Robins, Joshua

Barrier Determination Framework for Video Game Analysis Regarding Users with Visual Impairments

BARRIER DETERMINATION FRAMEWORK FOR VIDEO GAME ANALYSIS REGARDING USERS WITH VISUAL IMPAIRMENTS

JOSHUA A ROBINS

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements for the degree of MSc by Research (Computer Science)

The University of Huddersfield

January 2019

Abstract

People with visual impairments are not often considered as a target market within todays growing video game industry. A lack of funded research and development focused on this issue has left few alternatives for the growing demographic of visually impaired players. The most prominent solutions derive from user adaptations or low budget audio game development.

Both adaptions have severe problems in their delivery of quality products to satisfy player needs, as well as cater to specific visual impairment types commonly found within the demographic.

This thesis aims to determine the individual abilities and needs of visual impairment types, specifically in relation to activity and apply theories of activity to produce a framework of analysis for gameplay activity, resulting in barrier determination within gameplay as well as analysis of suitability within gameplay for specific visual impairment types.

Table of Contents

List of Tables

List of Figures

Dedications and Acknowledgements

This paper is dedicated to the memory of the late Game Designer and composer Kenji Eno, his work and ethics contributing to designing games for visually impaired players was a primary influence on this work.

I would also like to Acknowledge my personal supervisor Dr. Carlo Fabricatore for his guidance and advice throughout my academic career, as well as the SCE Research Staff for their help throughout the course.

List of Abbreviations and Definitions

UI – User Interface
BDT – Barrier Determination Tool
NPC – non-playable character
HCI – Human-Computer Interaction

Introduction

Accessibility within video games is not a modern concept; accessibility has been a subject of attention within computing since 1998 (Bierre, et al., 2005) however it remains a subject of contention for users with visual impairments within the video game market, despite efforts made by smaller development companies (Peters, 2009). Adaptation is often a user-driven solution for players with visual impairments, (Plunkett, 2011), however despite this feat; the non-inclusive design of modern titles significantly limits the genre and content of games that can be adapted this way (Bierre, et al., 2005). There are cases of research-driven adaption of non-inclusive games such as 'AudioQuake' (Atkinson, Gucukoglu, Machin, & Lawrence, 2006) however, the adaptation of non-inclusive games is rare due to the cost involved in adapting titles not initially designed for players with visual impairments against the target market value (Scimeca, 2016). The alternative solution to adaptation is the development of consoles and game content that consider players with visual impairments during the development process, as opposed to adaptation afterward. Again, this is not a modern concept; game development that considers accessibility goes as far back in video game history as the release of text-based adventure games, largely due to the development of assistive technology such as text to speech (Archambault, Ossmann, Gaudy, & Miesenberger, 2007). However, the issue lies within the scale and quality of this adaptation due to lack of budget.

The most common of intentionally inclusive games are audio games, which use audio feedback (and occasionally haptic feedback) to deliver essential information to the player (Archambault, Ossmann, Gaudy, & Miesenberger, 2007), however these are often produced by small studios and individual hobbyists (Archambault, Ossmann, Gaudy, & Miesenberger, 2007), resulting in a potential lack of playability requirements that the majority of contemporary games focus on providing to players, this is reflected in reviews for audio games (Schamerhorn & Frison, 2004).
Additionally, inclusion within these types of games is often limited to a generalised outlook on the needs of visual impairments, as opposed to the abilities and requirements of specific visual impairment types, often resulting in disregard of multiple aspects of personal development and abilities found between the demographic of players with visual impairments. Many types of visual impairments can be acquired congenitally or at an age of developmental significance, resulting in aspects such as world view and linguistic ability to factor into a user's ability to understand aspects of audio games or further: any game that has been developed for users with visual impairments (Greenaway & Dale, 2017).

In both cases of inclusion, it is fundamental to understand what elements within contemporary video games are barriers to players with visual impairments, additionally, the severity of barriers regarding visual impairment types. A successful understanding of this could result in development of inclusive games of the same playability and entertainment standard as todays modern titles as well as identify potential cost-effective methods of adaptation of non-inclusive games via solutions to determined barriers. Furthermore, the ability to determine barriers within activities in general could allow for evaluation of impact on the function as well as the determination of areas for adaption within many fields external to video games, such as medical and educational applications. In response to this; this body of work proposes to explore the effect of visual impairment types on elements of player experience, create a methodology to categorize potential hindrances using activity systems and development of a framework that identifies and analyses barriers against player abilities.

1 Background

Visual Impairment and Blindness

Definition and Measurement

Visual impairments and blindness are diversiform in characteristics effecting many aspects of user ability, both cognitive and motor ability depending on the type of impairment and are medically defined by an individual’s spatial awareness and visual acuity. These definitions can be considered as a scale, measured by the visual acuity of an individual against ‘perfect vision’.
In a clinical sense the scale ranges from perfect human vision to total blindness and is usually expressed via decimal number or fraction correlating to the method of testing used, the results are then calculated comparatively to healthy vision via the subject’s ability to correctly read letters at a distance that progressively scale down in size per line (Kaiser, 2009).
An example of this is 20/20 (foot) or 6/6 (meters) defines the subject’s ability to successfully interpreted visual information from 20 ft the same as an individual with perfect vision can from 20 ft away, giving 20/20 or 6/6 the categorisation of ‘normal vision’, other measurements are expressed in relation to 20/20 or 6/6 as a fraction, or 1.00 as a decimal.
A subject with 20/32 (feet) or 6/9.5 (meters) vision can see at 20 ft the same as an individual with perfect vision can from 32ft away and so on.

On the measurable scale, low vision is defined by a subject's vision being 20/70 (feet) or poorer (Duffy) however functionally it describes sight loss that is unable to be aided by prescription aids such as contact lenses, glasses or medical treatments (NHS, 2017).
‘Visual impairment’ is a heterogeneous term for multiple levels of visual acuity ranging from low vision to total blindness (Dandona & Dandona, 2006). The most recent classification of visual impairments from the World Health Organisation (The International Classification of Diseases 11 (2018)) defines two primary classes of visual impairment being distance and near vision impairment (World Health Organisation (WHO), 2018) with subsidiary classifications of mild (worse than 6/12), moderate (worse than 6/18), severe (worse than 6/60) and blindness (worse than 3/60) for distance vision impairment.
There are separate categorisations within the provided definitions based on the attributes of the affliction, which are often characterised by common trends in subject’s activity skill sets and physical/ psychological perspective (Schinazi, 2007). Congenital Blindness is defined by eye conditions prenatally developed by both infection and non-infection based causes (Janicijevic-Petrovic, Sarenac-Vulovic, Janicijevic, Vujic, & Vulovic, 2013) and can cause severe visual impairment in developmental stages and adulthood if undetected (Gogate, Gilbert, & Zin, 2011). Unlike adventitious visual impairments, congenital blindness has unique characteristics regarding adaptation and concepts such as self and world view as well as psychological differences in later life stages (Schinazi, 2007).

Broad Scale

In 2010 the World Health Organisation estimated 285 million blind people worldwide, a further 246 million people with low vision (World Health Organisation, 2012). In the World Health Organisation European areas alone, it was estimated that per million population: 31.7 thousand were visually impaired, 28.7 thousand suffered from low vision and 3 thousand were completely blind (World Health Organisation, 2012).
In 2016 3.1% of Americans aged 0-64 suffered from visual disability (Institute of Disability/UCED, 2016) equalling to 10,025,400 visually disabled people aged 0-64 in the United States during 2016 (calculated using census statistics from the U.S. Census Bureau) (U.S. Census Bureau).

Localized

Within the UK an estimate of 350,000 people are registered as partially sighted or blind (RNIB, 2018) with more than 2,000,000 living with visual impairments serious enough to significantly effect daily life (RNIB). This number is also set to double to an estimated 4,000,000 by 2050 due largely to health-related conditions that increase chances of visual impairments such as Diabetes, which is also increasing in frequency (RNIB), these figures determine that visual impairment accessibility is in growing demand worldwide.

Player Experience

User Experience

User Experience (UX) is a term describing many aspects that contribute towards what a target user experiences during interaction, encompassing: needs, requirements, entertainment, satisfaction, marketing, engineering, interface design and industrial design (Nielsen & Norman, The Definition of User Experience (UX)). UX is often referred to as either a step in the design process (being the consideration for the user's requirements), or as research, where UX is tested and evaluated with the intention of problem-solving or improving aspects of design.
The term 'User Experience' was popularised by Don Norman between 1993 and 1997 whilst working for Apple (Norman, 2016), at the time consideration for some aspects of UX did exist however they were often referred to as Usability and Human Centred Design (Cummings). Norman intended the term to encapsulate all aspects of experience as opposed to specifics such as the user interface or consideration for human interaction and believes that the term is often misused as a synonym for smaller aspects of UX such as user interface (UI) design or app design (Norman, 2016).

Usability

Usability and user experience's relationship is sometimes misunderstood and perhaps even thought of as the same thing. Usability measures quality of interaction ability, when referring to digital mediums it usually indicates the quality of experience with the UI (Nielsen, 2012). Like UX, usability is commonly used in both a design context, being a factor in one or more design stages or as a measurement of quality when evaluating design (Nielsen, 2012), UX however is a much wider concept of which usability falls under.
Usability focuses on the functionality and efficiency of interface, whether the user will enjoy using it, whether it's intuitive and easy to use, and is a vital step in design and testing. Nielsen defines usability via 5 essential factors (Nielsen, 2012):

- **Learnability** – The ease of carrying out tasks the first time
- **Efficiency** – The speed of which users can complete tasks as they learn
- **Memorability** – How easily users can continue performing tasks after a period of disuse
- **Errors** – The severity and quantity of errors users can make and insight into whether users can overcome errors
- **Satisfaction** – Whether users enjoy using the system/interface

Usability is important within design as it often defines whether a user will use the subject; with websites, if a user finds it hard to navigate through the site, they will often leave to find an alternative similarly regarding software; if an employee finds it difficult to learn or master software it costs time, efficiency and quality to the employer.

Human Computing Interaction

Unlike usability that is both the practice of design and a measurement; Human Computing Interaction (HCI) is solely a practice that considers the many aspects of social and cognitive sciences related to the interaction between human and digital mediums enveloping the cycle of searching, retrieving and processing information with the goal to produce effective and usable systems (Issa & Isaias, 2015), to which usability is part of when applied as a practice of design for digital systems.
Factors that comprise within HCI (Preece, et al., 1994):

- **Organisational factors** – Such as training given to employees, or roles within an organisation
- **Environmental factors** – Factors within a system environment such as heating, lighting or noise
- **Health and Safety** – The potential for negative physical and/or psychological effect on the user
- **The User** – A user's experience level, motivations, bias and personality
- **Comfort Factors** – Input/output devices, language, graphics, colour, user support, and multimedia
- **User Interface** – Dialogue structure, layout, icons and aesthetics
- **Task Factors** – Repetition, difficulty, time, skill requirements and allocation
- **Constraints** – Cost, budget, manpower, timescale, staff ability, equipment and environment
- **System functionality** – Software, hardware, and application
- **Productivity factors** – Increase/decrease in creativity, quality, errors, labour, production time and innovation

Player Experience and Playability

Player experience is an intrinsically driven outcome from the player and occurs both during and after game play and is derived from the interaction between the player and the game, whereas playability is an outcome from the game, and is used to measure experience (Nacke, 2009).

The term 'player experience' was developed as a necessity to define what users may experience during interaction with video games specifically, as video games could be considered a 'special' interactive system (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009), due to video games primary goal as an entertainment system for the user, as opposed to functional operations as for example a website as a websites subsidiary goal may be to entertain a user however, its primary goal is to provide information to the user, thus conforming to the framework of design and evaluation that usability and user experience provides. This adds an additional layer to player experience as success is determined not only by functional ability but also by user entertainment.

What defines player experience, as well as what elements of gameplay are most important regarding player experience are both well considered within contemporary game design however, many sources have different views on both the strict definition of player experience as well as what factors are important for successful, positive and/or intended player experience (Wiemeyer, Nacke, Moser, & Mueller, 2016). For example, during research on defining immersion as a factor contributing to player experience; Brown and Cairns noted immersion to be often critical to game enjoyment as well as noting that levels of immersion were results of individual abilities throughout the participants, such as empathy, resulting in different experiences via separate levels of immersion (Brown & Cairns, 2004), suggesting that not only is immersion an important influencer of player experience but also that player experience is derived from an individual's abilities and characteristics.

Player experience can result in a wide range of psychological, physiological and behavioural outcomes (Wiemeyer, Nacke, Moser, & Mueller, 2016) and is an individual response based on many characteristics of a player, these can effect many factors of gameplay such as actions, choices, reaction to outcomes and influencers as well as varying levels of immersion. Due to the number of factors both influencing player experience and the elements of the outcome of player experience it's understandably difficult to accurately measure and record.
Wiemeyer et al. (Wiemeyer, Nacke, Moser, & Mueller, 2016) conducted extensive work regarding factors that define and measure player experience, and identify multiple approaches and perspectives regarding the process and methodology of player experience. This work included the collective factors found through multiple models describing the structure of player experience.

This summarization included:

- Curiosity
- Fantasy
- Tension
- Competence
- Autonomy and control
- Involvement and engagement
- Immersion
- Challenge
- Positive and negative emotions
- Intrinsic goals
- Feedback and evaluation

It was also noted within the works that player experience was not solely defined by psychological outcomes and required an integrative model to measure the multi-faceted concept, physiological, psychological and behavioural models of testing were additionally used to measure player experience,

Playability is separated from usability via the notion that usability can measure efficiency within a system, such as measurement of completion rates and errors however playability can additionally measure factors of experience within gameplay such as enjoyment (Nacke, 2009). Gonzalez-Sanchez et al. define playability as 'a set of properties that describe the player experience using a specific game system whose main objective is to provide enjoyment and entertainment' (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009) and suggests that although playability is based on usability with a focus on games; it additionally uses an extensive elements to measure player experience. They give an example of this via the factor of 'effectiveness' as this within usability terms could relate to the speed of which a task is performed within software, whereas within a game; playability measures player driven experiences such as achieving goals within the game translating to how effective the game is at allowing the player to achieve said goals.

As playability is affected by elements of entertainment as well as function it's considered to have more elements of application for the user:

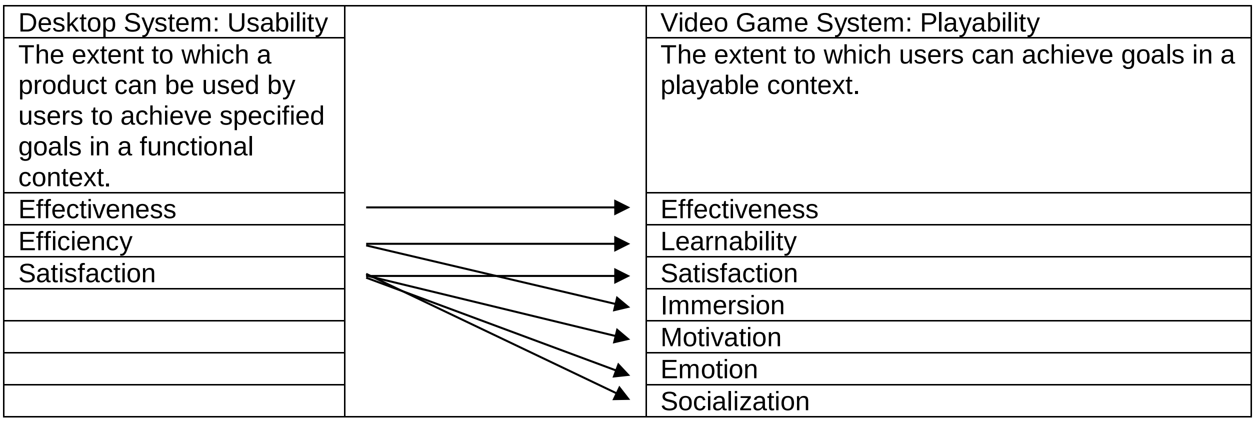

Figure 1 Usability to Playability attributes
(Adapted from (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009) *(Fig.1.))*

As additions to player satisfaction to be considered in this model; efficiency is transformed to learnability with subsidiary facets of game knowledge, skill, difficulty, frustration, speed and discovery (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009) (Fig.2.) which contribute to a players ability to master rules and mechanics within a game.
As well as this transformation to learnability; Immersion, motivation, emotion, and socialisation are also considered as contributing factors to playability within a game (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009).
In correlation to adapting usability to playability; the video game industry also often uses a model of development based on that of software development, however with additional stages and adaptions to accommodate the additional needs (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009).

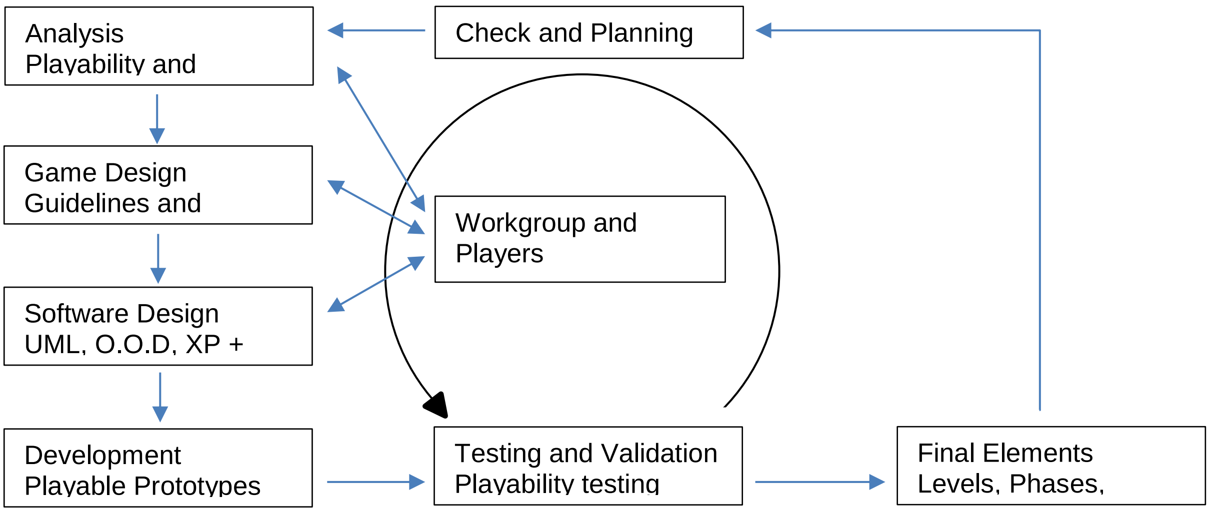

Figure 2 Process of playability within video game development
(Adapted from (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009) *(Fig.4.))*

It's been argued that playability consists of methods used to improve design through evaluation, whereas player experience methods evaluate the player to improve gaming using both to create a relationship between game, player, and design (Nacke, et al., 2009).

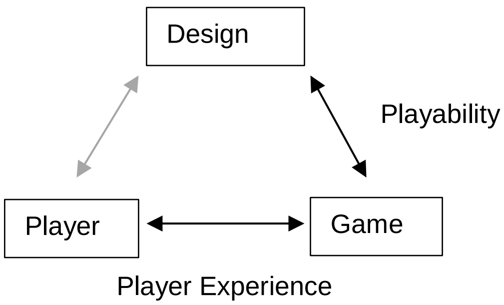

Figure 3 Relationship between Player Experience and Playability
(Adapted from (Nacke, et al., 2009) *(Figure1))*

Activity Theory

Activity Theory (AT) has roots in the works of Lev Vygotsky and his students in the 1920's (Hasan & Kazlauskas, 2014) as a means to better understand and rationalise human behaviour, as well as distinguish human behaviour as intentional unlike animals, however it has been evaluated and built upon multiple times since with regard to other contemporary applications, particularly recently as the demand for framework relating to HCI as well as criticisms of HCI's application have grown (Kaptelinin, Kuutti, & Bannon, 1995).
The core of activity is the relationship between the subject (being the subject of engagement) and the object (embodying the focus of activity resulting in activity outcome) (Hasan & Kazlauskas, 2014), Vygotsky defined activity as an analytical relationship between the subject and object where the object remains inactive whilst the subject adapts and reinterprets the object through the process of activity, he also proposed that this is achieved through the use of 'tools'.
Aleksei Leontiev, whom was one of Vygotsky's students developed activity theory from the perspective of individual activity with a focus on psychology, determining a construct of holistic activity that often forms around social collaboration, including the consideration for the social environment of which the activity takes place, be it cultural or historical (Kaptelinin V. , 1996). Leontiev's work also proposed activity is at the top of the human behavioural process, defined as a motivationally driven long-term process, whereas actions being below activity defined as lesser tasks relying on activity to become meaningful demonstrated in the figure below:

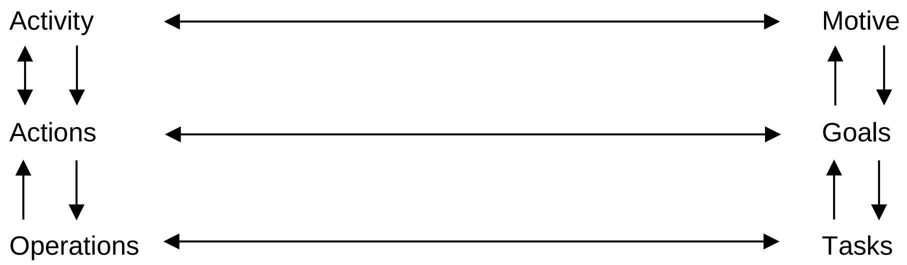

Figure 4 Leontievs' Activity Hierarchy
(Adapted from (Hasan & Kazlauskas, 2014) *(Figure2.)*

Within an activity mediation is controlled using tools, which include both psychological and physical tools used to accomplish tasks, as well as the context of the activity. In this sense, the tool is used both to determine the potential outcomes of activity as well as evaluating social and historical environments. At this point activity theory transforms for application from individual centred activity to inter-connected socio-influenced activity.
Further adaption on activity theory was produced by Yrjö Engeström to deliver a dynamic activity system that defines the object within activity as a transformative aspect influenced by interpretation and conceptualisation until producing an outcome, thus integrating environment and subject influencers interact with activity (Engeström, 2006), this was named 'cultural-historical activity theory'. Engeström produced a widely recognised summary of activity in the form of the below graph combining internalisation an externalisation processes, externalisation being creative activity resulting in objects and internalisation being the process of recycling culture and history by intergrading subjects into the activity system (Engeström, 1987):

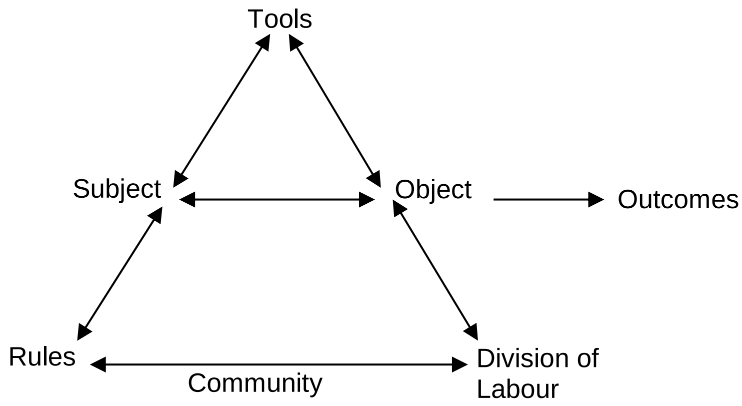

Figure 5 Theory of Activity (Engeström)
(Adapted from (Hasan & Crawford, 2007) *(Figure2))*

In this diagram of activity Engeström demonstrates activity mediated by the community, as well as tools (primary and secondary) via division of labour and rules to produce outcomes separate to the object by the subject (Hasan & Crawford, 2007).

Activity theory can be applied as a framework to analyse complex activities within a system, particularly considering human-computer interaction, where both influencing human elements/behaviours can be applied to activity common in technological mediums. This can be used to determine sense within both individual and group activities within systems allowing for evaluation as well as consideration for interactive design.
An example of this is within Dr C. Fabricatore's work in which activity theory is used as a framework to analyse player activity within games and justify goal-oriented meaning-making processes within games (Fabricatore, 2018).

Self Determination Theory

Self-determination theory is a psychological theory of motivation as well as development and wellness, led by the works of Edward Deci and Richard Ryan. Alternative motivational theories within psychology have attempted to develop structures regarding motivation with a focus on defining motivation as a measure of outcome, for example how to make someone less or more motivated to achieve something (Greenberg, 2017), however the works of Deci and Ryan focus on the categorisation of motivation and the characteristics and outcomes that are delivered by such categories.

Self-determination theories structure is split into two primary categories of distinction; the first being types of motivation. The primary types are defined as autonomous motivation and controlled motivation. Autonomous motivation describes self-induced motivational reasoning, when an individual is displaying signs of intrinsic willingness, acting on self-volition and choice. Contrast to this: controlled motivation is when motivation exists due to external factors that pressure or demand an outcome from an individual, such as to gain a reward or avoid a consequence (Ryan & Deci, 2012).
Many elements of organisation that aim to motivate individuals such as employers motivating an employee to perform better often follow structures of controlled motivation, with the addition of reward systems, such as performance-based bonuses as well as deadlines contributing to external pressure of an individual, whereas it's proven that individuals that are autonomously motivated perform better in many areas such as output performance, engagement, and wellness resulting in greater successes of outcome (Ryan & Deci, 2012).

The second distinction of self-determination theory is the theory of human needs, which states that all humans have a set of psychological needs that must be met in order to achieve optimal wellness and optimal performance especially regarding motivation (Ryan & Deci, 2000).
These needs are autonomy, competence, and relatedness.
Competence is described as the need to feel effectiveness and confidence in relation to a task, as well as control and mastery (White, 1959). Relatedness is described as the need to feel considered and cared for as well as the experience of providing care for others and feeling belonging and connection within a social

group, structure, movement or concept (Leary & Baumeister, 1995). Autonomy describes the innate need to be directed by self-motived purpose as opposed to controlled or external motivations and although described initially as a categorisation of motivation it is also considered a base human psychological need. It's important to note that this is not related to a sense of independence as this would hinder the need for relatedness (Deci & Vansteenkiste, 2004).

The concepts of human psychological needs within self-determination theory are important as they universally measure and evaluate the factors of which will promote or hinder autonomous motivation, self-determination theory promotes the logic that if an individual's needs are met then they will be autonomously motivated and thus positive outcomes will follow in both the individuals wellness and performance as well as outcomes of activity, countering this; if needs are not met; negative outcomes will follow in both the individuals wellness and performance as well as outcomes of activity.
Application of self-determination theory is applied widely in fields such as healthcare, education, and work environments as well as more recently: motivational studies regarding video games (Ryan, Rigby, & Przybylski, 2006).

2 Impact of Visual Impairments on Player Experience and Playability

Playability is used as the measurement of success within player experience (Nacke, et al., 2009). Player experience and playabilities successes can be measured by player feedback and expert reviews (Valve Corporation, n.d.) however, the accuracy of feedback varies on multiple bias such as preferences of game type but also the player skill set, for example: a player who is adept at racing games may not be particularly motivated whilst playing a fantasy adventure game if they find it more difficult. Similarly, the bias and skill set of a player with visual impairments may greatly affect player experience and must be considered for designing inclusive games or adapting non-inclusive games for players with visual impairments. This section explores the characteristics of various types of visual impairment as well as the skill sets sufferers are likely to possess to result in estimating potential effects on player experience and playability during gameplay.

Choosing Visual Impairments

Visual impairment types must be selected so that a clear set of characteristics is used to analyse against playability as visual impairments range in their effects upon the individual regarding motor and cognitive ability.
When determining visual impairments for the purpose of analysis, it's appropriate to consider two factors:

- The range of characteristics between the visual impairment types
- The relativity of visual impairment types regarding the demographic of video game players

A hybridized selection of visual impairments considering both aspects will allow for a broader understanding of how visual impairment characteristics can affect player experience, as well increased relevancy to demographics related to the study.
The visual impairments listed exhibit a wide range of defining factors such as age demographic effected, length of effect, the scale of vision loss and effects on psychological and physical skills.

Congenital Blindness
Inherited, effects babies, immediate total blindness in most cases (Janicijevic-Petrovic, Sarenac-Vulovic, Janicijevic, Vujic, & Vulovic, 2013).
This is not a specific condition however is an important category of impairment type, chosen as it affects vision from birth resulting in separate psychological and physical development in an individual than a visual impairment that is developed post-infancy.

Amblyopia
Caused by lack of use of usually one eye, effects children, reduced vision and blindness if untreated (Chen & Cotter, 2016).
Chosen as it (in most cases) effects one eye giving a unique disability regarding spatial awareness.

Cataracts
Usually caused by age degeneration however genetic disorders can increase the risk of cataracts, effects 50+ age most commonly, gradual deterioration of vision (RNIB, n.d.).
Chosen as it was the 3rd most common visual impairment in the UK during 2016 (RNIB, 2016).

Diabetic Retinopathy
Effects those with diabetes, symptoms include reduced vision and blindness if untreated (RNIB, n.d.).
Chosen as it is caused via an external health issue.

Glaucoma
Caused by increased pressure inside the eye, mostly affects older adults though babies can be born with it, often results in permanent vision loss although most retain useful vision (RNIB, n.d.).
Chosen as it is degenerative however doesn't usually result in complete blindness.

Macular Hole
Caused by age degeneration, affects older adults, progressive loss of central vision (RNIB, n.d.).
Chosen as it affects central vision specifically and has circumstances that increase the odds of developing.

Trachoma
Caused by contagious microorganism ‘Chlamydia Trachomatis’, effects individuals in poorer countries with poor sanitation, if not treated may cause blindness (WHO, 2018).
Chosen as it’s spread through contagious disease and effects a large demographic outside the UK. Figures estimate affecting about 1.9 million people worldwide (WHO, 2018) however is largely treatable.

Physical Damage/Loss of Eye (optic nerve injury)
Caused by blunt force and can be an additional effect of other physical damage, has a wide range of effects on visual ability depending on the incident and area damaged, often results in total blindness in at least one eye (RNIB, n.d.).
Chosen as has a varied effect on vision but also that it has varied physiological and psychological effects on affected individuals (Kondo, Tillman, Linberg, Schwartz, & Odom, 2013).

Myopia
Develops in nearsighted eyes and abnormal corneas, effects individuals with nearsightedness, can be degenerative and cause legal blindness (RNIB, n.d.).
Chosen as it is a mild visual impairment that is relatively common.

Retinitis Pigmentosa
Inherited degenerative disease, total blindness is rare however individuals’ visual field will deteriorate causing tunnel vision (RNIB, n.d.).
Chosen as it affects visual field around the center of vision (contradictive to Macular Hole) and has very little regarding a cure (RNIB, 2017).

Categories of Skill

As we consider player experience as not only a framework for activity within a game but also the outcome and feedback process by the player; it’s important not only to consider visual impairments effect on aspects such as motivation but also its individual effect on a player’s ability to understand and perform an activity.
The effects of specific visual impairments upon an individual or collective should consider aspects of ability determined by physiological and psychological skillsets displayed during development relevant to player experience, allowing for creation of a framework to analyse each visual impairment (Strickling) (DeCarlo, McGwin, Bixler, Wallander, & Owsley, 2012).

As the skills will be implemented in the analysis as a measure of effect; a range of effect is provided from 1 – 5 for each skill. Scores will relate to the likely prognosis of each visual impairment as well as available information that inform an individual’s experience or suggested experience with the visual impairment stated.

Sensory Skills

1. **Sensory skills –** The subjects’ ability to verify, understand and rely on input gained by senses excluding sight successfully.
   1/5 – Struggles greatly with understanding and relying on input from taste, touch, sound, and smell.
   5/5 – Can process information gained from taste, touch, sound, and smell and use it to function to a high level.

Motor Skills

1. **Motor Skills –** The subjects’ ability to successfully coordinate physical tasks (gross motor skills and fine motor skills here are both considered as one score).
   1/5 – Struggles greatly with coordination and performing physical tasks.
   5/5 – Can perform physical tasks and coordination to the same level as an individual with a visual impairment.

Cognitive Skills

1. **Acceptance –** The subjects' willingness and/or ability to integrate with reality outside their 'inner world' and desire for social interactions.
   1/5 – Does not accept the reality external of the individuals' needs and thoughts and feels little to no desire for social interaction.
   5/5 – Finds reward from social interaction and accepts a concept of reality like that of an individual with a visual impairment.
2. **Construct of World** – The subjects' successful understanding of reality compared to an individual with a visual impairment.
   1/5 – Does not understand the world outside their needs and self.
   5/5 – Understands a similar concept of reality to an individual with a visual impairment.
3. **Object Permanence** – The subjects' understanding of objects existence outside present sensory experience.
   1/5 – Will often forget about objects existence unless currently holding, smelling, tasting or hearing it.
   5/5 – Demonstrates good spatial memory skills regarding objects previously interacted with.
4. **External Relationship** – The subjects' motivation to cause action and effect.
   1/5 – Does not understand their ability to create action/reaction and is not motivated to retain pleasurable stimuli.
   5/5 – Understands cause and effect to a similar level to an individual with a visual impairment and is motivated to retain pleasurable stimuli.
5. **Classification** – The subjects' ability to identify variables and consistencies of objects.
   1/5 – Struggles to identify differences and/or similarities between objects.
   5/5 – Can easily identify differences and/or similarities between objects.
6. **Conservation** – The subjects' ability to retain attributes of an object such as weight, length, and volume.
   1/5 – Struggles to retain attributes of an object.
   5/5 – Can easily retain attributes of an object.
7. **Relationship of interaction** – The subjects' ability to socially interact despite the absence of visual cues such as facial expressions.
   1/5 – Often misinterprets information due to the lack of visual elements in social interaction.
   5/5 – Comprehension of social interactions is understood despite a lack of visual elements.

Language Development

1. **Use of language** – The subjects' use of language experience to communicate successfully.
   1/5 – Initiates few questions and has a lack of adjectives. The language used is echolalic, preservative and sparse.
   5/5 – Language used is intentional and functional.
2. **Personal pronoun** – The subjects' correct use of the personal pronoun 'I' backed with a regular sense of themselves separate from the environment.
   1/5 – Self-concept is lacking and often confuses/struggles to comprehend pronouns.
   5/5 – Self-concept and use/understanding of personal pronouns are similar to that of an individual without a visual impairment.

Experience

1. **Exploration** – The subjects' willingness to explore new experiences.
   1/5 – Hesitant to explore new experiences (commonly from fear of the unknown).
   5/5 – Exhibits healthy motivation to explore and seek out new experiences.

Analysis of Skill Set Against Visual Impairment

Table 1 Sources

The scores are estimations determined from sources found in the ‘choosing visual impairments’ section giving evidence of the variance between individual visual impairments likely effect on skill sets.

		VISUAL IMPAIRMENT									
		Congenital Blindness	**Amblyopia**	**Cataracts**	**Diabetic Retinopathy**	**Glaucoma**	**Macular Hole**	**Trachoma**	**Physical Damage**	**Myopia**	**Retinitis Pigmentosa**
SKILLS	**Sensory Skill**	1/5 – 3/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	2/5 - 3/5	1/5 – 3/5	1/5 – 3/5	2/5 – 3/5
	Motor Skill	1/5 – 2/5	2/5 – 4/5	2/5 – 4/5	2/5 – 3/5	3/5 – 4/5	1/5 – 3/5	2/5 – 3/5	2/5 – 4/5	3/5 – 5/5	2/5 – 4/5
	Acceptance	1/5 – 3/5	3/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	2/5 – 4/5	1/5 – 3/5	3/5 – 5/5	4/5 – 5/5
	Construct of world	1/5 – 3/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	2/5 – 4/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5
	Object Permanence	1/5 – 2/5	3/5 – 5/5	4/5 – 5/5	3/5 – 4/5	4/5 – 5/5	3/5 – 5/5	1/5 – 3/5	3/5 – 4/5	4/5 – 5/5	4/5 – 5/5
	External Relationship	1/5 – 2/5	4/5 – 5/5	2/5 – 4/5	2/5 – 4/5	4/5 – 5/5	2/5 – 4/5	1/5 – 3/5	3/5 – 5/5	4/5 – 5/5	3/5 – 4/5
	Classification	1/5 – 2/5	3/5 – 5/5	2/5 – 3/5	2/5 – 3/5	4/5 – 5/5	2/5 – 3/5	1/5 – 3/5	4/5 – 5/5	2/5 – 4/5	2/5 – 3/5

	Conservation	1/5 – 2/5	4/5 – 5/5	3/5 – 4/5	2/5 – 3/5	3/5 – 5/5	1/5 – 3/5	1/5 – 3/5	3/5 – 4/5	2/5 – 4/5	2/5 – 3/5
	Relationship of interaction	1/5 – 2/5	3/5 – 5/5	2/5 – 3/5	2/5 – 4/5	4/5 – 5/5	2/5 – 4/5	1/5 – 3/5	2/5 – 5/5	4/5 – 5/5	3/5 – 4/5
	Use of language	1/5 – 2/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	1/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 - 5/5
	Personal pronoun	2/5 – 3/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5	1/5 – 5/5	4/5 – 5/5	4/5 – 5/5	4/5 – 5/5
	Exploration	1/5 – 4/5	3/5 – 5/5	4/5 – 4/5	2/5 – 3/5	2/5 – 4/5	2/5 – 4/5	1/5 – 4/5	2/5 – 4/5	3/5 – 5/5	2/5 – 4/5

Table 1 Analysis of skill sets against visual impairment type

Results from table 1 show the variance of likely ability throughout the chosen impairments, determining that specific visual impairments should be considered when analyzing player experience as opposed to singularly whether the user has a visual impairment or not.

Results also show that congenital visual impairment types greatly impact the individuals cognitive, motor and language abilities as well as physical and psychological development, whereas non-congenital visual impairments acquired in adult stages of life can somewhat allow for retainment of skills pre-acquisition however, congenital visual impairment types display the advantage of developing skills of coping and adaption from birth, whereas those who gain visual impairments or blindness in later stages of life have more difficulty adjusting and adapting, particularly if the impairment isn’t degenerative over a long period of time.

There are also psychological effects on factors such as outlook, motivation, self-image, confidence, and positivity on those who develop visual impairments later in life as they are subject to a comparison of quality of life and ability pre-impairment and post-impairment, whereas the individual born with a visual impairment has nothing to compare with. These factors will affect player experience both practically and in a sense of individuals concept of input, activity comprehension, emotional response, and motivations during gameplay.

There is also evidence of trends between impairment characteristics such as those that are likely to have been acquired post-development displaying better cognitive ability regarding activity, whereas any congenital impairment is likely to perform motor driven tasks slightly better than acquired impairment types, but suffer a lack of cognitive abilities such as world view and concept of self,

Due to these conclusions its proposed that visual impairments are categorized to represent these characteristics:

Acquired visual impairment – Impairments attained after developmental periods of life.
Congenital visual impairment – Impairments attained prenatally.

Further, acquired and congenital impairments can be subcategorized into full vision loss and partial vision loss as these are factors that also share trends between affected skills in table 1:

Partial Vision Loss– For example low vision, intermittent blindness and loss of vision in one eye.
Total Vision Loss– The total loss of vision in both eyes.

Considering Playability

Using categories of player experience adapted from web user experiences (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009) we can measure the level of how playability is affected by the 4visuual impairment category types in a similar system to table 1, giving further insight to how impairment characteristics may affect activity during gameplay. These were chosen over other frameworks of playability (Wiemeyer, Nacke, Moser, & Mueller, 2016) as they included factors that were estimated to better record playability regarding players with visual impairments, specifically due to the conclusions established from table 1. Although Wiemeyer et al summarised the playability factors found within multiple frameworks of evaluation; they also concluded that certain elements were structured into separate components as well as elements listed were not particularly separable from one another, suggesting as compiled elements they may not suit a complete evaluation when used together, whereas the playability model proposed in the work of Gonzalez et al was suitably extensive, factoring in multiple characteristics of player experience and working well as a complete method (see fig. 2 (González-Sánchez, Gutiérrez Vela, & Padilla-Zea, 2009)).

The following are the proposed categories to measure playability:

Motivation – This describes Intrinsic Motivational attributes found in Self Determination Theory (Ryan & Deci, Self-determination theory and the facilitation of intrinsic motivation, social, 2000) such as curiosity and player self-improvement.

> **1/5** – Not confident in ability, unwilling to interact with game elements and mechanics, unwilling to make progress.
>
> **5/5** – Confident in ability, willing to interact with multiple game elements and mechanics, intrinsically driven to progress.

Effectiveness – The time taken to complete the goals and objectives of the game whilst the player has a positive experience.

> **1/5** – Does not find entertainment in completing goals and objectives.
>
> **5/5** – Shows interest in completing optional tasks as well as finds enjoyment in completing primary goals.

Learnability – This defines the players understanding and mastery of the game's mechanics (factors of learnability may include game difficulty, the frustration level of player, the speed of learning and discovery techniques).

> **1/5** – Easily frustrated at lack of progress, uninterested in mastery, finds learning game mechanics difficult.
>
> **5/5** – Shows interest in mastery, is persistent despite failure, understands concepts and mechanics easily.

Immersion – The state of immersion the player experiences during gameplay (believability in world, consciousness awareness, realism within game and absorption in-game).

> **1/5** – Remains on the level of 'engagement' (Brown & Cairns, A Grounded Investigation of Game Immersion, 2004) throughout gameplay.
>
> **5/5** – Frequently reaches 'total immersion' (Brown & Cairns, A Grounded Investigation of Game Immersion, 2004) during gameplay.

Satisfaction – This defines the amount of pleasure a player gains, how much fun they have and their experience of attractiveness and or disappointment with the game.

> **1/5** – Does not find the game enjoyable, is not satisfied during gameplay.
>
> **5/5** – Finds the game very enjoyable.

Emotion – A player's involuntary emotional reaction to the game as well as automatic behaviors in reaction to games content.

> **1/5** – Player has no emotional engrossment or reaction to gameplay elements/events.
>
> **5/5** – Player frequently has emotional reactions resulting from gameplay elements/events.

Socialization – A player's experience with social aspects of gameplay experience such as social consequence/reaction, sharing mechanics, social perception, communication, and social motivation.

1/5 – In the context of a multiplayer game: the player isn't willing to interact with others, doesn't value/understand the individual contribution to a group effort, and disregards communication from others.
5/5 – In the context of a multiplayer game: the player is willing to interact with others, enjoys collaboration, understands group contribution, communicates with others.

Analysis of Visual Impairments Against Playability Factors

Table 2 Sources

The scores are estimations determined from sources found in the 'considering playability' section giving evidence of the variance between the concluded categories of visual impairment (derived from table 1's results) and the likely effect on determined categories of playability.

	Categories of Playability						
	Motivation	**Effectiveness**	**Learnability**	**Immersion**	**Satisfaction**	**Emotion**	**Socialisation**
Acquired visual impairment	1/5 - 3/5	4/5 - 5/5	4/5 - 5/5	4/5 - 5/5	1/5 - 5/5	4/5 - 5/5	2/5 - 3/5
Congenital visual impairment	2/5 - 4/5	2/5 - 4/5	2/5 – 4/5	2/5 – 3/5	1/5 – 5/5	1/5 – 3/5	2/5 – 3/5
Partial vision loss	1/5 – 2/5	2/5 – 4/5	2/5 – 4/5	2/5 – 4/5	1/5 – 5/5	2/5 – 4/5	2/5 – 4/5
Total vision loss	2/5 – 4/5	2/5 – 4/5	2/5 – 4/5	2/5 – 4/5	1/5 – 5/5	2/5 – 4/5	2/5 – 4/5

Table 2 *Analysis of visual impairment category against playability factors*

Player Experience (via acquired visual impairments)

Players with acquired visual impairments will commonly suffer from depression and/or anxiety due to their condition (Thomas Pocklington Trust, 2016), this is more prevalent in younger ages as older ages seem to accept it in conjunction with other deteriorative health issues they may experience.
This is likely to effect the players intrinsic motivation at least initially, players with acquired impairments take longer to complete tasks due to impairment as difficulty reading text, processing level layout and understanding objectives relative to such take longer to understand then complete, this can lead to negative aspects of learnability such as frustration and anger especially if the game has been adapted rather than intended for those with acquired impairments. Many players seem to choose adapted games or even non-adapted games if possible as they enjoy the level of immersion it provides compared to audio games as more senses are engaged at one time.
Players with acquired visual impairments have slightly less positive experience with satisfaction elements during gameplay as disappointment in gameplay can stem from a feeling of being let down as a consumer due to disability and mentioned difficulty regarding learnability factors however, in contrast to that they have a separate level of satisfaction upon completing objectives and games due to their disability, this can come in the form of pride and self-achievement after a stage of perseverance.
Emotional reactions from players are predicted to be similar to players with no visual impairments, however, it's hypothesized that often the reactions may be delayed or not of the same level of response as those without an impairment. This prediction is based on the likelihood that many players with acquired visual impairments developed the ability for emotional reactions relevant to gameplay preceding the acquirement of the visual impairment, based on the characteristics of common types of acquired

impairments, those being usually degenerative due to age, an effect from a disease or infection or result of injury. Therefore, likely maintaining the same emotional reaction abilities after acquiring visual impairment.
This may be a result of the lack of full visual stimuli from the game for the player; for example, it's unlikely a scene within a game designed to provoke an emotional response through audio and visual information will have the same effect on a player with no visual processing ability as it will a player with visual and audio processing abilities.
This is only the case with adapted and non-adapted games as most intended games do not provide contextual emotional cues due to choosing practicality over immersion.
Regarding socialization factors, players with acquired visual impairments seem to greatly appreciate social elements within games and if able; this greatly improves positive player experience through motivation, emotion, learnability, and satisfaction.

Player Experience (via congenital visual impairments)

Perhaps the most prevalent observation with players with congenital visual impairments is that their self-awareness and concept of the world are commonly unique in contrast to players with acquired visual impairments (Bolat, Dogangun, Yavuz, Demir, & Kayaalp, 2011). This is to be a consideration when later thinking about goal formation and how players take information and how they transform this into action. Table 2 is a strong indicator that motor skills suffer in comparison to a player with acquired impairments, the scale of which depends on two factors:

1. The age of the player, the younger they are the less practice and time has been spent developing motor skills.
2. 2. The amount of exposure to games and game systems the player has experienced, unlike individuals' visual impairments and players with acquired visual impairments, the player with a congenital impairment doesn't necessarily carry the intuitive skill sets that allow for fast adaptation to new systems. As seen in examples found, many players with congenital impairments enjoy 1 – 3 games specifically as they have had time to master control systems and sound cues.

Player Experience Conclusion

The primary conclusion is that visual impairment types both individually and categorically have varied effects on players abilities, leading to a range of effect on playability and player experience between each type. Importantly also concluding that individual impairment types and/or categories should be considered as opposed to a broad consideration of visual impairments as one category of abilities when designing accessibility inclusion for games.

3 Recognising Activity Systems within the Games and Justification of Genre

Activity System, Core Gameplay and Problem Solving

Player experience within games is ultimately determined by human-computer interaction through gameplay. Gameplay is simply defined as player interaction within a game, it's structured by game mechanics. Game mechanics are part of game design and convey the rules of player interaction and possibilities/limitations defined within the game. Game mechanics are defined by game genre, which clusters specific game mechanic characteristics within a genre.
Therefore, the genre is a necessary study when considering player needs within gameplay, as it allows for analysis of specific mechanics against player ability as well as identifying player motivation, needs, and activities within gameplay.

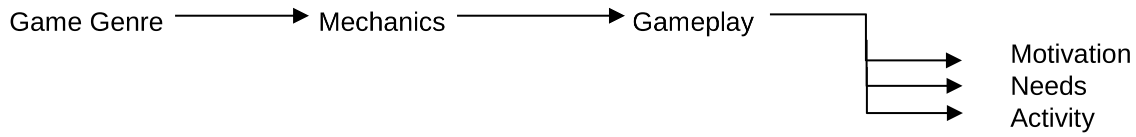

Figure 6 Relation of Player Experience within video games

A players' needs are psychological needs for competence, relatedness and autonomy (Ryan, Rigby, & Przybylski, 2006) determined by cognitive evaluation theory (Deci & Ryan, 1985) and result in effects on player motivation.
Player motivation within games is often supported by self-determination theory of which cognitive evaluation theory is a sub-theory. This is an important framework to consider when analysing game suitability as it conveys the resulting actions of players within gameplay. Activity theory is often used to accomplish analysis and design as it includes a framework for the cycle of information processing resulting in learning and activity within gameplay (Carvalho, et al., 2015).
A player's motivation, needs, and activity are all primary elements for evaluating games in relation to their inclusion, and should be considered as vital elements of design for games that aim to include players with visual impairments, as they contribute to playability and ultimately player satisfaction.
It's unsurprising that there are examples of genres that characteristically include mechanics more suited to visually impaired players especially in the context of adapted non-inclusive games such as musical or fighting games as sound cues are usually primary informers of information to the player, on the opposite side of this however there are also genres that are avoided by players with visual impairments due to external psychological influences. Kevin Satizabal, a gamer with congenital blindness discusses this in an article highlighting that many games will exploit blindness to create a more intense experience which seems to increase engagement however adds "they could be problematic if overplayed." (Webber, 2014). Satizabal also addresses the horror genre of audio games stating that they have their place but also that "visual impairment already has enough negative associations without it being brought out in the gaming world" suggesting that themes typical within the horror genre such as the dark, monsters and the unknown could relate to an individual's personal negative experiences having visual impairments, thus resulting in a negative experience within the playability of the game.

Acquiring Information

A player first experience in a game is the gaining of information, this may be contextual or functional information, it then forms the start of the process of goal formation in which the player attains direction and desires within the game and formulates action via using tools and continues throughout gameplay.
Information is commonly presented in games in four main categories (some of which are applied together). The first is two types of linear information which may come in the form of the core quest of a game, or the sequence of main goals to be achieved to finish the end goal or complete a narrative and non-linear information which may come in the form of side quests, these may be optional, but they lead to other directions within the game, some may interact with the main quest or may lead to other side quests.
The second types of information that a player will encounter are acquired information and assigned information. Assigned information is given to the player (subject), for example, the player is given instructions on how to use a new tool or operation within the game.

The acquired information is what the player has intrinsically gained through action by their own will, for example: information about a side quest that a player had to use a tool or interact with an object to gain. Information is to be referenced and analysed regarding importance and success chance with self-determination theory, as it's important to consider why a player would form goals through the gaining of information especially if the players' world view and self-concept are that of a player with congenital visual impairments.

Information as an Immersive Tool

It is acknowledged that stimuli such as sound or haptic feedback add quality via immersion to player experience through gameplay (Orozco, Silva, El Saddik, & Petriu, 2012). However, with the absence of visual and haptic media sound such as is in most audio games, the sound becomes the source of context, tools, objects, operations etc.

One of the challenges of this is that immersion suffers through a lack of enabling stimuli, however in some cases information is used as an enabler to increase stimuli through an implied physical effect.

A passive example of this is using the sound effect of fire alongside the assigned information that the player is in a room with a fire. An active example of this is the gaining of information that causes an intrinsic reaction with the player which may trigger an implied physical effect for example if said fire is described not only in relation to position and attainment but also regarding player (subject) stimuli.

An example of this comes from the audio adventure 'the fairy tree' in which the player is given a fire lit torch (using spatial sound effects and dialogue) but also told 'careful, the heat is intense and may burn your face!' (audioepics, 2016). This additional description of the physical effects of the torch on the player (or avatar) may cause the player to experience additional intrinsic stimuli i.e. the sensation of heat on the face, which acts as additional stimuli to sound, increasing the likelihood of engrossment or total immersion (Brown & Cairns, 2004).

Goal Formation

Goal formation is the process of what a player does with information gained through a constant process of transformation (Fabricatore, 2018). This transformation occurs when the player changes elements of game space to achieve a desired generation or preservation of the current game state. This system is key when considering how a player with a visual impairment may choose to plan and execute an action within certain genres to achieve goals.

Players with visual impairments can use stimuli such as audio and haptic to process information, they are able to then formulate a desired state and conduct the completion of goals, the consideration is how they use the transformative process to achieve this without hindrances that affect motivation and satisfaction.

Identifying Players Abilities and Limitations within Genre

To adapt the framework on activity to identify barrier elements for players with visual impairments: an investigation into common game mechanics is needed to better understand essential design requirements for the adaptation. Game mechanics and common trends of player activity within games are categorised into genres, therefore it's suitable to examine these genres both in the broad sense of studying mechanic and activity trends but also specifically to identify genres relevancy to the visually impaired players.

To do so the most popular genres on the gaming platform 'Steam' (Valve Corp., n.d.) are analysed below regarding typical activities found within the game type, hindrances, enablers and player experience factors that may occur in relation to players with congenital and acquired visual impairments. Analysis of genre can also determine suitable analysis subjects as well as a suitability test for development considerations of both adapted and inclusive games.

Action

Action games are defined by emphasizing the use of tools to achieve tasks, primarily physical challenges where the players motor skills and coordination are awarded with progression. As such, adventure games are almost entirely reliant on visual cues for goal formation and action procedure. It may be possible to transfer certain elements to other stimuli such as sound, however the challenge would be how the player progresses using the transformation process.

Mental mapping and spatial awareness can most likely succeed in the action genre in regards to giving an individual with visual impairments information about orientation and objects, however difficulty with the key rewarded aspects of the genre may hinder motivation as the player becomes frustrated at more complex mechanics with lack of reward.

Adventure

Adventure games focus on player experience and progression through objects and contextual information in a mix of linear and non-linear goals. This usually comes in the form of storyline, dialogue and puzzle solving and players use a transformative process in the form of making decisions as opposed to direct action however both are present. It is common for adventure games to also entirely focus on decision making as core gameplay and leave out the players ability to develop a desirable state due to not being fully presented with action consequence, which in turn plays to emotional reactions at the cost of guaranteed satisfaction. An example of this is the Tell-tale series of adventure games (Valve Corp., n.d.) Due to these factors, an adventure game may be the leading genre of game to apply to a framework for an enjoyable game for individuals with visual impairments.

Casual

Casual games are defined by simple rules and a low progression yield. Generally, they allow the player to use no more than one or two tools to affect the game state and remains the same throughout the game with no opportunity for the player to develop goals or action procedures that are more than 1 - 5 steps long. The simplicity of casual games lends itself to aspects of player experience such as learnability and short-term satisfaction but at the cost of immersion, motivation and emotion providing for a shallow experience long term.
These aspects particularly learnability make it easy to adapt casual game mechanics to a single stimulus such as haptics or sound, making them the leading game type for audio games designed for individuals with visual impairments. The negative as mentioned is they provide short-term enjoyment and have little to no chance for the advancement of the state beyond engagement.

Massively Multiplayer

This is a genre that will typically envelop another for its gameplay structure however does have commonly unique mechanics and approach to gameplay as well as the socialization aspect playing the biggest defining role in the genre's categorization.
Massively multiplayer games are defined by many real players existing in a single virtual environment (or world/level) at the same time, with the ability to both interact with one another as well as the object space through the transformative process. This allows players goals to be shared as operations and action procedures can be orchestrated and conducted through teamwork.
This type of gameplay can produce high levels of motivation through socialization and progression in a social environment, as it not only allows a player to progress through perhaps a storyline but also allows progression of status among others (usually through a leveling system). The downside is that due to the social aspect of the game, immersion and long-term motivation may suffer as the game relies on the social aspect i.e. real-world players using the game at the same time and that immersion aspects such as storyline are usually loose to account for differences in players individual progression timelines.

Racing

Racing games typically lack contextual information such as storyline, as the main goals of progression are to win races that incrementally increase in difficulty. Progression relies on the players' transformations via upgrading tools being the vehicles they drive. This is done by winning races, usually with the given option of side quests, where if the player puts more time into winning smaller races, they have more currency to spend on upgrading tools, increasing the chance they will progress through the main gameplay.
Functionally the gameplay relies entirely on visual stimuli to estimate corners, block other cars paths, take shortcuts etc all at a usually very fast pace. Players are rewarded for instinctive choices made as well as reaction time. Two factors that are not suited to players with visual impairments. It's hard to imagine what challenges could be implemented to this type of game if it was to transfer stimuli to purely audio or haptic feedback.

RPG

RPG games or roleplaying games are defined by the player assuming the role of a character in a fictitious setting and are commonly the most immersive genre of video game due to such. Regarding play style and gameplay, RPG games are like adventure games in that information is both given and attained, linear and non-linear however RPG games have a much stronger focus on the players' ability to transform the game space around them both functionally but also contextually.
Due to the core gameplay requiring a player to assume a character or role, the effort is put into immersion and emotion as opposed to learnability and socialisation which leads to high levels of immersive state and intrinsic motivation. RPG games are also the most widely used game type across various mediums, such as audio adventures, board games, turn page adventures, card games and even physical games such as 'LARP' (live action role-playing). RPG games also encompass most if not all game styles due to their open structure. Surprisingly however there are far fewer RPG games aimed at players with visual impairments than casual games.

Simulation

Simulation games are defined by the game's goals and activity systems emulation of real-world activities such as operating a vehicle or running a business. Contemporary simulation games often use linear and non-linear progression to increase player motivation throughout gameplay. Uniquely simulation games commonly implement or at least give the option for haptic tools to be used as well as typical inputs of video games. These can include joysticks, steering wheels, acceleration, and brake pedals, gear sticks and specially designed seating that all provide various haptic feedback as well as input functionality. Haptic feedback is a very useful tool regarding individuals with visual impairments, however, the visual aspect provides almost all contextual information and reward.
Realism and immersion are the primary goals for simulation games as opposed to satisfaction or emotion which may not appeal to users even if the mechanics and activities can be applied to a non-visual stimulus as a visual element, for example: when flying an aircraft provides the entertainment and satisfaction to a player as opposed to the sound of an aircraft. Successful actions such as landing an aircraft may provide motivation to players with acquired visual impairments that previously had an interest in the contextual nature of the simulation game however, it's unlikely a player with congenital visual impairments will gain satisfaction from it, not having experienced the real-life equivalent visually.

Sports

Sports games are like simulation games in the way that they emulate real-world activity, however, unlike simulation games they can either have mechanics of playing the sport at the core of gameplay or focus on strategy in the example of sports management. The latter requires the processing of a lot of given information and progression is determined by player choices based on the given information.
This style could be potentially transferrable to audio or haptic feedback via technology such as screen readers however the effectiveness of which may negatively affect satisfaction and motivation. The former style of a sports game can be compared regarding suitable and non-suitable attributes to action games as they both award players for motor skills such as reaction time as well as tactics. The challenge would not only be how to give information fast enough to a player with visual impairments to react but also how they could do so in a way that feels intuitive and rewarding.

Strategy

Strategy games are defined by autonomous decision making and success relies on a player's situational awareness ability and the ability to perform calculated operations. Gameplay activities commonly include resource management, a military strategic element, and interaction with other players (either real or more commonly AI (artificial intelligence)). Strategy games can suffer regarding learnability especially considering players with visual impairments as the mechanics are not easily transferrable to a non-visual stimulus. Depending on complexity, mental imaging and access to information of game state may allow a player with a visual impairment to perform tasks at an enjoyable level, however the greater number of elements within the game the more difficult it is to retain a full mental image of the game state.

To acquire a better understanding upon how game genre may specifically affect the player experience and playability, the table below was made to demonstrate estimated suitability of adaption for the described game genres for not only sensory stimuli but also the categories of experience used earlier in the thesis to analyse visual impairment types, this is measured between 1 and 5, 1 determining that the mechanics common within this genre are not suitable for either skillsets and abilities common in players with visual impairments or are not effective in respect to the particular element of player experience, 5 being the mechanics common within the genre are suited to skillsets and abilities common in players with visual impairments or are effective in respect to the particular element of player experience. This is done to give insight upon the effects of specific mechanics within a game in correlation with the affected elements of player experience. This was achieved by examining 3 prominent games within each genre via gameplay videos, user reviews and gameplay and mechanics descriptions. The games chosen as well as informer sources are listed below.

Action

Grand Theft Auto V (Valve Corp, n.d.)
Rocket League (Valve Corp, n.d.)
Team Fortress (Valve Corp, n.d.)

Adventure

MONSTER HUNTER: WORLD (Valve Corp, n.d.)
Rust (Valve Corp, n.d.)
No Man’s Sky (Valve Corp, n.d.)

Casual

Stardew Valley (Valve Corp, n.d.)
Slime Rancher (Valve Corp, n.d.)
Plants vs Zombies (Valve Corp, n.d.)

MMO (Massively Multiplayer Online)

The Elder Scrolls Online (Valve Corp, n.d.)
Path of Exile (Valve Corp, n.d.)
EVE Online

Racing

DiRT Rally (Valve Corp, n.d.)
GRID Autosport (Valve Corp, n.d.)
Need for Speed Undercover (Valve Corp, n.d.)

RPG (Role playing game)

Skyrim (Valve Corp, n.d.)
Fallout 4 (Valve Corp, n.d.)
The Witcher 3 (Valve Corp, n.d.)

Simulation

Euro Truck Simulator (Valve Corp, n.d.)
Arma 3 (Valve Corp, n.d.)
Microsoft Flight Simulator X: Steam Edition (Valve Corp, n.d.)

Sports

Steep (Valve Corp, n.d.)
The Golf Club (Valve Corp, n.d.)
International Snooker (Valve Corp, n.d.)

Strategy

Cities Skylines (Valve Corp, n.d.)
Hearts of Iron IV (Valve Corp, n.d.)
Stellaris (Valve Corp, n.d.)

		STIMULI AND PLAYER EXPERIENCE											
		Visual	**Sound**	**Haptics**	**Spatial**	**Motivation**	**Effectiveness**	**Learnability**	**Immersion**	**Satisfaction**	**Emotion**	**Socialisation**	**Average effectiveness/suitability of genre mechanics**
GENRE	**Action**	4/5	3/5	4/5	5/5	4/5	4/5	1/5	4/5	4/5	4/5	3/5	73%
	Adventure	4/5	4/5	3/5	5/5	4/5	3/5	3/5	4/5	4/5	4/5	1/5	70%
	Casual	5/5	3/5	4/5	2/5	2/5	5/5	5/5	1/5	3/5	1/5	3/5	61%
	MMO	3/5	1/5	1/5	3/5	4/5	2/5	3/5	3/5	3/5	2/5	5/5	54%
	Racing	2/5	2/5	2/5	3/5	3/5	4/5	4/5	5/5	3/5	1/5	4/5	60%
	RPG	2/5	4/5	4/5	5/5	5/5	4/5	3/5	5/5	5/5	5/5	2/5	80%
	Simulation	3/5	3/5	2/5	4/5	3/5	2/5	3/5	5/5	4/5	2/5	3/5	61%
	Sports	2/5	2/5	3/5	4/5	3/5	3/5	3/5	4/5	3/5	2/5	4/5	60%
	Strategy	1/5	1/5	2/5	2/5	4/5	3/5	1/5	2/5	4/5	2/5	4/5	49%

Table 3 Analysis of genre mechanic effectiveness against player experience factors and visual impairments

Table Key

Visual /Sound/Haptic – These categories refer to the potential effectiveness of the transfer of mechanics from an existing non-accessible game within the genre to solely stimuli associated with accessible games regarding players with visual impairments, those being: visual (within the abilities of low vision impairment sufferers) sound or haptics.
Spatial – This category refers to the potential the genre holds for use of spatial sound as a tool within the game.
Motivation, effectiveness, learnability, immersion, satisfaction, emotion and socialization **–** These are the categories of player experience which are defined in 'Analysis of visual impairment categories against playability factors'. and refer here to the potential effectiveness of each, in conjunction with the likely abilities of players with visual impairments.

The potential effectiveness of mechanics commonly used within each genre varies greatly between each element of player experience suggesting that genre is in fact a major determining factor for suitability for playability between users with visual impairments, with role-playing games (RPG) and action games leading in suitability for adaptation, likely to the heavy use of sound cues, commonly as conveyers of in game information to the player as well as the focus both genres have of elements of player experience such as immersion, emotion, and satisfaction. Lower scoring genres including strategy and massively-multiplayer online (MMO) games likely due to including predominantly 3rd person-based mechanics and complicated activities and motivation focus in strategy for success.

4 Using Activity Theory to Identify Influential Game Elements

Activity Theory and Limitations

Activity theory describes activity during gameplay as a hierarchical process of actions that can influence outcomes of the activity however it's been proposed that activity within games is, in fact, a multi-looped iterative and feedback-driven process that follows traditional problem-solving models (Fabricatore, 2018).

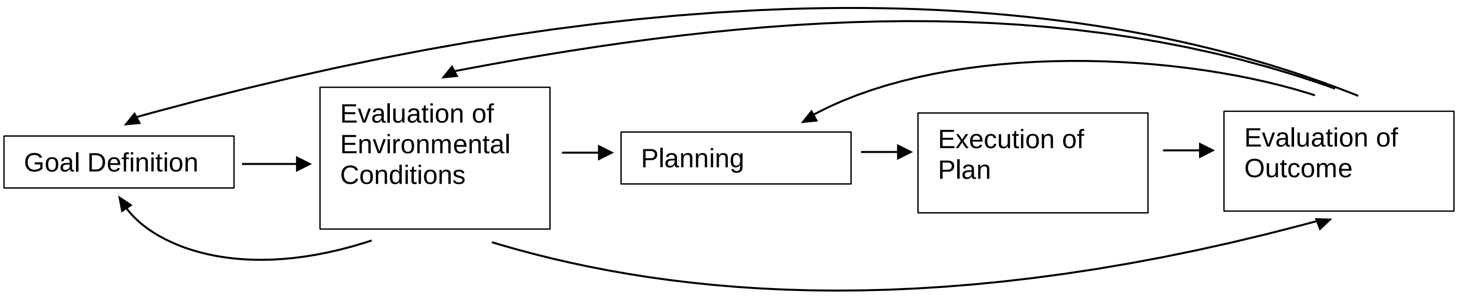

Figure 7 Activity as a multi-looped iterative, feedback-driven process
(based on 'Figure 3' from (Fabricatore, 2018)*)*

The smallest tasks contributing to progression are called activity blocks, which are defined regarding availability/achievability by the type of game being played but are also limited by player ability.
Player ability may come in the form of ability to grasp concepts within the game such as tools or processing information, but in the case of this work; cognitive and motor skills derived from visual impairments. It is then suitable to use Activity Theory and its key elements to evaluate the functional limitations of the user base and consequently how to solve them.
Below, analysis will take place of the steps during the process of activity regarding potential problem areas within gameplay for players with visual impairments.

Acquiring Information

The player is motivated (intrinsically/extrinsically) through external stimuli to seek information or is supplied information from objects within the environment.
Potential limitations include:

- Stimuli of which information can be transferred to the player is limited to non-visual mediums such as haptic and sound.
- Players concept of self and world may affect the success of the representation of information given.
- Information may be less intrinsically obtained especially if it explicitly relates to function within the game due to lack of visual information.
- Motivational drives to obtain information may differ especially from players with congenital visual impairments.

Problem Definition

The player uses information attained to identify 'problems' with which to solve through action achieving the desired game state.
Potential limitations include:

- Intrinsically motivating factors may differ between a player with acquired and congenital visual impairments, which may lead to lack of self-driven motivation and enjoyment in later stages of player experience.
- Players concept of self and world may affect the ability to identify problems and reasoning causing an error of judgment leading into no problem definition, misguided problem definition or problem definition that isn't supported by the game's framework of potential activities.

- The process of identifying the desired game state may take longer with a player with congenital visual impairments potentially leading to frustration.
- Players with visual impairments (particularly congenital impairments) may not be able to process an extensive hierarchical system of activities towards a specific goal and may benefit from short meaningful goals involving fewer actions.
- Information may not be immersive, leading to intrinsic motivation (through curiosity, emotional reaction or moral obligation) to develop identification of problems and meaningful activity.

Goal Formulation

The player uses information of environment, tools, constraints, and pre-conditions to formulate actions with which are needed in succession to achieve the desired game state.
Potential limitations include:

- Cognitive perception of tools may be incomplete resulting in frustration and hindrance of learnability.
- The spatial and functional properties of the environment may not be clear.
- Players with visual impairments (particularly congenital impairments) may struggle to formulate consecutive actions as well as all other aspects of the game from one stimulus and may feel overwhelmed.

Implementation of Strategy (Transformation)

The player uses tools to interact with the environment/objects through action composed of operations and is described in activity theory as a transformation process.
Potential limitations include:

- Enablers and hindrances may not be obvious to the player.
- Successes and failures of actions may not be clear.
- Transformative results may not be clear.
- Feedback from the articulation of tools may not be clear, the player may understand they are using a tool but not what it is changing or interacting with.

Evaluation of Strategy

The player evaluates the results of the transformative process against the conditions of the desired state. If the desired state has not been achieved, the player may improve the definition of the goal or re-define the goal, leading to modification of the strategy formed earlier.
Potential limitations include:

- Feedback of action may not be clear to the player.
- Successes and failures of strategy may not be apparent unless explained.
- Other options and routes of strategy may not be clear other than the strategy conducted. This may suggest that in some cases a linear approach may be beneficial.
- Current state against the desired game state may not be obvious to compare for the player.

An Initial Analysis of Gameplay Regarding Visual Impaired Users

Solutions to the listed issues can be found by examining contemporary examples of activity theory and seeing if enablers can be introduced to aid a player with visual impairments to overcome sensory barriers.

The Elder Scrolls V: Skyrim

Skyrim has been chosen as a subject of analysis as it's a role-playing game that has won multiple awards for the quality of design including outstanding achievement in story, best role-playing game and outstanding achievement in gameplay engineering (IMDb, 2012) meeting criteria of being highly immersive and a commonly referenced RPG. It also has many elements of gameplay that can be dissected and analysed for the purpose of further understanding what limits a player with visual impairments during gameplay.
During gameplay, players create an avatar (tool) and controls it throughout the game to perform tasks, achieve goals (both functional and contextual) and progress contextually throughout a storyline.
Skyrim has both linear and nonlinear activities throughout the game through the contextual representation of quests. Players may follow the main storyline which involves information being given to the player, leading to extrinsic motivation to achieve the main storylines intended game state or the player can choose to engage in side quests where the player is intrinsically motivated to seek out activities through interaction with game objects such as non-playable characters (NPC's).
The game has a large framework that allows for many passive and active activities that act as enablers to the player, through economics, level progression, and acquirement of items (tools) such as spells, weapons, and armour which may allow the player to perform operations better.

Example Activity

Activity – Combat with an NPC
Combat can be achieved within the game as either a hindrance or an enabler. For example, the player may initiate combat with an object that wasn't necessary to achieve a contextual goal however improves the players' skill level if successful, or the successful combat may allow the player to attain tools that make future combat activities easier to win.
The player may also need to initiate combat with an object to retrieve a quest specific object or tool such as a key to a door, sometimes the player may unavoidably find themselves in combat upon performing an action such as entering a room within a specific environment.
Following below is an analysis of each stage of activity against relevant requirements within combat from a video source (Youtube, 2012).

Stage 1 – Goal Definition
The player defines the goal of hunting and eliminating target non-playable character (NPC) within the environment, without knowing the target NPCs specific location, just the direction of 'encampment' nearby represented as a symbol on the navigation bar.

Influencers	**Cognitive Skills Required**	**Motor Skills Required**
Navigation Bar (visual)	Context (extrinsic goals/information)	
Environment (visual)	Context (NPC)	
Player Avatar (visual)		
Equipped Weapon (visual)		
NPC (visual)		

Table 4 Goal definition activity analysis

Stage 2 – Evaluation of Environment
Player identifies contextual visual and audio cues that target NPC is nearby. After controlling the avatar within the environment player then confirms target NPC visually.

Influencers	Cognitive Skills Required	Motor Skills Required
Navigation Bar (visual)	Context (extrinsic goals/information)	Avatar Movement
Environment (visual)	Context (NPC)	
Player Avatar (visual)	Context (audio cues)	
Equipped Weapon (visual)	Avatar Control	
NPC (visual)	Weapon Control	
	UI understanding	

Table 5 Evaluation of Environment activity analysis

Stage 3 – Planning
The player determines that for a goal to be achieved they must enter combat with target NPC without receiving enough damage for a game state of avatars death to be activated. To do this they formulate a plan to equip a bow, remain at distance from the target (knowing from the context that target deals damage from close attacks) and fire at the target.

Influencers	Cognitive Skills Required	Motor Skills Required
Navigation Bar (visual)	Context (extrinsic goals/information)	
Environment (visual)	Context (NPC)	
Player Avatar (visual)	Context (audio cues)	
Equipped Weapon (visual)	Avatar Control	
NPC (visual)	Weapon Control	
	UI understanding	
	Formulation of a staged plan	

Table 6 Planning activity analysis

Stage 4 – Execution of Plan
The player fires a weapon at the target activating a combat game state conveyed by UI elements on the navigation bar (red dot for engaged NPC) as well as audio cues that player is now in combat (combat music plays). Target NPC reacts by activating weapon and moving towards the player avatar. New UI elements appear displaying information relative to target NPC (health).

Influencers	Cognitive Skills Required	Motor Skills Required
Navigation Bar (visual)	Context (extrinsic goals/information)	Avatar Movement
Environment (visual)	Context (NPC)	Use of Weapon
Player Avatar (visual)	Context (audio cues)	
Equipped Weapon (visual)	Avatar Control	
NPC (visual)	Weapon Control	
	UI Understanding	
	Environment Evaluation	
	Game State Evaluation	

Table 7 Execution of Plan activity analysis

Stage 4 – Evaluation of Outcome
Player evaluates the effect of action upon targets health as well as game state change and resulting NPC action.

Influencers	Cognitive Skills Required	Motor Skills Required
Navigation Bar (visual)	Context (extrinsic goals/information)	
Environment (visual)	Context (NPC)	
Player Avatar (visual)	Context (audio cues)	
Equipped Weapon (visual)	Avatar Control	
NPC (visual)	Weapon Control	
UI - NPC Health (visual)	UI Understanding	
	Environment Evaluation	
	Game State Evaluation	

Table 8 Evaluation of Outcome activity analysis

Stage 5 – Repeat of stages
The player repeats evaluation of environment to assess paths of which avatar can traverse, planning to determine whether to remain using the current weapon to attack target and at what area of terrain to stop moving avatar so they can aim and shoot at the target, and execution of the plan.
This cycle of evaluating the environment and target NPC position, move avatar away, aim, fire repeats until goal objective has been completed and target NPC is killed, the player then finishes this activity with evaluating the outcome of the NPC game state change of death.

Evaluation of Activity Analysis Method

It's clear from the initial evaluation that activity theory can be successfully applied to gameplay to extract elements that may affect playability however, it's difficult to justify the specific effect elements will have on a player's ability with an impairment using this method alone.
Influencer elements that are purely visual are a high priority for inclusion consideration, whereas cognitive and motor ability may vary between visual impairment types.
Table 4 – Table 8 only convey the elements influencing the activity stage as well as cognitive and motor skills, which proves useful in justifying the need to identify potential barriers within gameplay however, using Dr. C Fabricatore's activity system framework: more in-depth analysis of activity within gameplay was possible (Appendix 1).
Using this framework, activities are split into a hierarchical analysis including task definition and outcome, act definition within tasks, outcome of the tasks performed and perhaps most importantly analysis of influencers within the act.
The analysis of influencers gives a broader understanding of what information the player receives during the activity process which is dependent on player skill sets and abilities determined in 'Table 1'.
This methodology is not however completely suitable for visual impairment considerations as its main goal is to break down activity it is not currently suited to determine relevancies to playability from players with visual impairments and will likely require adaptation.

5 Using Activity Theory to Determine Barriers Within Gameplay

Dr. C Fabricatore's activity system framework (Fabricatore, 2018) shows it's possible using activity theory to break down the activities of gameplay within a game and analyze these activities by examining elements of the activity, acts within the activity and influencers within the acts, however it's not strictly adapted to accommodate analysis of gameplay regarding players with visual impairments, it is therefore that a new methodology is to be developed.

The proposed methodology will adopt the principles within the activity system of individual element analysis; however the analysis would now assess activity elements as potential barrier factors as opposed to solely an analysis of activity.

The tool would also be split into separate stages; the first using activity theory to identify gameplay elements such as acts and dependencies. Secondly determining whether the dependency can be considered a barrier. The final stage takes the elements of gameplay determined as barriers and further categorizes the type of barrier in relation to visual impairments, thus following a process that results in successfully identifying potential and definite barriers within gameplay for players with visual impairments as well as determining barrier severity against skillsets.

Using this method: the players receptive, cognitive and motor skill abilities required to perform activity goals within gameplay can be determined through the format of categorization this method of analysis provides.

The analysis will allow for the examination of the iterative process of reformulation regarding activities a player determines during gameplay. These functions may serve many practical purposes for application within designing elements of gameplay activities for games of any genre and type and most importantly they will accommodate consideration for player abilities through previously determined categorization and sub-categorization of skill sets related to visual impairments.

The primary function of this method is the identification of barriers, and furthermore allow for methods of adaption.

The analysis itself does not accommodate all topics of evaluation previously determined to consider specific types of visual impairments, rather it examines players of assumed ability with no obvious impairments or hindrances to required skills. It is therefore determined that either adaptation of this method of analysis or the processing of results of the method is needed to extract relevant information as well as use the process of activity analysis to further analyze gameplay with relevance to the categorization of skill and ability previously determined for those with visual impairments.

It may be possible to excerpt elements of activity such as the specific player acts as well as the acts influencers to cross-analyse against the categories of skillsets determined relevant for activities from users with visual impairments.

To achieve this the act would have to be further analyzed regarding input to activities (such as pressing a button) as well as the output of the act and act influencer, as motor skills regarding player input have not been addressed specifically.

In conclusion; elements of gameplay analysis using activity theory (such as the specific acts within an activity task) can be used to determine the middle process of performance, however the input (being the start of the process) and output (being the end) must also be analyzed to determine barriers against previous evaluation of skill sets of specific visual impairments.

This outcome should provide evidence of clear barriers to the player with visual impairments against any gameplay activity analyzed through this method. It will then be possible to work solutions to these barriers.

Modeling Acts as player dependent methods

1. The beginning – Influencers of acts that allow the player to interpret information to decide what to do and influencers that perform this. e.g. HUD elements and sounds. These are determined and evaluated against skillsets of players with visual impairments.
2. The middle – the player dependency of the act (and sub-categorically if needed; the influencer), e.g. controller input or cognitive skill/interpretation needed to perform acts. These are determined and evaluated against skillsets of players with visual impairments.
3. The end – the influencers allowing the player to interpret outcomes of the act. These are determined and evaluated against skillsets of players with visual impairments.

6 Framework for Utilizing Acts as Player Dependant Methodology

Developing the Framework

Testing

There are three primary grounds of testing for the tool, the first being the tools user target group; the tool was developed with prior knowledge to not only activity theory but additional knowledge relating to players with visual impairments, therefore the tool may be less usable for users without prior knowledge to subjects relevant to the BDT, this also leads to a potential lack of credibility regarding results as users with less expertise in the relevant subjects may perceive a barrier differently to a user with relevant expertise.

The second is usability, is the tool effective? Is it usable? And by who?
At this stage, considerations were made whether the tool should cater to general use or use from experts from specific fields or with specific knowledge bases.
The third is the credibility of the results of the tool, i.e. were the barriers being identified through the tool's methodology via users with no impairments the same as the barriers a player with visual impairments would determine?
Initially testing was planned to cross-analyse barriers determined from the same gameplay but between a player with visual impairments (identifying barriers as they play) and a non-impaired user (using the barrier determination method to identify barriers from gameplay footage) however, there were concerns against the availability of players with visual impairments of varied types as well as the consideration that there was existing analysis of the likely skillsets, abilities, and motivations of various impairment types as well as analysis of genre against them (see table 1, 2 & 3).
Using the existing analysis would provide a stronger justification for barrier determination success across multiple impairment types if the skillsets, abilities, and motivations could be incorporated into the tool's barrier severity framework.

Framework Potential

The tool's primary function is to determine potential barriers within gameplay activity, with the aim that developers can use the barrier information to form solutions of gameplay to produce new games with accessibility to visually impaired users or to adapt current games to do so.
The framework, however, may serve other functions. For example, analysis of other activities such as that may be deemed inaccessible to users with visual impairments could be possible using the tool. An example of this would be using the tool to identify the barriers within educational activities.
Another potential use of the tool is rather than an identifying tool it could be used to prove the credibility of other testing analysis regarding users with visual impairments. The tool could also be adapted to determine barriers of activity for other disabilities such as loss of hearing or physical disability.

7 Barrier Determination Methodology

An Introduction to the Barrier Determination Tool

The Barrier Determination Tool (BDT) is part of a framework developed to take gameplay footage from a game and analyse it in a way that results in determining potential and definite barriers for players with visual impairments.
Users can identify barriers within gameplay to adapt elements to make it more accessible to users with visual impairments or identify common barriers within games to develop games for users with impairments. The tool also has further potential to identify barriers within other activities such as learning activities.

First Iteration

Framework

The first iteration was designed around the process of acquiring gameplay footage then following a process of analysis, determining input/output activity elements within the footage, of which were identified as barriers or not via user determination.
This process derives from Dr C Fabricatore's work on activity system analysis within gameplay, in which the players actions are split into hierarchical sections that can be further analysed and categorised regarding activity and feedback. This is essentially what is shown in Section 4 - 'Figure 7' however 'evaluation of environmental conditions', 'planning' and 'execution of plan' are split into categories of analysis such as 'activity tasks', 'acts' and 'influencers'.
This process allows a user to systematically analyse gameplay within categories and stages of a constant feedback driven process performed by the player.

The first iteration follows a similar pattern of categorisation however it has been developed to split gameplay activity into categorisations relevant to potential barriers.
The task goal is identified summarizing what the player is intending to do and is then split into three sections for barrier determination.
The first is initial influencers and influencer type. Influencers (similarly to Dr C Fabricatore's activity system analysis) are elements within the gameplay that influence the goal, for example a navigation bar showing a goal location will influence a player moving towards the goal. These influencers are then categorised into sensory types and users determine whether this is a full or partial barrier to a player with visual impairments. The influencers are then further analysed regarding the function and outcomes of the influencer.
Secondly, and separately to the influencers; the activity task goal is split into acts within the goal. These are literal actions the player performs to complete the activity task goal, such as moving a character or changing a game state. The acts are then sub categorised into player dependencies, which are skill elements of the act that are required from the player to perform each action, for example to move a character the player must understand how to use the controller to move as well as have the ability and skill to successfully move the character to the desired location. Identified dependencies are then analysed regarding the dependency type in relation to skill set, for example cognitive or motor skill sets as well as relevant input types such as controller input. These two points of analysis help the user to determine if the dependency is a partial or full barrier to players with visual impairments.
Thirdly within each act a separate type of influencer is identified once the act has been completed, these are outcome influencers that are elements within the gameplay that influence the player to evaluate the actions performed thus completing the activity feedback process within 'figure 7'. These are then further analysed the same as initial influencers to determine potential barriers.

These three categorisations of analysis within an activity task goal allows users to determine barriers before the player carries out an action, whilst they carry out an action and after they've carried out the action covering all elements of the activity feedback process a player goes through during gameplay.

All identified barriers from these three sections are then added into a separate table below to summarize within one section the found barriers and the identifying characteristics that make them so with the intention of using this to systematically go through the list and provide solutions to playability for users with visual impairments.

Testing

Procedure

The first version of the BDT was tested with 5 subjects, aged between 18 – 40 with varying levels of knowledge on subjects such as activity theory, allowing for evaluation to consider the user's knowledge base against the analysis ability using the tool. None had previous training on the BDT and only 2 out of 5 participants had knowledge of relevant subjects such as activity theory, self-determination theory, accessibility within games or game design theory.
The participants were given a blank version of the tool, a link to the video of gameplay to be analysed using the tool (as well as a time stamp for analysis), a filled example of the tool (to show examples of correct data entry as well as the flow of the BDT document), a link to a short questionnaire and the sole instruction of watching the gameplay, filling out the BDT document to identify potential barriers for players with visual impairments within the gameplay with no help other than helpers within the tool document and the example document, then finally filling in the questionnaire. No additional help was provided and any further instruction or answers to queries were denied.

Game analysis justification

The Elder Scrolls Skyrim was chosen as the subject for usability testing as the RPG genre was estimated the most adaptable regarding its commonly displayed mechanics (see section 3: Table 3), and the game is one of the most widely recognised games of the last 10 years as well as a standard in the RPG genre. It was suspected that it would have many elements within that were barriers but also many that were suitable for adaption as opposed to outright non-inclusive to users with visual impairments.

Results

Participants were given the questionnaire to provide feedback on aspects of usability and satisfaction, below are the results from the participants questionnaires that accompanied the task of using the BDT to analyse game footage.
The questionnaire used a scale of 0 – 100 to determine success for each question, 1 being a low success and 100 being a high success. Y = yes (100), N = no (0).

Respondent								
Satisfaction Aspect		1	2	3	4	5	Total	Asp Avr
	Previous training with BDT	N	N	N	N	N	0	0%
	Knowledge of relevant materials	N	Y	N	N	Y	2	40%
	Initial user friendliness	30	85	35	35	12	197	39
	Initial instinctive functionality	30	90	40	25	60	254	49
	Layout functionality	40	90	50	10	80	270	54
	Clarity of helpers	30	100	60	20	10	220	44
	Clarity of process	30	90	70	20	80	290	58
	Efficiency of barrier determination	30	90	85	45	90	340	68
	Complexity of user experience	30	75	35	60	30	230	46
	Need for additional usability training	Y	N	N	Y	Y	3	60%
	Need for visual impairment training	Y	N	N	Y	N	2	40%
	User Total	220	820	575	215	390		
	User Average Satisfaction	24%	91%	64%	24%	43%		
	Average Satisfaction from Users	49%						

Table 9 BDT first iteration usability evaluation results

Discussion

As suspected there's a sizable difference in usability between users with knowledge in subjects relevant to the BDT such as activity theory and self-determination theory, with this in mind: the tools ability to identify barriers within gameplay is based on users judgment – which isn't accurate if the user isn't

informed enough to decide, therefore changes to the tools method of element type determination needs to be automated through expertise-lead design elements within the tool.
The tools usability was also unfriendly to most participants as well as confusing.
Additional comments from the questionnaire suggest that many users found terms such as ‘outcome influencer’ and ‘player dependency description’ too difficult to understand regardless of helping descriptions.
Changing the terms may not be an option as the priority userbase is experts that have knowledge in at least one relevant subject, as they are more likely to be using the tool to contribute towards inclusion of players with visual impairments in regards to games, such as professors, researchers, and developers, who are more likely to understand the language used, however additional help and documentation was in demand and can be included for users that feel they need it.
The tool also needs to incorporate a method of further analysis of barriers found to justify them as well as provide additional information of severity and specific effects on skill types and abilities, which in turn could be used to identify barrier priority regarding adaptation and further analysis on how a specific visual impairments type could react to a specific barrier.
Microsoft Excel may also be an unsuitable medium for the BDT as it requires purchased software to use whereas alternatives such as google sheets may be more user-friendly, less costly (it’s free to use) and more accessible (cloud-based documents). It may also be suitable to develop software for the BDT so as to provide the most user-friendly experience possible without the limits of external software.

Conclusion

Results show that one of the participants that had previous knowledge on relevant materials (2) found the tool far more intuitive, clear and user-friendly than those without, scoring 27% higher in average satisfaction than the second highest scoring participant as well as scoring 90/100 for initial instinctive functionality, 100/100 for clarity of helpers, 90/100 for clarity of process and didn’t require additional usability training, those without previous knowledge on average seemed to struggle with the design of the tool and with the language and purpose of the tool.
The other participant that had previous knowledge on relevant materials (5) however, scored the lowest out of all participants for both initial user friendliness of the tool as well as the clarity of helpers despite also scoring higher in average satisfaction than 2 out of 3 of the users without prior knowledge relevant to the tool and scoring higher than average (of all 5 participants) for other aspects such as initial instinctive functionality, layout functionality and clarity of process, therefore it shouldn’t necessarily be concluded that knowledge of relevant materials prior guarantees an increase of initial intuitiveness and satisfaction of usability regarding the tool, however it may be more likely than a user without prior knowledge on relevant materials.
Most participants stated more training on the tool itself would help improve usability despite the helpers within the tool and example document, with the exception of one user (2) who had knowledge of relevant materials who felt they needed no extra training in the tools usability or visual impairments in general, and a participant (3) that despite having no previous knowledge of relevant materials or the tool found the clarity of both helpers and the process satisfactory.
The lowest scoring element of the questioning was initial user-friendliness which suggests perhaps the tool needs simplifying if possible, avoiding initial intimidation of the tool to users with no prior knowledge or experience, interestingly the two participants with relevant knowledge gave contradictory results regarding initial user friendliness, one scoring the highest out of all participants and one scoring the lowest.
The highest scoring element was the efficiency of barrier determination which suggests despite the tools lower usability scores it achieves its primary purpose, although barrier determination in the first iteration was based on user-determined barriers as opposed to tool determined barriers, so the accuracy of the barriers is questionable depending on the expertise of the user.
Another correlation with user expertise was the depth of input to the tool, the higher of which resulted in more determined barriers. It’s evident that the deeper the analysis of the subject (usually due to expertise) the more accurate the tool is at determining potential barriers.
External to the evaluation of usability testing; although the tool identifies barriers (to the extent of what the user considers a barrier) it has no measure for severity of the barrier nor the impact of the barrier on specific types of visual impairments.
In conclusion, the framework for the first iteration of the tool needs changes to how barriers are determined, as well as additional support for users with lower levels of expertise and an additional process of analysis with determined barriers to assess the barrier severity and effects on individual skills and abilities relevant to multiple visual impairment types.

Second Iteration

Tool Framework

The barriers are determined within the tool via the activity type elements within the table such as ‘influencer type’, as the evaluation of said elements is categorized into stimuli or skillset categories which are the primary affecters of a barrier for visual impairment related activity.
Barriers found are now analysed against skillsets correlating with impairment analysis in table 1 and used to determine an average score equalling to comparative severity, e.g. the more skills are needed (fully more so than partially) to overcome the barrier the less likely a player with visual impairments will be able to understand/process the initial influencer/dependency/outcome influencer (based on visual impairment severity is based on low scores for skills = severe impairment, high scores for skills = less severe impairment (ref table 1)), therefore determining the barrier to be more severe generally.
Skill specific scores can be used to gauge how barrier will affect specific visual impairment type in table 1; i.e. impairment types scoring high on skill in table 1 will struggle less with the barrier that requires the specific skill to overcome the barrier.

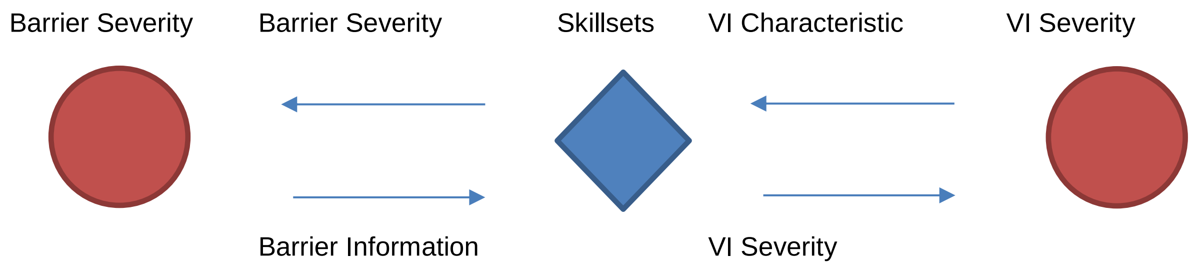

Figure 8 Barrier analysis via BDT

The First Table - Activity Analysis - User lists elements from the subject game displayed during the time stamp. These elements are analysed to identify if they would be a potential barrier for a player with visual impairments.
Similarly to the first iteration; it is split up into three sections: initial influencers (elements that influence the player's decisions in the next phase), dependencies (elements that depend on the player during the act phase) and outcome influencers (elements that influence the players understanding of the outcome for the previous stage).

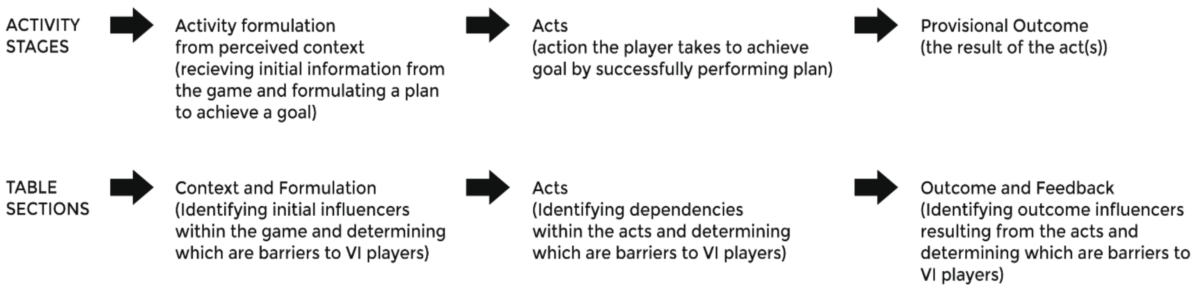

Figure 9 Activity analysis via BDT

- **Context and Formulation -** Contains the player's overall goal for the timestamp, lists elements in the subject game that may influence the players ‘act’ stage and analyses elements to identify potential barriers.
- **Act -** Lists elements from the subject game during the player's actions that depend on the player's skills and understanding to complete, and analyses elements to identify potential barriers.
- **Outcome and Feedback -** Lists elements from the subject game that have resulted from the player's actions, influencing the players processing of the outcome and analyses elements to identify potential barriers.

The Second Table - Barrier Analysis - Users take identified barriers from the first table and analyse them for justification, to determine barrier severity against users with visual impairments, as well as provide information for evaluation against specific types of visual impairment.

Barrier Analysis and Justification - Lists found barriers and provides information regarding form and type. The justification for identified barriers is pre-defined within accompanying research.

Barrier Skill Analysis - Determines effects of barrier regarding skills and attributes that impact (/have impacted during development) a player with visual impairment by rating whether the skill is needed to overcome the barrier.

Procedure

Expert review vs Usability Testing

There are multiple methodologies used for usability evaluation. Determining which are suitable for testing the BDT is integral to measure success for the specific intended user groups (thus also defining the user groups regarding testing).
Usability testing is an empirical method of analysis defined by the actual testing via the intended user groups, usually in large numbers to extend the odds of defining issues and identifying how severe/common issues found are (Musgrove & Lauesen, 2005). This approach has strengths such as user-defined preferences (when presented with choices) and practical user related issues external to the defined goal of the subject (e.g. time it takes to use analysis tool despite tools success of analysis) however the primary weaknesses are that to gain accurate results: large numbers of users are needed that match a specific criteria (Rosenbaum & Kantner, 1997) which can lead to further issues such as cost and time to find and test with said users (Musgrove & Lauesen, 2005).
This approach is relevant to the BDT as it recognises the usability for the general user, as is the premise of the testing methodology, however testing at a higher level of usability is also required as the tool is also intended for a user with expertise in specific fields, this may define issues with the tool that the general user does not recognise.
Nielsen and Molich's Heuristic evaluation was introduced in 1990 as an alternative methodology to both usability testing as well as other existing inspection methods (Molich & Nielson, 1990) and used small groups of usability experts to evaluate as opposed to larger groups of users with specific profiles, thus making for a cheaper and faster approach to testing than usability testing and other inspection methods (Novick & Hollingsed, 2007).
After comparisons between heuristic evaluation and usability testing, researchers found that heuristics found far more issues than any other method, however, usability testing found issues that were more severe (Jeffries, Millwe, Wharton, & Uyeda, 1991).
Other studies showed heuristics found more issues of usability to experts specifically, and non-experts found similar if not the same amount of issues within evaluation (Desurvire, Kondziela, & Atwood, 1992), Nielsen then later found expertise to be a major factor in regard to the effectiveness of heuristic evaluation (Nielson, 1992) and grouped experts into 3 main categories; the novice evaluators (no expertise in usability), the regular specialists and the double specialists (who had expertise in usability and the specific expertise in relation to what was being evaluated). He concluded that regular specialists were considerably better at finding problems than those without usability expertise, and as predicted; double specialists where much better at finding problems than usability experts with no expertise in the specific medium being evaluated. Nielson further concluded that you would only need 2 – 3 double specialists to find the same problems that a group of 3 – 5 regular specialists would find. Nielson also concluded that more severe problems are more likely to be found within heuristic evaluation, however, considerably more minor issues are likely to be found with higher numbered evaluation groups regardless of expertise, thus Heuristics should be accompanied with other methods.
Further criticism of Heuristic evaluation followed this stating three main points; the first being that to evaluate using heuristics the evaluator must be an expert (or both an expert in the relevant subject as well as a usability expert), second that you need multiple experts which could be argued is more of an issue than usability testing, having to find multiple non experts, and thirdly is the cost of heuristics being that many severe issues are found by other means of evaluation without experts and also that many issues found by experts weren't issues to the user and thus could be ignored (Desurvire & Jeffries, 1992).
It seems modern practice is to use multiple methodologies's at separate stages of development, using expertise evaluation at earlier stages of development to identify severe usability issues, complemented by

usability testing post development to detect minor issues, though it is still an ongoing debate (Novick & Hollingsed, 2007).

Evaluation in relation to the BDT

In earlier stages of testing the evaluators of the BDT (see section 7: First Iteration) were found within groups of individuals that played video games regularly and further found through snowballing methods to find additional testers. This was done in the aims of testing the BDT's usability to the non-expert, assuming if successful that any higher level of expertise would also find the tool successful. However, within the results it was found that the quality and depth of user input ranged drastically, and within feedback findings showed that expertise was relevant to this range. Quality and depth of input within the tool and thus the quality and quantity of barriers found within the tool was determined by the users' input (expertise).
Unfortunately, as expertise wasn't measured properly in these stages of testing it cannot be fully concluded that expertise ultimately affects the success of the tool regarding expertise groups or that there's a correlation between the number of barriers found within gameplay and level of user expertise however, it will be the basis of the next stage of testing.

In conclusion to which methodology is suited to the BDT; due to its range of end users being measured in expertise Nielson's evaluation groups (being a novice, expert and double expert) could be implemented within a tier system allowing for cross-analysis of results against each group of expertise level. This will give a solid understanding of the usability of the tool for the specific end user type as opposed to the 'general user' as well as justify a correlation between the number of barriers successfully found within game footage and the level of expertise the user possesses.

Due to the priority of success between usability of the tool and success of identifying barriers (the latter being more integral for the success of the tool); the 'expertise' referenced within groups should be referencing relevant industry experience as opposed to usability experience, also in the case of the double expert; the 'expertise' should reference both experience in a relevant subject as well as knowledge on activity theory.
A further tier that includes both subject experience and activity theory expertise, as well as usability, was considered however, it's unlikely any candidates will be found matching this criterion. This results in the expertise is relevant to the tool in context as opposed to the usability of interface design as much of heuristics was based.

Expertise selection and tier definition

Below are the tiered groups used for evaluation of the BDT and their definitions. Note expertise relevance (such as subject knowledge or area of expertise) has been listed in accordance with analysing video game footage to determine barriers as is relevant to this body of work. These can of course be adapted to suit the need of the medium the BDT is analysing.

Tier 3 – Non-Experts
Individuals with no expertise in fields relevant to visual impairments, education, digital development or accessibility and no thorough knowledge of activity theory and/or other activity analysis subjects.
Examples: Gamers, Students (studying non-related subjects), retail workers, tradesmen etc.

Tier 2 – Experts
Individuals with expertise in fields relevant to visual impairments, education, digital development or accessibility but with no thorough knowledge of activity theory and/or other activity analysis subjects.
Examples: University lecturers, professors, opticians and other optometry professionals, game developers (excluding game designers with understanding of activity theory), special needs workers, visual impairment care workers, visual impairment specialists, visual impairment hardware/software developers, students (at MSc level or above studying relevant subject(s)).

Tier 1 – Double Experts
Individuals with expertise in fields relevant to visual impairments, education, digital development or accessibility as well as thorough knowledge of activity theory and/or other activity analysis subjects.
Examples: University lecturers, professors, students (at MSc level or above studying relevant subject(s)), accessible game developers, accessible learning tool developers.

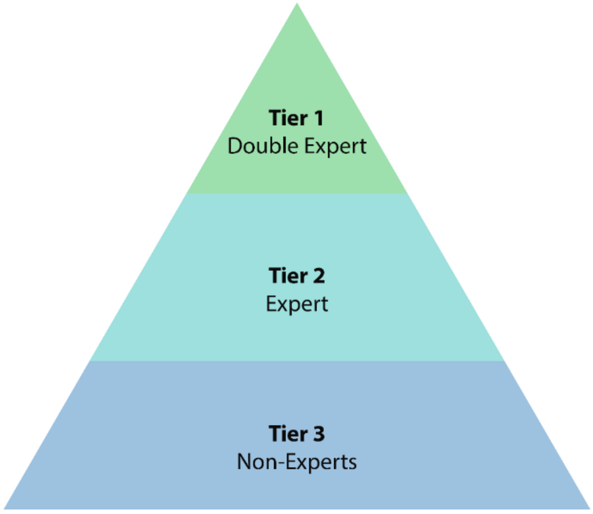

Figure 10 Hierarchy of expertise

Nielson concluded (Nielson, 1992) 2-3 double experts was the number of participates needed to identify the same issues nearly twice as many experts would find, therefore it's suitable to state a minimum of 2 double experts will be required and a minimum of 4 experts (as is equal measure regarding ability according to Nielsen's conclusion, as thus comparable). If only 1 double expert can be found, then an addition of 2 experts can be added to accommodate.
As non-experts will fill a role of evaluation that resembles usability testing their number can be anything from 10 – 20 candidates to increase the success of minor issue detection or usability issues.

Participant selection

The BDT's framework has consideration for the 'general user' (being anyone with any degree of skill/knowledge regarding relevant subjects) as well as users with expertise in relevant subjects (such as visual impairments, learning disabilities etc) with the aim that the tool is more widely accessible to users regardless of skill set/profession/knowledge base.
Due to this range of intended users, testing should include a form of categorisation to identify groups based on their level of expertise allowing for evaluation of the quality and depth of results between said groups.
Each user was sent a blank BDT document to fill out, as well as a usability questionnaire to fill after completion of the BDT. They were additionally supplied with a BDT help document listing useful information regarding the BDT including data entry, terminology help and general purpose for the tool as well as a filled example BDT document, this was to aid the users following usability feedback from the first iteration of the tool.

The chosen game was the 1979 classic 'Asteroids', this was due primarily because of resulting feedback from usability testing within the first iteration (using Skyrim). Non-experts found the tool non-user friendly especially regarding language used which in conjunction to the dense activities systems displayed in even minor actions within gameplay of Skyrim added unnecessary complexity to the test subjects' task, perhaps even to the level of potentially hindering results. Instead, Asteroids activity system is relatively simple with only core mechanics being present throughout gameplay. Additionally, 'casual games' as a genre is commonly used for audio games and scored moderately well in suitability of adaptation (see section 3: Table 3) and was therefore deemed suitable for usability testing between both non-experts and above.

The Questionnaire

The questionnaire will be written predominantly following Nielsen's Heuristics (Nielsen, 1995) however as they are primarily designed for digital systems there will be elements written in specifically for the BDT's evaluation.
The primary goals to be attained from the results are:

1. Using Heuristic Evaluation Methodology, attain severe problems with the BDT from a small number of experts regarding the method of identifying barriers and determining barrier severity, however additionally experts may identify major and minor usability issues with the BDT.
2. Using Usability Testing Methodology, attain minor problems with the BDT regarding usability.
3. Cross analyse results to determine tools usability regarding expertise as well as tools level of success regarding input by the different groups of expertise.

Results Table Notes

The tabled results summarize what was found in both the subjects' entries to their BDT tool documents as well as usability feedback via the questionnaire. The first section shows statistics related to data quality and quantity whilst the second shows usability statistics for the tool.
The questionnaire uses a range of 5 to record satisfaction for each usability element, ranging from 'Extremely Poor' to 'Extremely Good', therefore results are summarised out of a value of 100 (using increments of 20 for each satisfaction level), this is done to keep coherency with the data summary of the first iteration in the case that relevant comparisons are drawn. Exceptions to this are element 15, 16 and 17 in the BDT section where entries of 'Y' (yes) equal 0 as needing additional information is considered a negative reflection of the tools usability, whereas a 'N' (no) is considered a positive reflection of the tools' usability, clarity and intuitiveness and therefore is considered a score of 100. This does not include statistics from the identification section. Element 3 in the BDT example section has a scale of 5, the same as all other elements and is therefore summarised out of 100 however, the scale is reversed on the questionnaire as the scale measures how frequently the example document was referenced for help, 100 being 'none' (which is considered a positive as it reflects either the BDT document alone is intuitive enough to negate the need for the example document or the example document itself was so successful at instructing the user that they only needed to read it once) and 0 being 'constantly' (which is considered a negative for opposing reasons). All percentages in the format of #^% were rounded up from #.5 or above.

Results

#	Factor of BDT	Subjects								
		02	03	04	05	06	08	09	11	Element Total
/	Initial influencers determined	3	3	4	4	3	4	4	7	32
/	Acts determined	0	2	1	1	2	3	3	2	14
/	Dependencies determined	0	2	2	1	8	6	6	10	35
/	Outcome influencers determined	0	4	2	3	3	9	9	12	42
/	Total elements found pre-barrier determination	3	11	9	9	16	22	22	31	123
/	Barriers determined	0	6	2	11	0	13	13	5	56

#	Factor of Satisfaction	Subjects									
		02	03	04	05	06	08	09	11	Element Total	Average Satisfaction for element
Identification											
/	Double Expert	N	N	N	N	N	N	N	Y	1	/
/	Expert	N	N	N	N	Y	Y	Y	N	3	/
/	Non-Expert	Y	Y	Y	Y	N	N	N	N	4	/
/	Familiar with activity theory	N	N	N	N	N	N	N	N	0	/
BDT Document											
1	Providing general information about BDT	60	60	80	40	60	60	100	60	520	65%
2	Providing instruction of BDT use	40	60	80	40	60	60	80	60	480	60%
3	Providing information about editing the BDT	60	60	80	60	60	60	100	60	540	68^%
BDT Example											
1	Demonstrating how to edit the BDT	60	60	100	40	60	60	80	80	540	68^%
2	Demonstrating the information input	60	60	100	50	60	40	80	80	530	66%
3	Frequency example was referenced	0	20	40	0	40	0	40	100	240	30%
BDT											
1	Hint quality	40	60	80	60	60	40	100	40	480	60%
2	BDT intuitiveness	20	60	80	40	40	40	60	20	360	45%
3	Logistical layout	40	80	80	40	60	60	40	80	480	60%
4	Layout efficiency	40	80	60	40	40	60	80	40	440	55%
5	Information Clarity	40	60	80	80	40	60	60	60	480	60%
6	Avoidance of confusing information	20	40	80	40	40	40	80	40	380	48^%
7	Clarity of language	0	40	80	20	60	20	80	40	340	43^%
8	Usability problem prevention	20	60	80	100	40	0	80	40	420	53^%
9	Prevention of user stored information	0	60	80	20	20	0	60	40	280	35%
10	Accessibility of aids/help documents	60	80	100	80	60	100	60	80	620	78^%
11	Efficiency of barrier identification	60	60	80	80	40	40	80	100	540	68^%
12	Barrier identification proficiency	60	60	80	40	40	40	100	80	500	63^%
13	Barrier depth/quality found	40	60	80	60	40	20	100	80	480	60%
14	The effectiveness of barrier skill analysis	0	40	80	80	40	60	60	60	420	53^%
15	Need for additional training on VI	Y	Y	Y	Y	N	Y	N	Y	6	75%
16	Need for additional training on Activity Theory	Y	Y	Y	Y	Y	Y	Y	Y	8	100%
17	Need for additional training on the BDT	Y	Y	N	Y	Y	Y	N	Y	6	75%
User Total		720	1160	1700	1010	1060	816	1720	1240		
Average satisfaction for user		31%	50%	74^%	44^%	46%	35%	75^%	54^%		
Average satisfaction for Non-Experts/Experts/Double Experts		50^%				52%			54^%		
Average satisfaction for users		52%									

Table 10 BDT second iteration usability evaluation results

Usability Evaluation

The differences in results between the two iterations is difficult to accurately compare and cross-analyse, due firstly to the differences within the testing groups, as within the first iteration expertise was not considered, leaving only the potential for general usability issues to be determined. Secondly the scale of evaluation is much greater within the second iteration and thirdly only one game was tested with each iteration of the tool, which although satisfied the testing elements in regard to usability of the tool and ultimately its successes in determining barriers; it does also weaken the strength of conclusions made and future testing would benefit from a wider range of tested games as well as a larger testing group of various expertise. This said however some comparative evaluation can be made:

The first iteration had a wider difference between user average satisfaction, the lowest being 24% from two users both with no previous experience with activity theory or other relevant theories, and the highest being 91% from a user with previous knowledge of relevant theories included within the BDT giving the first iteration a range of satisfaction of 67% across 60% of the users. This could be translated into a category of 'expert' level of expertise considered within the second iteration, indicating that the first tool seemed highly suitable to users with relevant experience and knowledge but highly unsuitable for users with no expertise (non-expert), whereas the range difference in the second iteration is more narrow, at 31% being the lowest and 75% being the highest, giving a 44% satisfaction range between 25% of the users suggesting the second iteration is more suited to general use. Average satisfaction between all users increases by 3% within the second iteration, indicating average usability improvement however this statistic could be further strengthened with expanding the range of games evaluated as well as increasing the number of experts and non-experts that participate.

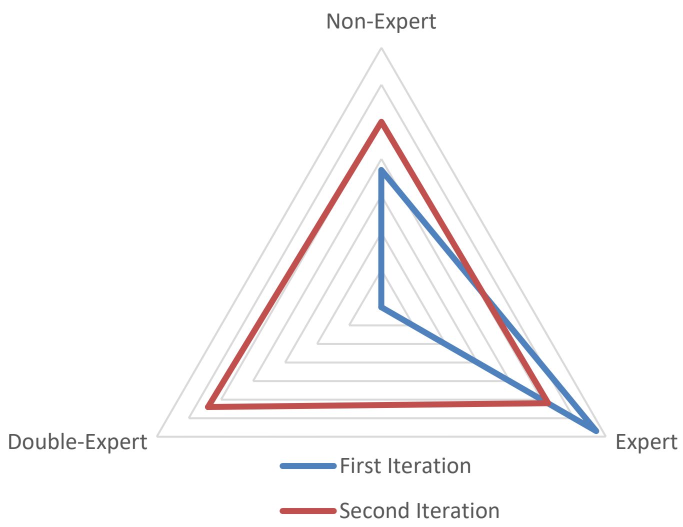

Table 11 Comparative analysis of user group satisfaction between iterations

Within the second iteration the strengths of usability determined are the accessibility of help documentation, the demonstration of how to edit the tool, the information provided regarding editing the tool and the efficiency of barrier determination within the tool, whereas the weaknesses determined are the frequency users felt they had to reference the help documentation, the tools intuitiveness and the clarity of the language used within the tool. This indicates that the help documentation increased satisfaction and understanding between user groups however the tool was difficult to comprehend and use between users particularly within non-experts, this is most likely due to the language used within the tool or the user not fully reading documentation before attempting to complete the analysis using the tool. Satisfaction of usability increase by 2% with each user group, non-experts displaying an average of 50% user satisfaction, experts with 52% and double experts with 54% indicating that a higher expertise level translates to higher usability, as predicted. This is particularly evident regarding frequency of which users had to reference help documentation with non-experts having to more frequently relying on the documentation, experts less so and the double expert relying completely on intuitiveness.

Between the expertise groups of the users; there's a clear increase in the quantity of activity analysis data input which correlates with the amount of barriers determined, however only between non-experts and experts, the double expert found the most activity analysis elements, but is only 1 barrier above the non-expert average, suggesting correlation between expertise and quality/quantity of data however only to the extent of the expertise level, also that for the most part; the increase in quantity/quality of information input into the BDT results in a higher rate of barrier determination.

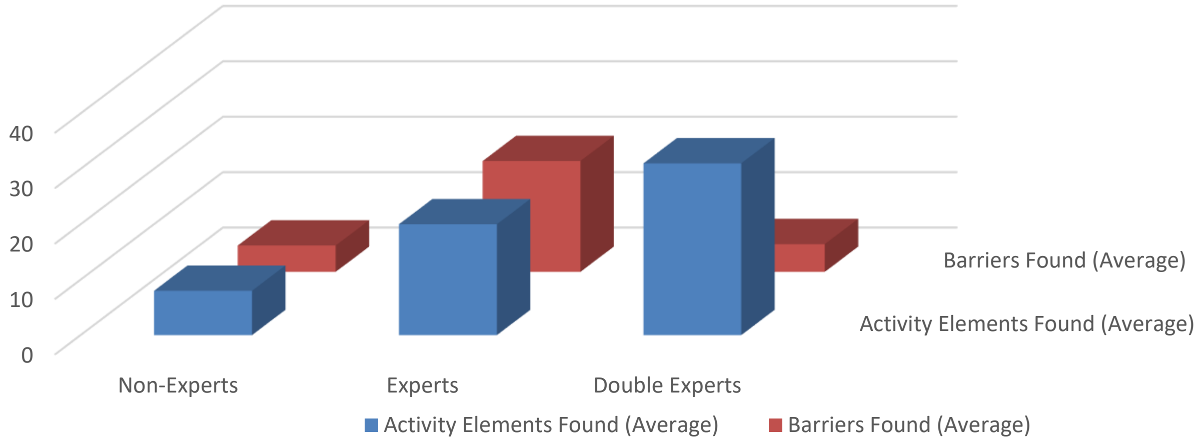

Table 12 Comparative analysis of activity elements and barriers determined between user expertise groups

Within the evaluation despite most users reading through the help documentation in full and scoring highly in satisfaction elements regarding the help documentation; most users felt they needed additional training in both the BDT (75%), activity theory (100%) and visual impairments (75%) which indicates that despite the additional help and training provided with the tool, it's likely that specific training or a far more intuitive system is needed for effective usability, especially within non-expert groups. This is likely related to the language used throughout the framework despite helper descriptions and examples of relevant data as users frequently reported needing additional explanation of terms. This may be resulting from a mental block or intimidation of unfamiliar terms or concepts between non-experts, or it may be derived from a lack of cognitive ability or interest, as experts performed well in analysis despite requiring additional training comparatively to non-experts, an indicator for disuse of help documentation or lack of interest comes from contradictions within feedback; one user suggested a key for 'jargon terms' such as 'initial influencer' when there is an exact definition for this term and many others used within help documentation provided.

Another example derives from feedback concluding that the tool is only concerned with identifying visual barriers as opposed to other types of barrier, however within this users data entry within the tool they identified activity elements that were categorised by the tool as potential or definite barriers external to visual barriers via the element type, however the user failed to transfer this to the barrier analysis section, this same user acknowledged via additional comments within feedback that they did not read any of the help documentation prior to filling out the BDT analysis. These examples suggest that users that did not properly read through the training/help documentation prior to using the tool suffered usability issues and understanding of the tools process.

Additional comments within the feedback determined additional problems, particularly within the BDT's process of transferring activity elements determined to be either potential or definite barriers into the second table for further analysis, furthermore many users struggled to complete the barrier severity analysis section, the reason for this seemed to be a lack of understanding for the process of the tool mixed again with the language used within the framework. One user also noted that the time it took to input data and then transfer the barrier data into the final section took so long it became a hindrance to usability, suggesting an automated process as a solution. The format of the tool itself became evident as a hindrance through additional feedback as multiple users said they had to keep zooming in and out of the document as well as found the process of data entry harder as they couldn't easily see all information on one screen simultaneously.

Ultimately the tool performed with an average of 52% satisfaction of usability rate between user groups, with 100% of users successfully using the tool to analyse activity within gameplay and 75% of users using data found to identify and analyse severity of barriers for users with visual impairments with 38^% of users finding over 10 barriers within 12 seconds of gameplay.

This concludes that the tool achieves the primary goal of analysing activity within gameplay and using this analysis to both determine barriers and analyse barrier severity. Additionally, although the tool may be accessible to non-experts; additional training is needed to achieve quality results. The tools primary user group should be aimed towards experts who wish to use the tool to analyse activity for a specific user group they have prior expertise on.

Further improvements to the BDT should focus primarily on automation likely via software development, allowing users to input minimal data with language catered to their expertise level and determine barriers at a faster rate of completion as well as likely UI improvements providing higher usability satisfaction.

8 Discussion

Within this thesis we categorised characteristics of ability and skillsets between visual impairment types to better understand the individual differences between visual impairments in consideration for playability and player experience, leading to the conclusion that visual impairment types can be grouped between common skill and ability traits, and that they should be considered individually regarding playability within video games as opposed to grouped as 'having visual impairments'.
We also applied the frameworks of relevant theories to analyse playability potential for users with visual impairments, allowing for measurement of ability and likely suitability to factors such as genre of games. Finally we developed framework that uses activity theory to analyse activity within gameplay, identify definite and potential barriers for users with visual impairments and measure the severity of barriers against visual impairments in general and against specific skillsets correlating with characteristics found within visual impairment types, allowing potential experts to use the tool developed to analyse gameplay or adapt the framework to other activity so as to analyse barriers for users that have visual impairments with the purpose of adaption or re-design to produce more inclusive activity based products.

Conclusion

The barrier determination tool proves successful in determining potential barriers within gameplay for players with visual impairments, additionally users successfully justified barriers found as well as determined barrier severity both generally and specifically to categorisations of visual impairments by using the tools process. Further work could continue the iteration and usability testing process of the barrier determination tools' design, including software development, as well as testing within separate areas of activity-based systems. This would appropriate the tool as a general framework for identifying barriers within activity as opposed to solely for the purpose of identifying barriers within video games for users with visual impairments.

Appendices

Appendix 1

ActivitySystem_Skyrim_v2

Microsoft Excel document
Framework developed by Dr Carlo Fabricatore

Appendix 2

BDT_v1_blank

Microsoft Excel document
The first iteration of the thesis’ developed methodology.

Appendix 3

BDT_v1_example

Microsoft Excel document
An example document of the first iteration of the thesis’ developed methodology given to usability testers.

Appendix 4

BDT_documentation

Microsoft Word document
The helper document given to usability testers.

Appendix 5

BDT_Usability_questionnaire_blank

Microsoft Word document
The questionnaire documentation given to usability testers

Appendix 6

BDT_v2_blank

Microsoft Excel document
The second iteration of the thesis’ developed methodology.

Appendix 7

BDT_v2_example

Microsoft Excel document
An example document of the second iteration of the thesis’ developed methodology given to usability testers.

Appendix 8

Usability_Testing_participation

Microsoft Word document
A document given to usability testers introducing them to the testing process and information.

Bibliography

Archambault, D., Ossmann, R., Gaudy, T., & Miesenberger, K. (2007). Computer Games and Visually Impaired People. *Information Technologies for Visually Impaired People*, 43-53.

Atkinson, M. T., Gucukoglu, S., Machin, C. H., & Lawrence, A. E. (2006). Making the Mainstream Accessible: What's in a Game? In K. Miesenberger, J. Klaus, W. L. Zagler, & A. I. Karshmer, *Computers Helping People with Special Needs* (Vol. 4061, pp. 380-387). Springer, Berlin, Heidelberg.

audioepics. (2016, 10 11). *The Fairy Tree available now!* Retrieved from audio-epics.com: http://audio-epics.com/2016/10/the-fairy-tree-available-now/

Bierre, K., Chetwynd, J., Ellis, B., Hinn, M. D., Ludi, S., & Westin, T. (2005). Game Not Over: Accessibility Issues in Video Games. *Human-computer interaction* (p. 677). Las Vagas, NV: Lawrence Erlbaum Associates.

Bolat, N., Dogangun, B., Yavuz, M., Demir, T., & Kayaalp, L. (2011). Depression and anxiety levels and self-concept characteristics of adolescents with congenital complete visual impairment. *Turk psikiyatri dergisi = Turkish Journal of Psychiatry*, 77-82.

Brown, E., & Cairns, P. (2004). A grounded investigation of game immersion. *Extended abstracts of the 2004 Conference on Human Factors in Computing Systems*, (pp. 1297-1300). Vienna.

Brown, E., & Cairns, P. (2004). *A Grounded Investigation of Game Immersion.* London: University College London Interaction Centre (UCLIC).

Brown, E., & Cairns, P. (2004). A Grounded Investigation of Game Immersion. *human factors in computing systems* (pp. 1297-1300). New York: ACM.

Carvalho, M. B., Berta, R., Islas Sedano, C. A., Hu, J., Bellotti, F., De Gloria, A., . . . Rauterberg, M. (2015). An activity theory-based model for serious games analysis and conceptual design. *Computers & Education*, 166-181.

Chen, A. M., & Cotter, S. A. (2016). The Amblyopia Treatment Studies: Implications for Clinical Practice. *Advances in Ophthalmology and Optometry*, 287-305.

Cummings, M. (n.d.). *UX Design Defined.* Retrieved from uxdesign.com: http://uxdesign.com/ux-defined

Dandona, L., & Dandona, R. (2006). Revision of visual impairment definitions in the International Statitical Classification of Diseases. *BMC Medicine*.

DeCarlo, D. K., McGwin, G., Bixler, M. L., Wallander, J., & Owsley, C. (2012). Impact of Pediatric Vision Impairment on Daily Life: Results of Focus Groups. *Optometry and Vision Science*, 1409-1416.

Deci, E. L., & Ryan, R. M. (1985). Cognitive Evaluation Theory. In E. L. Deci, & R. M. Ryan, *Intrinsic Motivation and Self-Determination in Human Behavior* (pp. 87-112). New York: Springer Science & Business Media.

Deci, E. L., & Vansteenkiste, M. (2004). Self-determination theory and basic need satisfaction: Understanding human development in positive psychology. *Ricerche di Psicologia 27*, 23-40.

Desurvire, H., & Jeffries, R. (1992, 10). Usability testing vs. heuristic evaluation: was there a contest? *ACM SIGCHI Bulletin*, pp. 39-41.

Desurvire, H., Kondziela, J., & Atwood, M. E. (1992). What is Gained and Lost When Using Methods Other Than Empirical Testing. In A. Monk, D. Diaper, & M. D. Harrison, *People and Computers VII* (pp. 125-126). Cambridge University Press.

Duffy, M. A. (n.d.). *Low Vision and Legal Blindness Terms and Descriptions.* Retrieved from www.visionaware.org: http://www.visionaware.org/info/your-eye-condition/eye-health/low-vision/low-vision-terms-and-descriptions/1235

Engeström, Y. (1987). The structure of a human activity system. In Y. Engeström, *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research* (p. 78). New York: Cambridge University Press.

Engeström, Y. (2006). Activity Theory and Expansive Design. In S. Bagnara, & G. Crampton Smith, *Theories and Practice in Interaction Design.* CRC Press.

Fabricatore, C. (2018). Underneath and beyond mechanics: An activity-theoretical perspective on meaning-making in gameplay. In B. Suter, M. Kocher, & R. Bauer, *Games and Rules: Game Mechanics for the "Magic Circle"* (pp. 87-111). Columbia University Press.

Ferrara, J. (2011, April 07). *The Elements of Player Experience.* Retrieved from

uxmag.com: https://uxmag.com/articles/the-elements-of-player-experience
Gogate, P., Gilbert, C. E., & Zin, A. (2011). Severe Visual Impairment and Blindness in Infants: Causes and Opportunities for Control. *Middle East African journal of ophthalmology*, 109-114.
González-Sánchez, J. L., Gutiérrez Vela, F. L., & Padilla-Zea, N. (2009). From Usability to Playability: Introduction to Player-Centred Video Game Development Process. *Human Centered Design*, 65-74.
Greenaway, R., & Dale, N. J. (2017). Chapter 18: Congenital visual Impairment. In L. Cummings, *Research in Clinical Pragmatics* (pp. 441-469). Springer International Publishing AG.
Greenberg, B. (2017, 11 17). Edward Deci - Self-Determination Theory. Rochester, New York, United States.
Greenberg, B. (2017, 11 17). *Edward Deci - Self-Determination Theory.* Retrieved from YouTube: https://www.youtube.com/watch?v=m6fm1gt5YAM
Hasan, H., & Crawford, K. (2007). Demonstrations of the Activity Theory Framework for Research in Information Systems. *Australasian Journal of Information Systems*, 49-68.
Hasan, H., & Kazlauskas, A. (2014). Activity Theory: who is doing what, why and how. *Being Practical with Therory: A Window into Business Research*, 9-14.
IMDb. (2012). *The Elder Scrolls V: Skyrim.* Retrieved from www.imdb.com: https://www.imdb.com/title/tt1814884/awards
Institute of Disability/UCED. (2016). *2016 Disability Statistics Annual Report.* Retrieved from disabilitycompendium.org: https://disabilitycompendium.org/sites/default/files/user-uploads/2016_AnnualReport.pdf
Issa, T. B., & Isaias, P. (2015). Usability and Human Computer Interaction (HCI). In T. B. Issa, *Sustainable design: Hci, usability and environmental concerns* (pp. 19-36). Springer.
Janicijevic-Petrovic, M. A., Sarenac-Vulovic, T., Janicijevic, K. M., Vujic, D. I., & Vulovic, D. D. (2013). Congenital Blindness and Visual Impairment Cause Infection or Non Infection. *Materia Socio Medica (Mat Soc Med)*, 101-104.
Jeffries, R., Millwe, J. R., Wharton, C., & Uyeda, K. M. (1991). User Interface Evaluation in the Real World: A Comparison of Four Techniques. *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 119-124). New Orleans: ACM.
Kaiser, P. K. (2009). Prospective Evaluation of Visual Acuity Assessment: A Comparison of Snellen Versus ETDRS Charts in Clinical Practice (An AOS Thesis). *Transactions of the American Ophthalmological Society*, 311-324.
Kaptelinin, V. (1996). Activity Theory: Implications for Human-Computer Interaction. In B. A. Nardi, *Context and Conciousness: Activity Theory and Human-Computer Interaction* (pp. 53-59). MIT PRess.
Kaptelinin, V., Kuutti, K., & Bannon, L. (1995). Activity Theory: Basic Concepts and Applications. *EWHCI: Human-Computer Interaction* (pp. 189-201). Springer.
Kondo, T., Tillman, W. T., Linberg, J. V., Schwartz, T. L., & Odom, J. V. (2013). Health-Related Quality of Life After Surgical Removal of an Eye. *Ophthalmic plastic and reconstructive surgery*, 51-56.
Leary, M., & Baumeister, R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychological Bulletin 117*, 497-529.
Marsh, T., & Costello, B. (2012). Experience in serious games: Between positive and serious experience. *Serious Games Development and Applications*, 255-267.
Molich, R., & Nielson, J. (1990, March). Improving a Human-Computer Dialogue. *Communications of the ACM, 33*(3), 338-348.
Musgrove, M. P., & Lauesen, S. (2005). Heuristic Evaluation of User Interfaces. In S. Lauesen, *User Interface Design - A Software Engineering Perspective* (pp. 443-463). Addison-Wesley.
Nacke, L. (2009). From Playability to a Hierarchical Game Usability Model. *FuturePlay at Game Developers Conference Canada* (pp. 11-12). Vancouver: ACM.
Nacke, L., Drachen, A., Kuikkaniemi, K., Niesenhaus, J., Korhonen, H., Van Den Hoogen, W. M., . . . De Kort, Y. (2009). Playability and Player Experience Research. *BREAKING NEW GROUND: INNOVATION IN GAMES, PLAY, PRACTICE AND THEORY.* DiGRA.
NHS. (2017, 06 26). *Low vision explained.* Retrieved from www.nhs.uk:

https://www.nhs.uk/live-well/healthy-body/living-with-low-vision/
Nielsen, J. (1995, 01 01). *10 Usability Heuristics for User Interface Design .* Retrieved from NN/g Nielsen Norman Group: https://www.nngroup.com/articles/ten-usability-heuristics/
Nielsen, J. (2012, 01 04). *Usability 101: Introduction to Usability.* Retrieved from nngroup: https://www.nngroup.com/articles/usability-101-introduction-to-usability/
Nielsen, J., & Norman, D. (n.d.). *The Definition of User Experience (UX).* Retrieved from nngroup: https://www.nngroup.com/articles/definition-user-experience/
Nielson, J. (1992). FINDING USABILITY PROBLEMS THROUGH HEURISTIC EVALUATION. *Proceedings of the SIGCHI Conference On Human Factors In Computing Systems* (pp. 373-380). New York: ACM.
Norman, D. (2016, 07 2). Don Norman: The term "UX". (A. Li, Interviewer)
Novick, D. G., & Hollingsed, T. (2007). *Usability inspection methods after 15 years of research and practice.* El Paso: University of Texas at El Paso.
Orozco, M., Silva, J., El Saddik, A., & Petriu, E. (2012). The Role of Haptics in Games. In A. El Saddik, *Haptics Rendering and Applications* (pp. 217-234). Ottawa: IntechOpen.
Peters, M. (2009, August 25). *Spot On: The blind gaming the blind*. Retrieved from www.gamespot.com: https://www.gamespot.com/articles/spot-on-the-blind-gaming-the-blind/1100-6215457/
Plunkett, L. (2011, February 22). *How a Blind Man Plays Video Games*. Retrieved from kotaku.com: https://kotaku.com/5766791/how-a-blind-man-plays-video-games
Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., & Carey, T. (1994). *Human-Computer Interaction: Concepts And Design (ICS).* wokingham: Addison-Wesley.
RNIB. (2016). *The State of the Nation Eye Health 2016.* Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/sites/default/files/RNIB%20State%20of%20the%20Nation%20Report%202016%20pdf.pdf
RNIB. (2017). *Understanding Retinitis Pigmentosa and other inherited retinal dystrophies.* Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/sites/default/files/APDF_Understanding_Retinitis_pigmentosa.pdf
RNIB. (2018). *Eye health and sight loss stats and facts.* Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/sites/default/files/Eye%20health%20and%20sight%20loss%20stats%20and%20facts.pdf
RNIB. (n.d.). *Cataracts*. Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/eye-health/eye-conditions/cataracts
RNIB. (n.d.). *Eye Conditions*. Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/eye-health/eye-conditions
RNIB. (n.d.). *Eye conditions related to diabetes*. Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/eye-health/eye-conditions/diabetes-related-eye-conditions
RNIB. (n.d.). *Glaucoma*. Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/eye-health/eye-conditions/glaucoma
RNIB. (n.d.). *Key information and statistics on sight loss in the UK.* Retrieved from www.rnib.org.uk: https://www.rnib.org.uk/professionals/knowledge-and-research-hub/key-information-and-statistics
Rosenbaum, S., & Kantner, L. (1997). Usability Studies of WWW Sites: Heuristic Evaluation vs. Laboratory Testing . *Proceedings of the15th Annual International Conference on Computer Documentation (SIGDOC '97)* (pp. 153-160). Salt Lake City: ACM.
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social. *American Psychologist*, pp. 68-78.
Ryan, R. M., & Deci, E. L. (2000). The "What" and "Why" of Goal Pursuits:. *Psychological Inquiry*, 227-268.
Ryan, R. M., & Deci, E. L. (2012). Motivation, Personality, and Development Within Embedded Social Contexts: An Overview of Self-Determination Theory. In R. M. Ryan, *The Oxford Handbook of Human Motivation* (pp. 85-107). New York: Oxford University Press.
Ryan, R. M., Rigby, S. C., & Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion*, 344-360.
Schamerhorn, R., & Frison, L. (2004). *Audyssey; Games Acessible to the Blind.* Retrieved

from www.audiogames.net: https://www.audiogames.net/page/_Audyssey_Magazine_issue_42_-_third_quarter_2004_
Schinazi, V. R. (2007). *Psychosocial implications of blindness and low-vision.* London: ULC.
Scimeca, D. (2016, March 28). *The $128 million reason blind games can't play Grand Theft Auto 5.* Retrieved from www.thedailydot.com: https://www.dailydot.com/parsec/game-accessibility-game-developers-conference-2016/
Strickling, C. (n.d.). *Impact of Visual Impairment on Development.* Retrieved from www.tsbvi.edu: https://www.tsbvi.edu/infants/3293-the-impact-of-visual-impairment-on-development
Thomas Pocklington Trust. (2016). *Visual Impairment, Depression and.* London.
U.S. Census Bureau. (n.d.). *Public Data.* Retrieved from www.google.com: https://www.google.com/publicdata/explore?ds=kf7tgg1uo9ude_&met_y=population&hl=en&dl=en
U>S. Census Bureau. (n.d.). *Population in the US.* Retrieved from www.google.com: https://www.google.com/publicdata/explore?ds=kf7tgg1uo9ude_&met_y=population&hl=en&dl=en
Valve Corp. (n.d.). *Arma 3*. Retrieved from store.steampowered: https://store.steampowered.com/app/107410/Arma_3/
Valve Corp. (n.d.). *Cities: Skylines*. Retrieved from store.steampowered: https://store.steampowered.com/app/255710/Cities_Skylines/
Valve Corp. (n.d.). *DiRT Rally*. Retrieved from store.steampowered: https://store.steampowered.com/app/310560/DiRT_Rally/
Valve Corp. (n.d.). *Euro Truck Simulator*. Retrieved from store.steampowered: https://store.steampowered.com/app/227300/Euro_Truck_Simulator_2/
Valve Corp. (n.d.). *EVE Online*. Retrieved from store.steampowered: https://store.steampowered.com/app/8500/EVE_Online/
Valve Corp. (n.d.). *Fallout 4*. Retrieved from store.steampowered: https://store.steampowered.com/app/377160/Fallout_4/
Valve Corp. (n.d.). *Grand Theft Auto V*. Retrieved from store.steampowered: https://store.steampowered.com/app/271590/Grand_Theft_Auto_V/
Valve Corp. (n.d.). *GRID Autosport*. Retrieved from store.steampowered: https://store.steampowered.com/app/255220/GRID_Autosport/
Valve Corp. (n.d.). *Hearts of Iron IV*. Retrieved from store.steampowered: https://store.steampowered.com/app/394360/Hearts_of_Iron_IV/
Valve Corp. (n.d.). *International Snooker*. Retrieved from store.steampowered: https://store.steampowered.com/app/299500/International_Snooker/
Valve Corp. (n.d.). *Microsoft Flight Simularot X: Steam Edition*. Retrieved from store.steampowered: https://store.steampowered.com/app/314160/Microsoft_Flight_Simulator_X_Steam_Edition/
Valve Corp. (n.d.). *MONSTER HUNTER: WORLD*. Retrieved from store.steampowered: https://store.steampowered.com/app/582010/MONSTER_HUNTER_WORLD/?snr=1_tags_4__201
Valve Corp. (n.d.). *Need for Speed Undercover*. Retrieved from store.steampowered: https://store.steampowered.com/app/17430/Need_for_Speed_Undercover/
Valve Corp. (n.d.). *No Man's Sky*. Retrieved from store.steampowered: https://store.steampowered.com/search/?snr=1_5_9__12&term=no+mans+sky
Valve Corp. (n.d.). *Path of Exile*. Retrieved from store.steampowered: https://store.steampowered.com/app/238960/Path_of_Exile/
Valve Corp. (n.d.). *Plants vs. Zombies GOTY Edition*. Retrieved from store.steampowered: https://store.steampowered.com/app/3590/Plants_vs_Zombies_GOTY_Edition/
Valve Corp. (n.d.). *Rocket League*. Retrieved from store.steampowered: https://store.steampowered.com/app/252950/Rocket_League/
Valve Corp. (n.d.). *Rust*. Retrieved from store.steampowered: https://store.steampowered.com/app/252490/Rust/
Valve Corp. (n.d.). *Slime Rancher*. Retrieved from store.steampowered: https://store.steampowered.com/app/433340/Slime_Rancher/?snr=1_7_15__13
Valve Corp. (n.d.). *Stardew Valley*. Retrieved from store.steampowered: https://store.steampowered.com/app/433340/Slime_Rancher/?snr=1_7_15__13
Valve Corp. (n.d.). *Steep*. Retrieved from store.steampowered:

https://store.steampowered.com/app/460920/Steep/
Valve Corp. (n.d.). *Stellaris*. Retrieved from store.steampowered: https://store.steampowered.com/app/281990/Stellaris/
Valve Corp. (n.d.). *Team Fortress 2*. Retrieved from store.steampowered: https://store.steampowered.com/app/440/Team_Fortress_2/
Valve Corp. (n.d.). *The Elder Scrolls Online*. Retrieved from store.steampowered: https://store.steampowered.com/app/306130/The_Elder_Scrolls_Online/
Valve Corp. (n.d.). *The Elder Scrolls V: Skyrim*. Retrieved from store.steampowered: https://store.steampowered.com/search/?snr=1_7_7_230_12&term=skyrim
Valve Corp. (n.d.). *The Golf Club*. Retrieved from store.steampowered: https://store.steampowered.com/app/269730/The_Golf_Club/
Valve Corp. (n.d.). *The Witcher 3: Wild Hunt*. Retrieved from store.steampowered: https://store.steampowered.com/app/292030/The_Witcher_3_Wild_Hunt/
Valve Corp. (n.d.). *Thief Simulator*. Retrieved from store.steampowered: https://store.steampowered.com/app/704850/Thief_Simulator/?snr=1_tags_4__hub-tags-specials
Valve Corp. (n.d.). *Steam*. Retrieved from https://store.steampowered.com/: https://store.steampowered.com/
Valve Corp. (n.d.). *Telltale Games*. Retrieved from store.steampowered.com: https://store.steampowered.com/developer/telltalegames
Valve Corporation. (n.d.). *Steam Reviews*. Retrieved from store.steampowered.com: https://store.steampowered.com/reviews/
Webber, J. E. (2014, 10 13). *Video games which open the door for the blind to play.* Retrieved from www.theguardian.com: https://www.theguardian.com/technology/2014/oct/13/video-games-that-let-blind-people-play
White, R. W. (1959). Motivation Reconsidered: The Concept of Competence. *Psychological Review*, 297-333.
WHO. (2018, October 18). *Trachoma*. Retrieved from www.who.int: https://www.who.int/news-room/fact-sheets/detail/trachoma
Wiemeyer, J., Nacke, L., Moser, C., & Mueller, F. (2016). Player Experience. In R. Dörner, S. Göbel, W. Effelsberg, & J. Wiemeyer, *Serious Games* (pp. 243-271). Darmstadt, Waterloo, Salzburg, Melborne: Springer International Publishing.
World Health Organisation (WHO). (2018, 10 11). *Blindness and vision impairment.* Retrieved from www.who.int: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment
World Health Organisation. (2012). *Global Data on Visual Impairments 2010.* Retrieved from www.who.int: https://www.who.int/blindness/GLOBALDATAFINALforweb.pdf
Youtube. (2012, 8 19). *Skyrim - Attacking A Giant - 720p.* Retrieved from www.youtube.com: https://www.youtube.com/watch?v=yrZbn34Y4DQ