participants seemed to find that haptic cues made it easier to navigate through the level. No participants indicated that the haptic cues caused their performance to suffer, or that they found the haptic cues to be frustrating. Participants provided mostly positive feedback when provided with the opportunity to share about their experience. However, multiple suggestions were given for ways to improve the design of the gloves to enhance comfort and effectiveness. For example, the suggestion made by P8 to develop a wireless version of the gloves may influence future work to make the gloves more comfortable and practical to wear, enhancing their usability in contexts beyond a lab setting. As well, multiple suggestions seemed to indicate a desire for an enhanced visual component to accompany the gloves, indicating that their use may not be self-explanatory for new players. Perhaps by adding a visual indicator of where to place your hands prior to beginning the level, as well as during each tutorial section for each mechanic, the system could better support the use of the gloves and ensure that the haptic cues are fully understood in context. This, along with the previous suggestion to implement a pause during tutorial sections which requires confirmation from the user to bypass, may lead to a more effective solution that minimizes stress for the player and ensures that the haptic cues are fully comprehended.

From the various results and findings related to the design and use of the haptic gloves, I can come to a tentative conclusion that the use of haptic cues to guide new players with learning video game control schemes may be a valid technique to engage novice gamers with video games, particularly first-person shooter games on PC.
Evidently, more research is required to understand the full extent of the effectiveness of this technique, as well as to try different variations in design and implementation in order to find the most effective configuration for aiding novice players.
Chapter 5

Conclusion

As the video game industry grows and gaming communities become more and more experienced and familiar with gaming conventions in various genres, the novice experience may be becoming more neglected than ever. Novice players, particularly adults who did not grow up playing video games, present a challenge to video game developers as they may be entirely unaware of gaming conventions that have been prevalent in the genres for years or decades. This thesis aimed to examine the experiences of the novice gamer and offer a potential solution to help these novice gamers more easily overcome the barriers that make it difficult for them to participate in games and the gaming community as a whole. This work involved an exploratory survey of players of various skill and ability to better understand the differences between the novice and experienced player, as well as a pilot user study of a novel technique for addressing one of the barriers that was identified in the survey study; namely, learning unfamiliar control schemes.

In the first study, I surveyed gamers of varying degrees of skill and ability about their preferences for genre, difficulty, and tutorial techniques. Additionally, I asked
novice players about any barriers that they perceive that prevent them from effectively engaging with video games or the video game community, and asked intermediate and expert players if they perceived any barriers in games that could prevent new players from being able to engage effectively. The results indicated that various barriers to entry exist in video games including stigma surrounding being an unskilled player, assumed knowledge about prominent gaming conventions, game complexity leading to inaccessibility as a result of poor tutorials, and difficulty with learning new and unfamiliar control schemes. Additionally, feedback was gathered on what can be done to make tutorials successful, and what causes them to be unsuccessful. Participants indicated preference for simple, hands-on tutorials which cover basic mechanics, and leave secondary mechanics to be learned through experimentation rather than strict tutorials. Alternatively, participants disliked over-reliance on text and audio explanation, as well as tutorials which are too long and cover too many mechanics.

From the findings of the survey, I developed a prototype glove interface that utilized vibrotactile feedback in order to aid players with learning to interact with an unfamiliar control scheme in a first-person shooter on PC. This design was based on the technique of using multimodal interfaces to enhance understanding and improve user experiences, which has previously been research within and outside of gaming contexts [25, 36, 24, 37, 12]. In order to test the viability of this novel design, I conducted a pilot between-subjects user study with ten participants to compare performance data and subjective questionnaire results between players who played the tutorial without haptic aid and those who received haptic cues guiding them to perform actions during the tutorial. The results indicated a tentative conclusion that the addition of finger-based haptic cues to a first-person shooter tutorial has a positive impact on the
user experience and the player’s ability to perform the tasks required to complete the tutorial. Although performance data could not be analyzed for statistical significance to determine effectiveness, anecdotal data as well as qualitative survey responses indicate that the haptic glove interface was felt to be useful as a supplementary technique for learning to use keyboard and mouse controls in a first-person shooter, although there were various suggestions made by participants for ways that the design could be improved. Additionally, this research supports the use of hands-on tutorials, as previously found in the survey study, as an effective technique for ensuring comprehensive understanding of mechanics. Although further research is required to determine effectiveness, this study serves as a proof-of-concept of a new technique for incorporating haptic feedback into video game design that supports novice gameplay and provides supplementary information to those who require it. Although these findings are encouraging, it is important to recognize that using haptic cues to help with learning controls is only one step towards supporting novices. Video games often require the player to have previous knowledge about how the system operates as a whole, and therefore there can be many barriers that novices must overcome in order to effectively play any given game. Namely, players may have gained a better understanding of the control scheme of the game in this study, but the addition of haptic cues did not instruct them on how to effectively use the mechanics that they have learned in combination with one another, which may still hinder their ability to engage with the game. Further research into these barriers may uncover new ways that we can support novice gamers, whether that be through haptic means or otherwise.
5.1 Contributions

The primary contributions of this thesis are as follows:

1. The prototype design of a novel haptic glove device for use with a first-person shooter and keyboard/mouse controls.

2. Preliminary performance and user experience data about the effectiveness of the aforementioned haptic glove device as a technique for aiding novice video game players with learning unfamiliar controls.

3. Survey data concerning the perspectives of players with various levels of skill and experience on video game difficulty, tutorial design, and barriers that prevent new players from engaging with video games.

5.2 Limitations

The survey study was limited by the relatively small and underrepresented nature of novice gamer communities in online spaces. Due to the difficulties related to sourcing online spaces that could reliably provide novice participants, I was required to open the study to participants of all levels of gaming experience in order to ensure an adequate data set. Because of this, the survey is overly representative of the experiences of intermediate and expert gamers, rather than novices. While this is valuable information, as it helps us to better understand the greater social implications of being a novice gamer, it would have been beneficial to have a more equal representation of novice and experienced gamers providing their thoughts in the survey.
The user study had several limitations that impacted the degree to which conclusions were able to be derived. Most notably, the study of the haptic glove prototype took place on campus during the COVID-19 pandemic, and was one of the first studies to be approved for in-person recruitment at Carleton University after the fifth wave of the pandemic in early 2022. Because of restrictions associated with public health, I was unable to recruit a large number of participants, therefore limiting my ability to gather conclusive evidence about the effectiveness of the system. Despite this, I was able to come to tentative conclusions about the study and offer my own insight into possible avenues for future work, which will be discussed in Section 5.3.

Another limitation of the user study is the relatively low-fidelity nature of the haptic glove prototype. As a result of my own limited experience with programming and prototyping within Arduino, the system did not interface directly with the game and instead required a human operator to provide the user with haptic cues. Due to the requirement for me to operate as both the observer and the operator, human error inevitably impacted this study and required several participants’ data to be removed. Additionally, the inherent imprecise nature of Wizard of Oz studies means that each trial with the system was slightly different due to my own reaction time when providing the cues to the participant as the game progressed. This may have impacted the fidelity of the performance data gathered. Lastly, a limitation of this study was the physical design of the prototype, which required participants to be physically connected to an Arduino board via cables that may have restricted movement and comfort while interacting with the game. This may have impacted participants’ experiences, as one participant did suggest the development of a wireless version to negate the need for so much wiring for players to navigate.
5.3 Future Work

Due to the limitations of this work and the tentative conclusions that were brought forward as a result of these limitations, there is ample room for future work on the topic of haptic interfaces as a technique for aiding novice gameplay. The foremost suggestion is to run the same user study of the haptic glove prototype with a larger participant number in order to gather significant data about the effectiveness of the system on the novice gameplay experience. Additionally, it would be interesting to conduct the same study as a between-subjects design with multiple configurations of the tutorial system that incorporate multiple variations in the design of the system, particularly focused on those variations mentioned by participants in this thesis. Possible configurations could include a version of the gloves with haptic motors on the bottom of the finger rather than the top, or a version of the tutorial which includes a visual or audio indicator at each step to guide the placement of the hands in tandem with vibrational cues. This would be valuable data to collect as it helps us to understand the precise effect of haptic cues in different scenarios, as well as their impact as a standalone feature as opposed to part of a larger visual-haptic or audio-haptic component of the tutorial.

Another avenue for research into this topic could be the application of the haptic glove prototypes in different video game genres and with various input techniques. It would be interesting to consider how haptic cues could be utilized to help players effectively learn to play a turn-based RPG or third-person action-adventure game, or to learn to interact with a game using a controller or racing wheel. Further study into the use of haptics in a variety of novice gameplay scenarios may shed further light on the novice gameplay experience as a whole, as well as the best avenues for applying haptic cues in order to maximize their effectiveness in helping players learn to play.
games. Finally, research could be conducted to explore whether information other than tutorials such as low-health indicators, damage taken, and low-ammunition indicators which normally are explained through the HUD could be moved to the haptic channel and instead transmitted through vibrational cues. This may be applicable to both novice and experienced gamers, as it would both provide new players with various channels through which to process information, as well as provide experienced players with the opportunity to play with a decreased clutter in the HUD while still being told all relevant information that they need to play the game effectively, which may be desirable to those who prefer to play with a more minimal HUD system. It is worth noting that commercial systems already use haptics to some extent, and there may be avenues for future work that incorporate these systems with haptic capabilities already present to transmit this information.

In general, the topic of haptic feedback as it relates to facilitating learning within a video game is relatively under-researched. I believe that the opportunities for haptic feedback as a tool for enhancing the novice user experience are incredibly exciting, and I encourage further research into this topic in order to fully understand how these technologies can be leveraged to create games that are more accessible to people of all levels of experience and skill.
Appendix A

Survey Study Materials
A.1 Questionnaire

Survey Questions

Thank you for agreeing to participate in this survey. This survey will consist of both multiple choice and short answer questions. If at any point you are unwilling to continue, please close the window and your data will be promptly deleted.

1. Please indicate your age.
   - __________
   - Prefer not to say

2. Please indicate your gender.
   - Man
   - Woman
   - Non-Binary
   - Gender-Fluid
   - Two Spirit
   - Something else
   - Prefer not to say

3. How would you classify your relationship with video games?
   - I am a frequent gamer. I spend upwards of five hours per week playing video games.
   - I am an infrequent gamer. I play video games for less than five hours in an average week.
   - I am not a gamer. I rarely play video games, although I do have some experience.
   - I have never played video games. (END SURVEY)

4. How would you classify your relationship with video games?
   - Expert. I have a high level of skill and a strong understanding of gaming conventions.
   - Intermediate. I am somewhat skilled and have an adequate understanding of how games work, although I am unfamiliar with some game genres.
   - Novice. I am relatively new to gaming in general, and I am actively learning how to play games in one/multiple genre(s).

5. Please indicate which of the following game genres you have played and are familiar with.
   - Shooters (First-Person, Third Person)
   - Real-Time Strategy
   - Turn-Based Strategy
   - Role-Playing (RPG)
   - Racing
   - Puzzle
   - Action-Adventure
   - Fighting
   - 2D Platformer
   - 3D Platformer
6. How does game difficulty impact your choice of games to play? Please choose the answer that best represents your experience.
   - I prefer the most difficult games. I want to be challenged to perform to the best of my ability.
   - I prefer a balance of difficulty. I want to overcome challenges, but not at the expense of enjoyment.
   - I prefer games that don’t challenge me too much, as I am more focused on the story experience.

7. Think back to a game that you have recently started playing. What was the tutorial experience like? Was it effective in teaching you the mechanics of the game? Please be as detailed as possible in your response.

8. When playing a new game, how likely are you to play through an optional tutorial, regardless of whether you are familiar with the genre or not?
   - Very likely
   - Somewhat likely
   - Somewhat unlikely
   - Very unlikely

9. What factors influence your likelihood of playing through an optional game tutorial?

10. In your experience, what factors make a good game tutorial?

11. In your experience, what factors make a bad game tutorial?

12. (ONLY SHOW TO INTERMEDIATE/EXPERT PLAYERS) Thinking on your experience as a gamer, do you perceive any barriers that may make it difficult for new players to engage with video games?
   - Yes
   - No
   - Unsure
   - (IF YES) Please describe some of these barriers.

13. (ONLY SHOW TO NOVICE PLAYERS) As a novice gamer, what influenced you to become interested in gaming?

14. (ONLY SHOW TO NOVICE PLAYERS) When playing a new game for the first time, what are the most important things that a tutorial or onboarding session can do to help you understand and feel comfortable engaging with the game?
15. (ONLY SHOW TO NOVICE PLAYERS) As a novice gamer, what do you see as the most significant barrier to playing video games for someone with limited prior knowledge of gaming conventions?

16. If there is anything else you would like to share about this topic, please do so below.

17. Thank you for participating in this study. Please provide your contact information in the form below to be entered in a draw for two $50 Amazon eGift Cards on December 14, 2021. Entry into this draw is entirely optional. Please skip the question if you are not interested in being entered into the draw.
   - Email address: ________
A.2 Consent Form

Informed Consent

Thank you for agreeing to participate in this study on the topic of designing effective game tutorials and onboarding. The purpose of this study is to gain an understanding of how video game tutorial sections impact the gaming experience for players at varying levels of skill. We hope to shed light on what can be done to aid new/novice gamers to bridge the gap of difficulty and game-related knowledge when learning to play a specific game for the first time. In order to be eligible to participate, you must have some level of experience playing video games. You must be 18 years of age and speak English fluently.

We estimate that the online survey will take about 15 minutes to complete. Your participation in this survey is voluntary, and you may choose not to take part, or not to answer any of the questions. Participants of this study can choose to be entered into a draw for one of two $50 Amazon eGift Cards on December 14, 2021 and will be prompted to input their contact information after completing the survey. If you decide to withdraw your responses, please email the lead researcher (saraczerwonka@cmail.carleton.ca) by December 31, 2021.

We do not anticipate any risks from taking the online survey, nor do we anticipate that you will derive any benefit.

With your consent, the online survey answers will be electronically stored and retained in a secure location until December 31, 2021. De-identified data will be kept for 5 years and will be used in a master’s thesis. It may also be used in publications and presentations, but the data will be presented so that it will not be possible to identify any participants. All research data will be password-protected and there will be no hard copies of the data. Your data will be stored and protected by Qualtrics in their Canadian data center but may be disclosed via a court order or data breach.

This research has been cleared by Carleton University Research Ethics Board-B (CUREB-B Clearance #). If you have any ethical concerns with the study, please contact the Carleton University Research Ethics Board. During COVID, the Research Ethics Staff are working from home without access to their Carleton phone extensions. Accordingly, until staff return to campus, please contact them by email at ethics@carleton.ca.

Please find the contact information of the researcher below.

- Sara Czerwonka, School of Computer Science, Carleton University, SaraCzerwonka@cmail.carleton.ca
- Vicky McArthur, Associate Professor - School of Journalism and Communication, Carleton University, Victoria.McArthur@carleton.ca

Statement of consent

Do you voluntarily agree to participate in the study? Yes _______ No _______
DO YOU HAVE EXPERIENCE PLAYING CONSOLE OR COMPUTER GAMES?

We are actively recruiting participants for a survey study on how video game tutorials impact the gaming experience for players with varying levels of skill and experience. **Novice, intermediate, and expert players are welcome!**

The survey will take approximately 15 minutes to complete. Participants will be entered into a draw for two $50 Amazon Gift Cards! The chances of winning are estimated to be approximately 1:25.

**REQUIREMENTS TO PARTICIPATE**

- 18 years of age or older.
- Fluent in the English language.
- Access to a computer or mobile device to complete the survey.
- Some recent experience playing video games.

This research has been cleared by Carleton University Research Ethics Board-B (CUREB-B Clearance #116586).

If you have any questions, please contact the Lead Researcher, Sara Czerwonka at saraczerwonka@cmail.carleton.ca or the Faculty Supervisor, Dr. Vicky McArthur at victoria.mcarthur@cunet.carleton.ca
A.4 Ethics Clearance

CERTIFICATION OF INSTITUTIONAL ETHICS CLEARANCE

The following research has been granted clearance by the Carleton University Research Ethics Board-B (CUREB-B). CUREB-B is constituted and operates in compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2).

Ethics Clearance ID: Project # 116586

Project Team Members: Sara Czerwonka (Primary Investigator)
Victoria McArthur (Research Supervisor)

Study Title: Towards an Adaptive Haptic and Audio Interface Design to Aid Novice Gamers

Funding Source: (If applicable):

Effective: November 17, 2021  Expires: November 30, 2022

This certification is subject to the following conditions:

1. Clearance is granted only for the research and purposes described in the application.
2. Any modification to the approved research must be submitted to CUREB-B via a Change to Protocol Form. All changes must be cleared prior to the continuance of the research.
3. An Annual Status Report for the renewal or closure of ethics clearance must be submitted and cleared by the renewal date listed above. Failure to submit the Annual Status Report will result in the closure of the file. If funding is associated, funds will be frozen.
4. During the course of the study, if you encounter an adverse event, material incidental finding, protocol deviation or other unanticipated problem, you must complete and submit a Report of Adverse Events and Unanticipated Problems Form.
5. It is the responsibility of the student to notify their supervisor of any adverse events, changes to their application, or requests to renew/close the protocol.
6. Failure to conduct the research in accordance with the principles of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans 2nd edition and the Carleton University Policies and Procedures for the Ethical Conduct of Research may result in the suspension or termination of the research project.

IMPORTANT: Special requirements for COVID-19:

If this study involves in-person research interactions with human participants, whether on- or off-campus, the following rules apply:
1. Upon receiving clearance from CUREB, please seek the approval of the relevant Dean for your research. Provide a copy of your CUREB clearance to the Dean for their records. See Principles and Procedures for On-campus Research at Carleton University and note that this document applies both to on- and off-campus research that involves human participants. Please contact your Dean's Office for more information about obtaining their approval.

2. Provide a copy of the Dean's approval to the Office of Research Ethics prior to starting any in-person research activities.

3. If the Dean's approval requires any significant change(s) to any element of the study, you must notify the Office of Research Ethics of such change(s).

Upon reasonable request, it is the policy of CUREB, for cleared protocols, to release the name of the PI, the title of the project, and the date of clearance and any renewal(s).

Please email the Research Compliance Coordinators at ethics@carleton.ca if you have any questions.

CLEARED BY: Bernadette Campbell, PhD, Chair, CUREB-B

Date: November 17, 2021

Kathryne Dupre, PhD, Co-Chair, CUREB-B
A.5 Codes and References

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentiments</td>
<td>Refers to the connotation of the individual statement, and whether it can be perceived as positive or negative.</td>
<td>85, 108, 9</td>
</tr>
<tr>
<td>Positive</td>
<td>Refers to positive connotations.</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Refers to negative connotations.</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>Positive or negative connotations can not be determined, or none are present.</td>
<td>9</td>
</tr>
<tr>
<td>Barrier to Entry</td>
<td>Refers to those barriers which may make it difficult for new players to engage with video games.</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>Refers to mechanics or options that are specifically meant to provide assistance to individuals who are unable to effectively play the game without modification.</td>
<td>4</td>
</tr>
<tr>
<td>Game Complexity</td>
<td>Refers to the degree of complexity of a game, based on the number of mechanics and systems that are required to learn and understand in order to play the game effectively.</td>
<td>15</td>
</tr>
<tr>
<td>Player Matchmaking</td>
<td>Refers to multiplayer games which pair players of different skill levels to play a game against or with one another.</td>
<td>7</td>
</tr>
<tr>
<td>Assumed Knowledge</td>
<td>The inherent assumption that players have a specific degree of knowledge about the game/genre prior to playing for the first time.</td>
<td>8</td>
</tr>
<tr>
<td>Controller Familiarity</td>
<td>Refers to an individual's comfort and familiarity with a particular controller or button layout required to play a game.</td>
<td>12</td>
</tr>
<tr>
<td>Toxic User Base</td>
<td>Refers to a game's player base which may be perceived as hostile or negative, particularly towards new players.</td>
<td>1</td>
</tr>
<tr>
<td>Stigma</td>
<td>The social stigma around being a &quot;bad&quot; gamer, which may deter new players from learning a new game due to embarrassment.</td>
<td>4</td>
</tr>
<tr>
<td>Memory</td>
<td>Barriers associated with remembering things that were explained in a previous gaming session, which may be difficult to recall as time passes between sessions.</td>
<td>9</td>
</tr>
<tr>
<td>Hand-eye Coordination</td>
<td>The ability for an individual to correlate their understanding of game mechanics to physical button presses in order to effectively play a game.</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty</td>
<td>All references to a video game's inherent difficulty.</td>
<td></td>
</tr>
<tr>
<td>Difficulty options</td>
<td>The ability to select one of multiple difficulty levels in order to cater a gaming experience to one's specific skill level.</td>
<td>1, 3</td>
</tr>
<tr>
<td>Mechanical difficulty</td>
<td>Refers to the difficulty associated with participatory interaction primarily based on skill.</td>
<td></td>
</tr>
<tr>
<td>Interpretive difficulty</td>
<td>Refers to the difficulty associated with the ability to understand and respond to stimulus analytically.</td>
<td>3</td>
</tr>
<tr>
<td>Perceived difficulty</td>
<td>The assumed difficulty of a game that a player develops by reading, watching, or beginning to play the game.</td>
<td>10</td>
</tr>
<tr>
<td>Optimal difficulty</td>
<td>The feeling that a game is providing the optimal amount of challenge to be engaging and enjoyable.</td>
<td>1, 10</td>
</tr>
<tr>
<td>Easy</td>
<td>The perception that a game will be easy to learn.</td>
<td>2</td>
</tr>
<tr>
<td>Too difficult</td>
<td>The assumption that a game is too difficult to be enjoyable.</td>
<td>8</td>
</tr>
<tr>
<td>External research</td>
<td>The act of researching a game in order to understand its difficulty and how to overcome it. This also refers to researching games which have not yet been purchased in order to understand whether the difficulty is aligned with the player's intended experience.</td>
<td>4</td>
</tr>
<tr>
<td>Familiarity of genre</td>
<td>Refers to the degree of familiarity which a player has with games in a specific genre, and how this may impact the understanding of mechanics required to play.</td>
<td>23</td>
</tr>
<tr>
<td>Learning Techniques</td>
<td>Refers to the techniques utilized to teach players the necessary skills and information required to play a game.</td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>Repeating information to ensure that a player grasps the most important concepts thoroughly.</td>
<td>6</td>
</tr>
<tr>
<td>Onboarding</td>
<td>The technique of scaffolding the presentation of mechanics and other material in a video game to allow the player to learn new skills without becoming overwhelmed.</td>
<td>14</td>
</tr>
<tr>
<td>Learning through experience</td>
<td>The technique of learning to play a game simply by playing the game and experimenting with what different inputs do, rather than taking part in a tutorial.</td>
<td>18</td>
</tr>
<tr>
<td>Tutorial</td>
<td>Defined sections of a game which are solely meant to teach new mechanics, often providing an extremely forgiving space for players to experiment and familiarize themselves with new mechanics.</td>
<td>6</td>
</tr>
<tr>
<td>Short</td>
<td>A short tutorial.</td>
<td>15</td>
</tr>
<tr>
<td>Long</td>
<td>A long tutorial.</td>
<td>15</td>
</tr>
<tr>
<td>Walkthrough</td>
<td>The technique of stopping gameplay to provide information on how to play the game through text and graphics.</td>
<td>12</td>
</tr>
<tr>
<td>Hands-on</td>
<td>The technique of placing the player in a situation in which they must use a new mechanic in context to bypass an obstacle.</td>
<td>15</td>
</tr>
<tr>
<td>Mixed approach</td>
<td>A mix of both the walkthrough and hands-on approaches to tutorial design, which aims to maintain flow while ensuring that mechanics are understood fully.</td>
<td>4</td>
</tr>
<tr>
<td>Mandatory tutorial</td>
<td>Tutorials that cannot be skipped and must be completed in order to progress further in the game.</td>
<td>12</td>
</tr>
<tr>
<td>Optional tutorial</td>
<td>Tutorials which are not required and can be skipped.</td>
<td>36</td>
</tr>
<tr>
<td>Teacher</td>
<td>Learning to play a game by being taught by another player with considerable experience with the game.</td>
<td>6</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Refers to the specific characteristics present in an onboarding or tutorial session.</td>
<td></td>
</tr>
<tr>
<td>Connected to the plot</td>
<td>The connection between learning mechanics and progressing the story further.</td>
<td>15</td>
</tr>
<tr>
<td>Built-in to the game</td>
<td>Teaching mechanics through progression through a level, rather than through a specific tutorial section.</td>
<td>23</td>
</tr>
<tr>
<td>Hand-holding</td>
<td>Providing a high level of assistance and direction to the player to ensure that they fully understand a concept.</td>
<td>8</td>
</tr>
<tr>
<td>Explanation</td>
<td>The explanation of mechanics or skills through a variety of means.</td>
<td>14</td>
</tr>
<tr>
<td>Under explanation</td>
<td>Not explaining a mechanic enough, therefore leaving the player confused.</td>
<td>10</td>
</tr>
<tr>
<td>Over explanation</td>
<td>Explaining a mechanic too intricately, therefore leaving the player bored and frustrated.</td>
<td>14</td>
</tr>
<tr>
<td>Entertaining</td>
<td>The ability for a game to provide entertainment and enjoyment to the player.</td>
<td>9</td>
</tr>
<tr>
<td>Replayable</td>
<td>The ability to return to a tutorial section and replay it in order to revisit concepts and mechanics which may have been forgotten.</td>
<td>5</td>
</tr>
<tr>
<td>Reward system</td>
<td>Providing the player with a reward for completing tutorials or onboardingsessions.</td>
<td>2</td>
</tr>
<tr>
<td>Autonomy</td>
<td>Refers to the notion of providing the player with the ability to control their play and progression in order to ensure that they feel their achievements in the game are self-directed.</td>
<td>8</td>
</tr>
<tr>
<td>Content</td>
<td>Refers to the content which is being taught to the player in a game.</td>
<td></td>
</tr>
<tr>
<td>Basic mechanics</td>
<td>Simple mechanics that allow for basic interaction with the game. (i.e. move, look around, attack, etc.)</td>
<td>31</td>
</tr>
<tr>
<td>High-level mechanics</td>
<td>Complex mechanics that allow for more effective and varied interaction with the game (i.e. use of flash-bang grenades to blind enemies)</td>
<td>26</td>
</tr>
<tr>
<td>Strategy</td>
<td>Developing a plan of action to solve a problem within the context of the game.</td>
<td>2</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Decisions or choices which influence the way that a game responds to the player.</td>
<td>2</td>
</tr>
<tr>
<td>Controls</td>
<td>The button-mappings on a keyboard or controller that govern the way that a game is played.</td>
<td>35</td>
</tr>
<tr>
<td>Interface</td>
<td>Refers to the presentation of the game to the player.</td>
<td></td>
</tr>
<tr>
<td>Visual indicators</td>
<td>Refers to text or graphics which are used to draw attention to certain aspects of the screen.</td>
<td>13</td>
</tr>
<tr>
<td><strong>Use of color</strong></td>
<td>Refers to the use of color to draw attention to or away from certain aspects of the screen.</td>
<td>5</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td><strong>Text pop-ups</strong></td>
<td>Intermittent display of text as a way to teach players a new mechanic or remind them of those which they have previously learned.</td>
<td>21</td>
</tr>
<tr>
<td><strong>Audio cues</strong></td>
<td>Refers to the use of audio or voice-over to explain game mechanics.</td>
<td>4</td>
</tr>
<tr>
<td><strong>User experience</strong></td>
<td>Refers to the player's experience interacting with the game's interface.</td>
<td>2</td>
</tr>
<tr>
<td><strong>Feelings</strong></td>
<td>Refers to the feelings or emotions associated with playing a game.</td>
<td></td>
</tr>
<tr>
<td><strong>Frustrated</strong></td>
<td>The feeling of being frustrated.</td>
<td>2</td>
</tr>
<tr>
<td><strong>Bored</strong></td>
<td>The feeling of being bored or disinterested in a game.</td>
<td>3</td>
</tr>
<tr>
<td><strong>Discouraged</strong></td>
<td>The feeling of discouragement or lack of belief in one's ability to learn to play a game effectively.</td>
<td>3</td>
</tr>
<tr>
<td><strong>Embarrassed</strong></td>
<td>The feeling of embarrassment associated with being a novice or new gamer.</td>
<td>2</td>
</tr>
<tr>
<td><strong>Confused</strong></td>
<td>The feeling of confusion as a result of the way that a game mechanic or technique is presented.</td>
<td>4</td>
</tr>
<tr>
<td><strong>Annoyed</strong></td>
<td>Feeling annoyed by something being presented as part of the game.</td>
<td>6</td>
</tr>
<tr>
<td><strong>Engaged</strong></td>
<td>Feeling entertained and engaged by the game.</td>
<td>4</td>
</tr>
<tr>
<td><strong>Intimidated</strong></td>
<td>Feeling intimidated by the daunting task of learning a new game or new mechanic due to perceived difficulty</td>
<td>2</td>
</tr>
<tr>
<td><strong>Confidence</strong></td>
<td>The feeling of being confident in one's abilities and skills as related to the game.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Overwhelmed</strong></td>
<td>Feeling stressed by the amount of information being provided at once.</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix B

User Study Materials
B.1 Post-Test Questionnaire

Post-Test Questionnaire

Please answer the following questions thinking back on your experience playing through the tutorial section of the game.

PART 1: DEMOGRAPHICS

1. What is your age?
   ○ _______
   ○ Prefer not to say

2. What is your gender?
   ○ Man
   ○ Woman
   ○ Non-Binary
   ○ Gender-Fluid
   ○ Two Spirit
   ○ Something else
   ○ Prefer not to say

3. What is your experience level with playing computer games prior to today?
   ○ Expert. I have experience with many computer games and I feel comfortable playing them.
   ○ Intermediate. I have played a few computer games and feel somewhat comfortable playing them.
   ○ Beginner. I have played one or more computer games, but I do not yet feel comfortable playing them.
   ○ I have never played a computer game.

4. What is your experience level with playing first person shooters prior to today?
   ○ Expert. I have experience with many first-person shooter games and I feel comfortable playing them.
   ○ Intermediate. I have played a few first-person shooter games and feel somewhat comfortable playing them.
   ○ Beginner. I have played one or more first-person shooter games, but I do not yet feel comfortable playing them.
   ○ I have never played a first-person shooter game.

PART 2: ENJOYMENT

These questions refer to your general enjoyment while playing through the game.

1-7 Likert scale (not at all true - somewhat true - very true)

1. I enjoyed playing this game very much
2. This game was fun to play.
3. I thought this was a boring activity. ◆
4. The game did not hold my attention at all. ◆
5. I found this game very interesting.
6. I thought this game was quite enjoyable.
7. While I was playing this game, I was thinking about how much I enjoyed it.

1-7 Likert scale (not at all true - somewhat true - very true)
1. I did not feel nervous at all while doing this ®
2. I felt very tense while playing this game.
3. I was very relaxed when playing this game. ®
4. I was anxious while playing this game.
5. I felt pressured while playing this game.

Open ended questions:
1. What did you enjoy most about playing the game?
2. What did you dislike the most about playing the game?

PART 3: EASE OF USE (only for haptic group)
These questions refer to the use of haptic vibrational cues during the tutorial. Please share your thoughts on the use of vibration in the game tutorial by answering the questions below.

1-5 Likert scale (Agree-Somewhat Agree-Neutral- Somewhat Disagree-Disagree)
1. Navigating the world would be difficult to do without haptics.
2. The haptic cues made it easier to navigate.
3. I was confused by the haptic cues.
4. The haptic cues caused my performance to suffer.
5. I found the haptic cues frustrating.
6. I found it easy to recover from mistakes while receiving haptic cues.
7. The haptic cues often behaved in unexpected ways.
8. Overall, I found the haptic cues useful.

1. Please share any thoughts related to the design and functionality of the haptic gloves.

PART 4: EFFORT AND COMPETENCE
These questions refer to how competent you felt when playing the game, and the amount of effort that you put in when playing.

1-7 Likert scale (not at all true - somewhat true - very true)
1. I think I am pretty good at this game.
2. After playing this game for awhile, I felt pretty competent.
3. I am satisfied with my performance in this game.
4. I was pretty skilled at this activity.
5. This was an activity that I couldn’t do very well. ®

1-7 Likert scale (not at all true - somewhat true - very true)
1. I put a lot of effort into playing this game.
2. I didn’t try very hard to do well at this activity. ®
3. I tried very hard on this activity.
4. It was important for me to do well.
5. I didn't put much energy into this. ®

PART 5: DIFFICULTY
These questions refer to your perceived difficulty of the different tasks that you completed in the game.

4 Item Likert Scale (Very Difficult - Somewhat Difficult - Somewhat Easy - Very Easy)
1. How difficult would you consider the game to be as a whole?
2. How difficult did you find navigation in the game?
3. How difficult did you find jumping in the game?
4. How difficult did you find aiming/shooting in the game?
5. How difficult did you find using obstacles as cover in the game?
6. How difficult did you find changing weapons in the game?

PART 6: FINAL THOUGHTS
2. How effective do you think the tutorial was in teaching you to play the game? Please be as specific as possible.
3. If you could change one thing about the tutorial to make it more effective for you, what would it be?
4. Do you have any other comments?
B.2 Consent Form

Informed Consent Form

Name and Contact Information of Researchers:

Sara Czerwonka, Carleton University, School of Computer Science
Tel.: 403-519-7521
Email: saraczerwonka@cmail.carleton.ca

Supervisor and Contact Information:

Dr. Vicky McArthur, Associate Professor, School of Journalism and Communications, Carleton University

Project Title

Toward a Supplemental Haptic Interface to Aid Novice Gameplay

Carleton University Project Clearance

Clearance #: 117190        Date of Clearance: February 18, 2022

Invitation

You are invited to take part in a research project because you are a novice video game player who has minimal to zero experience playing first-person shooter games on a desktop computer with keyboard and mouse controls. The information in this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study. Your participation in this study is voluntary, and a decision not to participate will not be used against you in any way. As you read this form, and decide whether to participate, please ask all the questions you might have, take whatever time you need, and consult with others as you wish.

What is the purpose of the study?

The purpose of this study is to test a novel haptic glove interface as a tool for providing supplemental feedback to novice video game players who are learning to play a first-person shooter for the first time. We aim to understand if the addition of haptic feedback provides any benefit to the player through improved performance or enjoyment, as well as the feasibility of a glove-based haptic system for teaching new players to play games.

What will I be asked to do?

If you agree to take part in the study, we will ask you to:

• Spend approximately 30 minutes with the researcher in the Human-Computer Interaction building at Carleton University with all COVID-19 related protocols in place.
• Complete a tutorial level of a custom first-person shooter game, either with or without the addition of a set of haptic-enabled gloves providing vibrational feedback.
• Consent to audio and screen recording of the session via Zoom. Note that this does not constitute video recording of you, only of the screen on which you are playing the game.
• Provide thoughts and opinions on the experience through a post-test questionnaire.
Risks and Inconveniences
Because this study involves in-person interactions, there is some risk that you may be infected with the COVID-19 virus during study participation. Researchers will take precautions in accordance with provincial, federal, Carleton University and other public health guidelines to minimize the risk of transmission of COVID-19. However, persons who are older, or who have certain medical conditions, and others, have been shown either to be at greater risk of contracting COVID-19, or to suffer more serious effects from the virus.

Possible Benefits
You may not receive any direct benefit from your participation in this study. However, your participation may allow researchers to better understand how tutorials can leverage haptic guidance as a technique for aiding novice video game players.

Compensation/Incentives
$10 Amazon Gift Card

No waiver of your rights
By signing this form, you are not waiving any rights or releasing the researchers from any liability.

Withdrawing from the study
If you withdraw your consent during the course of the session, all information collected from you before your withdrawal will be discarded.

After the session, you will not be able to withdraw your consent as your data will be promptly anonymized.

Confidentiality
We will treat your personal information as confidential, although absolute privacy cannot be guaranteed. No information that discloses your identity will be released or published without your specific consent. Research records may be accessed by the Carleton University Research Ethics Board in order to ensure continuing ethics compliance.

All data will be kept confidential, unless release is required by law (e.g. child abuse, harm to self or others). You will be assigned a code so that your identity will not be directly associated with the data you have provided. All data, including coded information, will be kept in a password-protected file on a secure computer. “In-session” data, such as the audio and video recordings of the screen, will be stored locally on the researcher’s computer. We will password-protect any research data that we store or transfer.

The results of this study may be published or presented at an academic conference or meeting, but the data will be presented so that it will not be possible to identify any participants.
Data Retention
After the study is completed, your de-identified data will be retained for future research use for a period of five years.

New information during the study
In the event that any changes could affect your decision to continue participating in this study, you will be promptly informed.

Ethics review
This research has been cleared by Carleton University Research Ethics Board-B (Clearance #117190). If you have any ethical concerns with the study, please contact Carleton University Research Ethics Board (by phone at 613-520-2600 ext. 4085 or by email at ethics@carleton.ca). During Covid, the Research Ethics Staff are working from home without access to their Carleton phone extensions. Accordingly, until staff return to campus, please contact them by email.

Statement of consent – print and sign name
I voluntarily agree to participate in this study. ___Yes ___No

________________________     ________________________
Signature of participant       Date

Research team member who interacted with the participant
I have explained the study to the participant and answered any and all of their questions. The participant appeared to understand and agree. I provided a copy of the consent form to the participant for their reference.

__________________________ __   _____________________
Signature of researcher      Date
SEEKING PARTICIPANTS: HAPTIC INTERFACE TO AID NOVICE GAMEPLAY

We are actively recruiting participants for a study about the effectiveness of a supplemental haptic feedback device as a tool to aid novice gameplay in a first-person shooter PC game.

The study will take place on campus. Participants will be required to play through a 20-30 minute tutorial of a video game and complete a questionnaire about their experience. Participants will be compensated with a $10 Amazon Gift Card after completing the study.

REQUIREMENTS TO PARTICIPATE

• 18 years of age or older.
• Fluent in the English language.
• No limitation or disability related to motor function.
• Able to be on campus for a limited period of time.
• Have zero to minimal experience playing video games, especially first-person shooters.

If you are interested or have any questions, please contact the Lead Researcher, Sara Czerwonka at saraczerwonka@cmail.carleton.ca

This research has been cleared by Carleton University Research Ethics Board-B (CUREB-B Clearance #117190).
B.4 Ethics Clearance

CERTIFICATION OF INSTITUTIONAL ETHICS CLEARANCE

The following research has been granted clearance by the Carleton University Research Ethics Board-B (CUREB-B). CUREB-B is constituted and operates in compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2).

Ethics Clearance ID: Project # 117190

Project Team Members: Sara Czerwonka (Primary Investigator)
Victoria McArthur (Research Supervisor)

Study Title: Toward a Supplemental Haptic Interface to Aid Novice Gameplay

Funding Source: (If applicable):

Effective: February 18, 2022
Expires: February 28, 2023

This certification is subject to the following conditions:

1. Clearance is granted only for the research and purposes described in the application.
2. Any modification to the approved research must be submitted to CUREB-B via a Change to Protocol Form. All changes must be cleared prior to the continuance of the research.
3. An Annual Status Report for the renewal or closure of ethics clearance must be submitted and cleared by the renewal date listed above. Failure to submit the Annual Status Report will result in the closure of the file. If funding is associated, funds will be frozen.
4. During the course of the study, if you encounter an adverse event, material incidental finding, protocol deviation or other unanticipated problem, you must complete and submit a Report of Adverse Events and Unanticipated Problems Form.
5. It is the responsibility of the student to notify their supervisor of any adverse events, changes to their application, or requests to renew/close the protocol.
6. Failure to conduct the research in accordance with the principles of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans 2nd edition and the Carleton University Policies and Procedures for the Ethical Conduct of Research may result in the suspension or termination of the research project.

IMPORTANT: Special requirements for COVID-19:

If this study involves in-person research interactions with human participants, whether on- or off-campus, the following rules apply:
1. Upon receiving clearance from CUREB, please seek the approval of the relevant Dean for your research. Provide a copy of your CUREB clearance to the Dean for their records. See Principles and Procedures for On-campus Research at Carleton University and note that this document applies both to on- and off-campus research that involves human participants. Please contact your Dean’s Office for more information about obtaining their approval.

2. Provide a copy of the Dean's approval to the Office of Research Ethics prior to starting any in-person research activities.

3. If the Dean’s approval requires any significant change(s) to any element of the study, you must notify the Office of Research Ethics of such change(s).

Upon reasonable request, it is the policy of CUREB, for cleared protocols, to release the name of the PI, the title of the project, and the date of clearance and any renewal(s).

Please email the Research Compliance Coordinators at ethics@carleton.ca if you have any questions.

CLEARED BY: 

Date: February 18, 2022

Bernadette Campbell, PhD, Chair, CUREB-B

Kathryne Dupre, PhD, Co-Chair, CUREB-B
### B.5 COVID-19 Attestation

#### COVID-19 -- Attestation of Lead Researcher

This Attestation form is for REB purposes only. It is to be completed and submitted with any new Protocol Submission or Change to Protocol for research projects involving, or which will be amended to involve, in-person interactions with participants, whether on or off the Carleton campus.

For further information, see Principles and Procedures for On-campus Research at Carleton University. Please note that this document applies both to on- and off-campus research that involves human participants.

<table>
<thead>
<tr>
<th>1. Study Information</th>
<th></th>
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<tbody>
<tr>
<td><strong>Study Title</strong></td>
<td>Toward a Supplemental Haptic Interface to Aid Novice Gameplay</td>
</tr>
<tr>
<td><strong>REB Protocol Number:</strong></td>
<td>117190</td>
</tr>
<tr>
<td><strong>Submission Date (Today’s date):</strong></td>
<td>2022-04-15</td>
</tr>
<tr>
<td><strong>Lead Researcher Name and Email:</strong></td>
<td>Sara Czerwonka <a href="mailto:saraczerwonka@cmail.carleton.ca">saraczerwonka@cmail.carleton.ca</a></td>
</tr>
<tr>
<td><strong>Academic Supervisor (Name and Email address, if applicable):</strong></td>
<td>Dr. Victoria McArthur <a href="mailto:Victoria.mcarthur@cunet.carleton.ca">Victoria.mcarthur@cunet.carleton.ca</a></td>
</tr>
</tbody>
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<thead>
<tr>
<th>2. Attestation</th>
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<tbody>
<tr>
<td>I confirm that I will abide by the most current applicable local (provincial, regional, national) public health guidance, requirements and measures relating to COVID-19 infection control when conducting any in-person research activities.</td>
<td></td>
</tr>
<tr>
<td>Further, I will abide by current Carleton policy, and on-going changes thereto, including Environmental Health and Safety guidelines and complete on-line Infection, Prevention and Control training.</td>
<td></td>
</tr>
<tr>
<td>For further information on Environmental Health and Safety training, please contact <a href="mailto:ehs@carleton.ca">ehs@carleton.ca</a>.</td>
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<tr>
<th>3. Further Information</th>
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<tbody>
<tr>
<td>3.1 ☒ Upon receiving clearance from CUREB, I will seek approval of this project from my Dean’s Office. I will submit a copy of the Dean’s approval to the Office of Research Ethics prior to starting any in-person research activities. If the Dean’s approval requires any change(s) to study methods, I will notify the Office of Research Ethics of such change.</td>
<td></td>
</tr>
<tr>
<td>3.2 ☒ Any informed consent form, text or script used in this study includes the following language:</td>
<td></td>
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</tbody>
</table>

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Because this study involves in-person interactions, there is some risk that you may be infected with the COVID-19 virus during study participation. Researchers will take precautions in accordance with provincial, federal, Carleton University and other public health guidelines to minimize the risk of transmission of COVID-19. However, persons who are older, or who have certain medical conditions, and others, have been shown either to be at greater risk of contracting COVID-19, or to suffer more serious effects from the virus.

### 3.3 I will ensure the following infection control precautions are met while engaging in face-to-face research activities (please check all that apply).

- ☒ Screening of all participants and research team members. (Please describe, and identify any screening tool to be used, for example Ontario Screening Guidance Document found [here](#)).

  As this study will take place on campus, CUScreen will be the primary mode of COVID-19 screening. Participants will have to show their check-in screen for the building in which the study will take place and will be required to be fully vaccinated (at least 2 doses). Additionally, before beginning the study the participant will need to provide verbal confirmation in accordance with the Ontario Screening Guidance Document. The lead researcher will ask the participant the required questions and will only continue the study if the participant’s answers constitute a negative screening result.

- ☒ Ensuring that the setting or settings in which in-person interactions will be conducted are spacious enough to maintain physical separation, in accordance with applicable guidelines, between persons whenever possible. (Please explain if any exception are proposed)

  2 metres of distance will be always maintained between the participant and researcher throughout the study. The lead researcher will make contact with the computer station prior to the arrival of the participant to set up the appropriate windows and screens to allow the study to take place. The lead researcher will wear gloves and a mask while doing so to ensure minimal risk. Once the participant has arrived, all communication will take place from a safe distance.

- ☒ Ensuring an adequate supply and use of appropriate Personal Protective Equipment, including masks, shields, and other equipment. In general, the research team should supply participants with any needed PPE. (Please describe)

  The researcher will ensure that appropriate PPE is worn, including masks and gloves as required. The participant will be required to wear a mask for the duration of the interaction, and they will be supplied with high quality medical masks if they do not have one of their own. Additionally, participants will be required to sanitize their hands prior to entering the study space.

- ☒ Ensuring that research team members wash their hands before interacting with each participant and sterilize all potentially affected equipment and surfaces. (Please explain if any exceptions are proposed)

  As this study requires one group of participants to use a haptic interface attached to a pair of gloves, complete sterilization of the device will not be possible. To counteract this, the haptic interface will be attached to a new pair of gloves for each participant interaction. All other items that the participant interacts with will be sterilized before and after each interaction (i.e. chair, keyboard, mouse, computer screen, desk surface). All participants and researchers will be required to sanitize their hands before and after completing the study.
Bibliography


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