Information Visualisation in Games: How do you know what you know?

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Abstract

Information Visualisation is a field of research with ties to Human-computer Interaction and Cognitive Science. It concerns the way complex information is represented in order to enhance the viewer’s ability to comprehend the information. Video-games are instances where information and the way it is presented are vital, yet not much research exists about Information Visualisation in games. The two questions that guide this thesis are: How is Information Visualisation used in video-games? How does Information Visualisation help players understand what is going on in the game? The first part of the thesis describes what Information Visualisation is, as well as a few techniques it uses. Then, Information Visualisation in games is presented. Later, the thesis details the results of applying Information Visualisation to games, finding visualisation techniques, as well as a study conducted by showing gameplay to gamers and non-gamers, having them describe what they comprehend. From these results, conclusions were drawn that games may use similar visualisation techniques based on where the focus is directed, as well as that when and how information is displayed is important for players to comprehend events within the game.

Keywords: Information Visualisation, Games, Interface, Human-computer Interaction

1. Introduction

Making decisions can be hard. Choosing one thing over another, deciding on a particular action out of several possible, all rational decisions require one thing at the very least: information. The manner in which information is presented to you can have an influence on your behaviour and the decisions you make (Hong, Thong, Tam, 2004); which makes it very important to think about how different types of information should be presented, in order to enable users to understand and act more efficiently.

Much of the data and information in the modern world can be quite complex and difficult to comprehend at a glance. One must often be a trained specialist in a field to be able to understand the raw data that can be found quite easily on the internet these days. People who are not electrical engineers may not know what they are seeing when presented with a calculation of the impedance in a given electrical circuit, just the same as these electrical engineers may not know what to make of complex financial data that would give an economist no trouble. In video- and computer-games there is often complex data that must be presented in a palatable way to the largest amount of people.

The way we go around this problem is through presenting the data visually, for example in graphs or symbols and iconography. We also present some data aurally, sometimes even through touch. The visual system however is usually a person’s most efficient and powerful processing mechanism because it can process information automatically, unconsciously, and in parallel, as well as circumventing the limitations of working memory (Zhang, Johnson, Malin, Smith, 2008).

This is particularly useful in video-games, since they are made up of libraries of code and contain several databases worth of information which they attempt to communicate to players continuously. If we apply the lens of Information Visualisation to video-games, then we should be
able to find those visualisation techniques that are used and note just how they aid the user in understanding the game.

In this thesis I aim to clarify what Information Visualisation is, and how it is applied in video-games in order to convey the complex information within them to the player. Section 2 describes Information visualisation, and some techniques that can be implemented, Section 3 describes Information Visualisation in games, Section 4 presents the methodology, Section 5 contains the results of my study and Sections 6 and 7 are discussion and conclusions based on those results.

1.1 Research Questions

The questions that this research means to answer are “How is Information Visualisation used in games?” and “How does Information Visualisation help players understand what is going on in the game?”. This is to investigate how various Information Visualisation methods and techniques are used to aid players in comprehending the games they play.

2. What is Information Visualisation?

The term “visualisation” is defined as “the act or process of interpreting in visual terms, or putting into visible form” but also as “formation of mental visual images” (Merriam-Webster Online Dictionary - Visualisation). Information Visualisation, then, should be about putting information into a visible form, to facilitate the formation of mental visual images in the user. This would imply that Information Visualisation has a basis in cognition, something that has been brought up in previous research (Card, Mackinlay, Shneiderman, 1999; Spence, 2001).

In his book “Information Visualisation” Robert Spence says that visualisation is a human activity and has nothing at all to do with computers - although they do greatly support and enhance the ability to visualise. Alan Dix (2012) defines visualisation as “making data easier to understand using direct sensory experience”. In his definition, he makes room for the use of the other senses besides sight to aid visualisation. Dix maintains that his definition and the dictionary definition are both about insight and understanding, but that his definition encompasses perception in general and deliberate design (of the mental image). As an example, he refers to the audible clicks of a Geiger counter, whose variable speed indicates more or less radiation. This would aid your perception of whether or not an environment is radioactive or not- thus it is relevant for your mental model (visualisation) of your environment.

According to Dix, “Information” Visualisation is termed as such in order to differentiate it from “Scientific” Visualisation, in which many phenomena have direct physical properties despite being invisible to us. The data of concern under Information Visualisation on the other hand is often abstract and to some degree disconnected from the physical world, having no direct physical influence. Fluctuations on the stock market would be one example, organisational hierarchies yet another.

Riccardo Mazza (2004) calls Information Visualisation a discipline that is concerned with the creation of visual artefacts aimed at amplifying cognition and refers to definitions offered by two research institutes (Institute for Software Research, University of California, and UI Research group of PARC-XEROX) to define the scope of the discipline. The definition offered by the University of California regards Information Visualisation as the development and analysis of methods to present information in a visual form, and the one offered by PARC-XEROX states that Information Visualisation is a form of external cognition using the resources of the world to
amplify the abilities of the mind, that resource being visual representations of abstract data generated on computers in this case.

Card, Mackinlay and Shneiderman (1999) wrote that the evolution of the computer has made it easier to create graphical representations that automatically assemble massive amounts of data objects into pictures, which can reveal properties of the data that may have been hidden in its raw form. It also allows for interactivity, letting the user alter and shape the representation according to their needs, creating new methods for enhancing the cognition of the user. The means by which Information Visualisation can enhance cognition is by grouping related information to minimise search actions, as well as reducing working memory load and transforming hard-to-digest data (ex: financial data) into easily understandable representations such as bars in a graph.

So, in sum, what is Information Visualisation? According to the definitions, Information Visualisation is how a person creates a mental model of a given data set based on their understanding of it. One might draw a parallel to the practice of giving metaphorical representations to some abstract concept in order to communicate some aspect of that concept, such as “the monkey on your back” when referring to an addiction in order to illustrate the nagging craving that addicts can feel. In essence, this is what Information Visualisation can be understood as: the practice of giving representational form to abstract data. Based on the above review, the key points characterising information visualisation are as follows.

**Information Visualisation:**
- Can be defined as the representation of data in a way that enhances the ability to understand it
- Supports the ability to comprehend large amounts of data
- Provides aid in communicating certain aspects of data
- Provides a foothold for uninitiated persons to understand data beyond their expertise
- Can make visible properties that might be hidden by the apparent complexity of the data

### 2.1 Methods of Information Visualisation

There are many different ways in which information can be visualised. If adhering to a definition like Dix's (2012), those methods grow to include aural and tactile visualisation, perhaps even more if engaging the sense of smell, balance or perhaps even kinesthesia and other lesser known senses. In this thesis I will tend toward strictly visual-based methods of Information Visualisation, meaning methods that make use of sight in order to communicate data and its properties.

According to Mazza (2004), there are several issues to consider before using Information Visualisation techniques. These include:
- That which is to be presented
- The type of data (Numbers, Categories, ...)
- How many dimensions the data contains (1-4+)
- How the data is structured (Linear, temporal, spatial, hierarchical and network)
- How the data can be interacted with

Based on these, one can identify which techniques are useful for visualising a certain set of data. Dix (2012) also lists several kinds of visualisation techniques based on the type and structure of the data to be presented. There are several groups of visualisation techniques (Young, 1996), such as mappings: the mapping of aspects of the data to objects within the visualisation. Presentation techniques focus on the appearance of the data to allow a more intuitive reading, and dynamic techniques allow the visualisations to respond to changes in the data or actions of the user.
2.1.1 One- and Two-dimensional data
These types of data are some of the most commonly visualised data, and are easy to do so using scatter-plots, charts, histograms and various other graphics using one or two axes (Mazza, 2004; Dix, 2012). Two-dimensional visualisations enable a viewer to identify relationships between two variables more easily, time vs. effort for example, while one-dimensional visualisations can help identify data-points of interest based on a single attribute such as finding the lowest value in a set of numbers.

2.1.2 Three-dimensional data
Three-dimensional data is easy for us to present and comprehend because we ourselves exist in a three-dimensional world. However, the devices we use to present this data can only represent it in two dimensions, a limitation of current state of display-technology. To be able to display information in three dimensions on computers and other such devices, we use tricks and shortcuts to get around the limitations (Spence, 2001).

One of these tricks is to use occlusion to simulate depth. Occlusion is when a closer object partly or entirely obscures an object that is further away. Another trick is to make things smaller the “further” away they are or bigger if they are closer. What most of these tricks have in common is that they attempt to emulate the depth of objects in the real world while the representation is constrained within a two-dimensional display.

2.1.3 Multidimensional data
Multidimensional data is data that has more than three dimensions or properties of interest. An example of this might be the articles in academic databases, which have multiple keywords to identify their content and allow users to search for any combination of subjects.

Dzemyda, Kurasova and Žilinskas (2013) discuss several strategies for multidimensional data visualisation, and ways in which visualisation can be applied, such as visualising economical, social and medical data. These strategies are divided into two different types: Direct Visualisation and Dimensionality Reduction. Their focus is mostly on the mathematics behind different visualisation methods.

Direct Visualisation directly translates the data into a visual form that a human viewer can comprehend. The aforementioned scatter-plots are one such method. Dzemyda et al. (2013) describe three strategies that fall under the category Direct Visualisation. The first is Geometric Methods. These methods use geometric shapes to display multidimensional data along their axes. Scatter-plots for example display points of data within a square shaped field in two dimensions, or a box shape in three or more dimensions. The geometric methods are quite useful in that they can be very clear and support a high number of dimensions, perhaps due to its simple and direct nature.

The second strategy they discuss is Iconographic Displays. These are meant to aid perception of the data, in addition to mapping them onto an n-dimensional space. Each object or property that is defined by the number of dimensions is represented by an icon, or glyph, whose features, such as colour, shape, and location, depend on the values of the data that it represents. The two most famous methods are Chernoff faces and the star method (Dzemyda et al., 2013). The Chernoff method maps the features of the data to facial features such as the eyes, the ears, or the nose. The features of the data will vary the size, placement and orientation of the face and its features. Faces generated from similar data will look similar to each other, while two different sets of data might vary significantly, such as with larger heads but a smaller nose and eyes. The Star method
represents objects as star shapes, with features of the data appearing as lines within these shapes, their length determined by their values.

Hierarchical displays are discussed by Dzemyda et al. (2013) as examples of Iconographic Displays, but also as separate points by others (Mazza, 2004; Dix, 2012). The most common method to show hierarchical data is tree diagrams, displayed as charts with objects connected by lines that flow in a certain direction. As these trees start to display larger amounts of data, the display can quickly run out of space and portions of data might be obscured by other data due to the limited nature of the two-dimensional display. Placing the tree in a three-dimensional space, allowing objects to exist behind others, and then letting the viewer change the angle of their view can solve this problem in a simple way.

Dimensionality Reduction is the third strategy of Direct Visualisation, and concerns the reduction of the dimensionality of data in order to display high-dimensional objects on a lower-dimensional space, while preserving the features of the data as faithfully as possible. The methods under this strategy attempt to transform the higher-dimensional data and approximate it to a lower-dimensional form in order to make it more manageable to display given the limitations set by these lower dimensions.

As mentioned, Mazza (2004) also lists a few methods and techniques to visualise data with more than three variables. Similarly to Dzemyda et al. (2013) he lists Geometric, Icon and Hierarchical methods such as scatterplots, Chernoff faces and Trees. He also lists Pixel, Distortion and graph-based methods.

Pixel methods use and manipulate pixels to represent data, using techniques such as space fillings and mosaic plots. Space fillings use dithering and clusters of pixels to represent the data (Velho & Gomes, 1991). Mosaic plots are a graphical method used to represent qualitative data with two or more variables. Each variable is represented as a square shape whose area grows or shrinks with the value of its variable (Schlotzhauer, 2007).

Distortion methods distort the three-dimensional space to allow more information to be represented. Some techniques include perspective wall, fish-eye view, and Benediktine space (Young, 1996). Perspective walls allow the user to navigate and view large, linear data. They can focus on a particular area of information and still have an idea of context in the larger data set. The perspective wall technique avoids problems of information overload and loss of context by allowing the user to focus on specific information, while offering contextual cues to adjacent information. Fish-eye views are similar in that they allow viewers to focus on certain information while keeping the relation to other adjacent information visible. It does this by distorting the view, similar to a magnifying glass, so that objects in the center of focus are magnified, while those approaching the periphery are smaller the further away from the focal-point they are. This allows viewers to focus on what they deem important while still being aware of the surrounding information. Benediktine space refers to the mapping of attributes onto intrinsic and extrinsic spatial dimensions, intrinsic specifying attributes of the object and extrinsic the position of the object in a space. An example set forth by Young (1996, p.5) would be mapping student names along an x-axis and their exam results along the y-axis, and their degree could be an intrinsic dimension such as shape or colour.

Graph-based methods use nodes and lines to represent data and include such methods as basic graphs and hyperbolic graphs, where the graph is mapped in a hyperbolic space.

Some other techniques discussed by Mazza (2004) are composition, layering and separation, micro-macro readings and small multiples. Composition techniques such as single-axis...
composition align data that use the same axis, along that axis. Recursive composition divides the represented space into regions, which can each have visualisations of their own types (Card, Mackinlay, Shneiderman, 2009). Layering and separation deals with visually differentiating aspects of the data. Distinguishing information by colour, shape, size, other visual cues or ordering in layers, helps avoid informational noise that might otherwise be a hindrance in viewing the data. Micro-macro readings present large amounts of data with a high density. It resembles composition in that different variations of data can be combined within the same image. What it means is that informational detail cumulates into larger structures of information. An example of this is a visualisation of sleep-and-wake cycles of newborn children, where each individual observation can be seen on the micro level, and the larger cycle of observations of the circadian rhythm on the macro level (Meyer, Thomas, Diehl, Fisher, Keim, 2010). Small multiples repeats the same graphical design several times, enabling viewers to compare a series of graphics at a glance, all containing the same variables which can change between each. This emphasises changes in the data.

2.2 View Transformations and interaction

It is important for viewers to be able to manipulate the data in order to suit their needs. For example, if more information is displayed than a viewer can handle they should be able to reduce the amount of information that is displayed, or they risk suffering from information overload (Wang Baldonado, Woodruff, Kuchinsky, 2000; Gershon, 1998). The amount of information that is available for view can easily exceed the amount that can be displayed on computers at once, which can cause some information to be obscured by other information that is perhaps irrelevant to the viewer’s current focus.

The techniques used to transform and navigate through data on computers have been in use for quite some time, such as zooming, panning, scrolling, scaling, rotation, Focus+context and magic lenses (Mazza, 20014; Haber, McNabb, 1990). Zooming in or out magnifies or contracts a part of or a whole two-dimensional representation. Panning refers to moving the viewing port (viewport) across a representation of a greater size than can be displayed at once. Scrolling similarly moves data past the viewport, the difference being that panning moves the viewport while the position of the data is static, and when scrolling, the viewport is static while the data is moved. Focus+context is a view transformation technique which uses the same principles as the fish-eye view to illustrate the larger data as well as the data that is in focus. In this technique, users can expand and contract parts of a larger image, allowing them to focus on certain information and still maintain an overview. Magic lenses function similarly to Focus+context, though in this case more detailed information that is hidden from view can be accessed by placing a “lens” over an object of interest.

These methods of view transformation can also be considered interaction with the data. Interactivity can make simple visualisation methods much more powerful and allows the user to dynamically alter the information that is presented (Dix, 2012). Interaction goes a bit further than simple view transformation as interactivity can impact not only the view of the data, but the actual data itself, as well as the viewer (Yi, ah Kang, Stasko, Jacko, 2007). Interactive representations of information make it easier for viewers to find and digest the information that is relevant to them. Computers enable high interactivity with data and information that would not be possible with analog representations. This is especially important in applications such as computer games, which are interactive by nature. Without it, they might simply be digital storybooks.
3. Information Visualisation in games

Games played on the computer or on video-game consoles are different in nature than simple board games or other games played in the physical world. Analog games, games that take place in the real world, can be complex but are still comprehensible to humans without the need for too many extra steps. Throwing a ball is throwing a ball, and something like Monopoly is rolling dice and moving pieces around a board. These games are so simple that explaining them is almost more difficult to do than playing them.

Not so for videogames. This type of game consists of large amounts of data with many variables, often just a bunch of numbers, and vast libraries of code that only make sense to a computer (Dalmau, 2004). In truth, a videogame is a collection of information that possesses various attributes that exist in certain states. When the game is played and the player performs certain actions, the state of this information is changed. For example, the line of code playerHasKey=0 changes to playerHasKey=1 when the player picks up a key, or npcTar=npc[48], then npcTar=npc[52] as the player switches target, and so on. But a game that looked like that would be hard to play, and also quite boring.

Videogames themselves might be considered a form of information visualisation; however this thesis deals with the ways information is visualised within the game, not that the game is already a visualisation of itself. Current Information Visualisation research hardly discusses games at all (Mazza, 2004; Dix, 2012; Card, Mackinlay, Shneiderman, 2009), and those that do are usually about such things as telemetry collected about users and how to visualise such data (Rhyne, 2002; Medler, Magerko, 2011), rather than the information the game itself presents to the player. This is the type of visualisation this thesis will focus on, not the visualisation that builds the gameworld, but the visualisation that tells the player what is happening within the gameworld.

Videogames (referred to simply as games hereafter) use some of the visualisation methods described above, as well as some variations and other methods that are specific to games (Bowman, Elmqvist, Jankun-Kelly, 2012). Modern games sometimes also incorporate more traditional methods of visualising data, such as simple tree-diagrams and bar graphs.

There are some key differences between how visualisation methods are implemented in games and how they are used when viewing non-game information. One such difference is that games are meant to be entertaining, and any visualisations that take place within it must not disrupt that aspect. This often means that the visualisation must be “useful” and “pleasing” (Bowman et al., 2012), rather than just maximising utility.

Bowman et al. (2012) developed a framework to classify visualisation techniques in games which looks at five elements of these visualisations in order to identify them. These are:

- **Primary purpose:** What information is intended to be conveyed?
- **Target audience:** To whom is this information conveyed?
- **Temporal usage:** When are these visualisations displayed? What period of time does the information come from, is it historical or predictive?
- **Visual complexity:** How complex is the visualisation? Is it bars and graphs, or something more advanced like a heatmap?
- **Immersion:** Does the visualisation fit the spirit of the game? Does it seem separated in terms of aesthetics? Does it support immersion or is it simply informative?
4. Methodology

For this thesis I have studied literature pertaining to the field of Information Visualisation, in order to learn more about the subject and also to see how much research has been done into games from an Information Visualisation perspective. I learned that there is very little research done about visualisation techniques in games, which I find odd since it seems to be a perfect example of what Information Visualisation is good for.

The greater part of my research for this thesis has been a literature study, as the first step in any research project is knowing the current status of the body of knowledge in that research field (Levy & Ellis, 2006 p.183). After learning about Information Visualisation techniques and how to identify them, I selected and examined two games, searching for how they used visualisation techniques. After that, for each game, I selected two five-minute videos of gameplay and showed them to two groups of people, one group of experienced players and one group of people who have little or no experience playing videogames. In this section, I will describe the process used to acquire the materials and conduct the interviews. At the end of the section I further discuss the reasoning behind my choices regarding the methods used in this study.

4.1 Literature Study

The literature study I conducted for this thesis was meant to give an overall insight into the field of Information Visualisation, in order to get an overview of the body of knowledge and see where it might be lacking. Literature studies are meant to enable the development of theories, to close saturated areas of research and to reveal areas that need more research (Webster & Watson, 2002 pp.13). Literature studies provide a foundation for other research, in this case my own, by gathering and presenting concepts and findings of previous research and so strengthening the body of knowledge (Ibid. 2002). I have taken a qualitative approach in this literature study, in order to see where current theory and research is inadequate (Creswell, 2013), which is the case regarding Information Visualisation in games.

4.2 The Choice of Database

To gather the knowledge used to write this thesis, my main source has been the online electronic article database, Google Scholar. Through this database I have also accessed other databases and publishing sites when the articles have not been directly available, such as the ACM Digital Library and IEEE databases. As a note, Google Scholar does not usually host articles itself, but provides links to these articles on other databases.

I used Google Scholar mainly because it is easy to use, offers a wide pool of results and has an easy-to-use citing system. The massive amount of results one sometimes gets on Google Scholar can be a hindrance however, as it makes sifting through the articles a chore, at best.

4.3 The search for materials

The initial terms and combinations I used to search for articles were: Information Visualisation, Information Visualisation Techniques, Information Visualisation Methods, and Information Visualisation in games. This gave me some initial results, from which I learned new terms to search for such as: Interactive Visualisation, Multivariate data visualisations, and the various names of strategies and techniques of Information Visualisation. I selected articles after reading their abstracts and then, if it seemed relevant, I read the whole article. The search terms returned a large amount of results, from over 500 000 to around 1 000 000. To make this more manageable I
switched around the search combinations and altered the filters in order to make sure I was getting relevant results. After I had found a few articles, I saw that several names and works seemed to be recurring in their references, and searched for those too. This helped me build a network of related research from which to draw the knowledge used in this thesis.

4.4 The “Player” studies

After gathering enough information and learning what I needed to about Information Visualisation, and then selecting two games to analyze, I recruited two groups of people, “gamers” and “non-gamers”, to view gameplay videos and vocally externalise what they understood about what was going on in the game, and what it was that made them understand. I conducted this study in order to investigate the research question: “How does Information Visualisation help players understand what is going on in the game?”

The games I selected were Battlefield 4 and World of Warcraft (WoW). These two games were selected after compiling a list of popular games (WoW, Battlefield 4, DOTA 2, Starcraft II, Call of Duty: Black Ops III, Wildstar, along with a few others) and randomly choosing two with separate genres.

I chose two videos for each game, with each video being 5 minutes long. These pairs of videos were characterised as “busy” - in these videos there was a lot of action and consequently a lot of information to take in, and “slow” - in these, the gameplay was a bit calmer and the stream of information was less intense. The videos were selected based on how much information was being displayed and the in-game situations they displayed.

I then showed these videos to the people in each group, varying the order in some cases to avoid an order effect, and recorded their sessions. I obtained permission to record them prior to starting the study, and the participants are anonymised.

4.4.1 The Groups

The groups (Table 1) consisted of non-gamers and gamers, separated based on how much they have played games and the degree of their familiarity with game interfaces.

<table>
<thead>
<tr>
<th>Group</th>
<th>Non-gamers</th>
<th>Gamers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>Little or none, don't play games often</td>
<td>Played several games and/or play regularly</td>
</tr>
<tr>
<td>Age</td>
<td>18-25</td>
<td>18-25</td>
</tr>
<tr>
<td>Genders</td>
<td>4 Female, 1 Male</td>
<td>4 Female, 1 Male</td>
</tr>
</tbody>
</table>

Table 1 – Details of group composition

The ten participants were those who volunteered to be a part of the study. I wanted to avoid possible gender bias, so I recruited the same ratio of men and women for each group. Some of the participants in the gamer group had experience with World of Warcraft and previous games in the Battlefield series, which may have influenced the results of the study.

4.5 Method Criticism

Many of the decisions made regarding the method and execution of this study and thesis were made with the resources available and time constraints in mind. I had five participants in each
group because that’s how many I was able to recruit in a reasonable amount of time. Most of the people that I approached declined to participate, saying they weren’t interested or they didn’t have time. I wanted to avoid gender bias in my study, but it’s not certain that there would be any difference between genders regarding what they see and understand in the games. I had a difficult time finding females for the gamer group, if I had ignored the possibility of gender bias I could have made the groups larger.

I selected the games World of Warcraft and Battlefield 4 because I thought that they were different, based on their genre and perspective. In terms of Information Visualisation however, it turned out they weren’t so different after all – as will be apparent in the results section. In hindsight, I should have chosen a game that is played in a completely different way from either of the two I selected, such as a strategy game. I didn’t choose from within a single genre because I wanted a broader picture of how Information Visualisation is used in games, including differences between genres. I didn’t choose more than two games because I felt that having more would mean too great an increase in the time required for the study, both for my own analysis and for the viewers. Participants may not have been interested if they had to watch thirty or forty or more minutes of gameplay videos, 20 minutes was already plenty. Furthermore, I chose to use videos of gameplay, rather than letting the participants play the games themselves, because it would take longer for them to learn how to play than to simply watch the video.

5. Results

In this section I have applied the knowledge I have gained through my literature search to the two games Battlefield 4 and World of Warcraft. I examined the interface of these games and identified some techniques that can be considered as Visualisation techniques. In this section I also describe the results of my study with the player groups and in the next section I discuss and compare my analysis and expectations with my results from the study.

5.1 Visualisation techniques in Battlefield 4

Battlefield 4 is a war-themed shooter game in the first-person perspective. Players can choose a class of soldier (Engineer, Scout/Recon, Assault, etc.), and are sorted into teams randomly upon joining a match but can switch as desired, so long as the teams remain balanced. Teams are also divided into squads of 5, so each team consists of a number of squads which are encouraged to complete objectives together.

When examining the interface of the game, one can see many instances of information being presented to the player. Many of these instances seem to be a blend of several visualisation techniques, such as a Fish-eye view, icons and perspective wall. There is a small map (minimap) in the corner (fig. 1), giving the player a view of their immediate surrounding, as well as icons that show the state and direction of various battlefield objectives. Included around the minimap is information showing team membership, squad membership, time remaining in the game as well as an overview of the “lives” left for each team, though this is interchangeable with a different metric based on the type of objectives in the current game, such as a point total based on holding certain positions on the map.
As a whole, the minimap can be considered an implementation of a perspective wall, using layering and separation and Benediktine techniques to visualise the different information it has to offer. The map allows the player to have an overview of their surroundings while keeping their main focus on the view in front of them. Shown on the map is orientational information within the game world such as the cardinal directions North, East, South, West. The direction of Battlefield Objectives that are further away than the map can display are shown by icons, with colour and shape indicating team ownership and the name of each represented by letters. The area striped in red in the lower-left corner is the “no-man’s-land” where players cannot enter and have 10 seconds to return to the field or be immediately killed. Squad and team membership are shown by the green and blue colours, with enemies being orange. The players position is always in the center of the minimap, and their field of view is depicted by a cone overlaid on top of the minimap. The icons in the map-field show players, friend or foe (if spotted by the player or a teammate), and their current status as on-foot (triangle) or in a vehicle/gun-emplacement. From this, in fig. 1 we can gather that the player is currently riding in a tank, is positioned next to an allied tank, close to a held objective (defending), with a squad-mate manning a gun-emplacement off to their right. No enemies have been spotted in the immediate vicinity. The squad-leader is marked by a green star, and the commander of the team as a blue star with a different design. As mentioned before, information about how the battle is going overall is displayed above the minimap, such as team names and numbers as well as bars showing a teams “lives” or points. A list of squadmates and the battlefield commander is shown on the right. There is also a bar there that fills up as the player accrues points, giving access to various perks based on what class of soldier the player has chosen.

With the way this minimap presents different information to the user, we can see how it could be said to use Layering and Separation techniques. The distinct colours and shapes of the icons help the user differentiate between other players, objects and objectives. That allies and squadmates also have separate colours is a type of layering of information. Acting together with your squad is encouraged by the game through extra points, placing the value of information to keep track of your squad above that of keeping track of your other teammates.

The overall design of the minimap indicates something of a fish-eye view however, given the placement and importance of the information. The players position and surroundings are given the most focus, with objects that are further away and thus might currently be of less concern (or threat) to the player clustered around the edges of the map. This way, they are granted situational
awareness, not only of their immediate surroundings, but also of the battlefield at large. Ultimately, this enables the player to perform micro-macro readings of the state of the game, particularly through viewing the objective-markers at the top of the minimap, showing the status of each individual objective right next to each other. For example, in fig. 1, the player can see that objective B is unclaimed, but also that their team controls 50% of the objectives.

As mentioned at the beginning of this section, Battlefield 4 is a game set in a first-person perspective. This means that the player sees through their avatar’s eyes. This gives the player a frame of reference similar to what they would have if they themselves were out on the field. The game environment is shown as though looking at it through the player’s own eyes. This raises some questions as to how the game might help a player visualise their perspective as being connected to a body, and not just a viewport showing the picture from a camera. First-person shooter (FPS) games these days address this by showing various parts of the avatar’s body depending on the stance and actions of the player. Holding a rifle will bring a rifle - and the avatar's arms and hands carrying it - into view. Vaulting a railing will also bring the avatar's legs into view. Other solutions have been simulating the movement of the head while running, making the view bob up and down, or a slight crouch before jumping. Most common though is having the hands and weapon in view at all times, along with the player being able to look down and see their “body”.

Fig. 2 shows an example of the player's perspective while playing the Recon (sniper) class. This player has just shot another player from a great distance with his rifle, earning him the marksman ribbon as seen at the top of fig. 2. A rundown of the points the player received for this ticks by on the lower center of the screen, above a series of icons displaying special items the player can use and which keys to press to activate them.

At the top right of the image is the action feed, showing who died recently, how, and by whom. Also in this corner is a menu bar, with information about how to activate the menu (image of the backspace key), friends that are online, game achievements and a leaderboard. The numbers in the top right display the frame-rate that the player has, and is not part of the game itself. Not pictured in fig. 2 is the chat-box which, when active, resides in the top left corner. On the bottom left is the minimap and on the bottom right is information about the player's resources: ammunition, amount of grenades and health points.
The player perspective fits the criteria of the fish-eye view visualisation technique, since the information of most importance and the focus of the player is in the center of the screen, around the crosshairs. Players themselves direct their focus in FPS games, though one could say that the focus is always on the environment in front of the player. Since the player focus is inevitably directed to the center of the perspective, information must be placed in a way such that important information is closer to the focal-point, and information that may not be as pressing but still required is placed further towards the edges of the perspective.

If the player is shot by an enemy, there will be a flash of red and a blood-like overlay will be placed on a side of the field of view roughly corresponding to the direction they were shot from (fig. 3). If the player fires at an enemy and hits, there will be a “tick” that appears around the crosshairs as an indication of this. The tick is slightly rotated, to fit in the spaces of the crosshairs, but otherwise is identical to the crosshairs.

![Fig. 3 – A player has been shot, but has also struck his opponent](image)

It is through these aspects of the interface that the player can visualise the context and events within the game. They are given detailed information, about the various situations across the battlefield, their own actions and surroundings in a novel, immersive and, ultimately, entertaining way. Each of these aspects serve a different purpose, according to the framework proposed by Bowman et al. (2012). The minimap would serve the purpose of “status” and “communication”. Status visualisations provide important information about the state of the game and the player, to the player. It also serves the communication purpose because it can communicate other players’ status, as well as be used to communicate with others through markers, pings and orders on the map. The vitals information in the bottom right also has the purpose of status, but not communication. The action feed in the top right fills a communication purpose about allied and enemy players having killed another player or been killed themselves, but it could also be said that it is a status visualisation as well, perhaps showing that many more friendly players are dying than enemies, indicating the way the game is going. However, if one were to be required to state a single main purpose for each interface element, nearly all of them would be “status”. Everything the player sees in the interface conveys something about the status of the player relative to the game. In some instances, it will also convey something about the status of other players. For example, the
player has just shot and killed an enemy. They are informed about this by the ribbon they receive, the hit marker that appears, and the points that scroll by below their focal-point.

In this sequence, status update and communication both occur through the same elements. What this indicates is that classifying certain elements to one type of visualisation might require making a decision about what is the most important information conveyed by that element.

5.2 Visualisation in World of Warcraft

World of Warcraft (WoW) is a fantasy-theme MMORPG, a Massively Multiplayer Online Role Playing Game. What this means is that a large amount of players are playing the same game together at the same time. In 2014, WoW had 10 million subscribers, with several hundred thousand players per server.

WoW is a role-playing game, which means that players can create a character as their avatar. They select a race, gender, and class, then name their character and start playing. A large difference between RPG-games, especially MMORPGs like WoW, and FPS games like Battlefield 4 is the duration and persistence of the game.

WoW is a game that is played in the long term, with players leveling their characters and acquiring items over a period of time, and when you log out, you log back in at the same place with the same progress. Battlefield 4 is more episodic, each match is unique and you start over from the beginning. If you leave a match, the next match will be a new one with new allies and opponents, even new objectives. The pace of the games are also different, with WoW being of a slower, often more methodic type, and Battlefield 4 being a frantic rush.

This makes a difference in what type of information is required by the user. Character development requires a view of the character's individual statistics, such as health, skill resource (mana, energy, fury, etc.), their survivability, their damage potential and so on. Planning out which character talents to take requires an overview of what is available and what is yet to come. Knowing which items to keep and which to throw away is also important.

Examining the interface of WoW, one can easily see that the staples of RPG information are present (Fig. 4). Presented in the top left are the health and resource bar in a frame along with the character's name, level and portrait. Next to that is a similar frame showing the player's targeted enemy's portrait, health, eventual resources, name and level.
Fig. 4 – A player fighting an undead ghoul

At the bottom, a “bar” spans the length of the screen - we’ll call this the main bar. The left half of this bar is the skill bar, where players can view and use their skills. The player in fig. 4 has activated additional bars that appear around the screen as clear, shaded boxes until a skill is placed within them. The player can page through several different configurations of the main skill bar using the arrow buttons in the middle, with the number displaying which page they are on. The character's experience points are also displayed along the top of the main bar in purple, with a numerical value of the required amount to level and the current amount.

On the right half of the main bar are buttons that lead to the various windows of information that are required by the player in order to play the game effectively, in the long term. The first button displays the face of the character, and is the character window, which the player can bring up to view their character's statistical data and attributes, such as strength and agility. In addition to this, around a “paper doll” of their character they can view which items and armour they have equipped.

Next is the skill book, which shows all the skills that a character has and can obtain. In the more recent versions of the game, it also offers tips on how to use certain abilities. Next to that is the character's talent window, which players can use to assign points to various extra skills and talents in order to further customise their character. The rest of the buttons are to an achievement list, the quest log, the player's guild (persistent player groups that can be joined) page, the social window/friends list, mount (transportation) list, the in-game store page and finally the menu and options button. Further to right of these buttons are bags that serve as the player's inventory.

Other than this, there is a quest tracker on the right side of the screen, along with a minimap. In the lower right corner, above the main bar is a tooltip, an information box that identifies objects the player moves the mouse pointer across. Along the top right of the screen is also an area where buffs (beneficial effects on the character) and debuffs (negative effects) appear. Finally, there is a chat window along the left side of the screen.

Overall, the interface of WoW follows the same scheme most RPGs do, with the skill bars, the health and mana bars, buffs, debuffs, quest log, along with the placement of each of these. Many games had similar layouts before, but WoW has been around and been successful for so long that
the gaming community often compares other games, especially MMORPGs, to WoW (And are often found lacking).

While WoW often isn't as frantic as Battlefield 4 can be, there is still plenty of information that needs to be visualised. The player in fig. 4 is well aware that they are in combat, as they have actively targeted and are attacking their opponent. Other ways in which this is shown are the red outlines placed around the character's and opponent's frames in the top left, as well as the character's level being replaced by crossed swords. The damage done to and received from the ghoul scrolls upward above the character, and the casting time for the player's spell is shown below the character. The ghoul's healthbar is almost empty and shows that it has almost been defeated, which will end combat. Looking at the skill bar, we can see that the player's skills are currently in a "cooldown" phase, meaning they can't be used for a short period. This cooldown was initiated by the player casting the spell “Wrath” as displayed by the cast-time bar below the character. Error messages are also displayed near the top of the screen, showing that the player has issued invalid commands. From the message it seems that they had killed another ghoul and tried to cast a spell before targeting the this one. The tooltip in the corner supports this as it specifies the player has their pointer over “corpse”; if it had been an undefeated monster, it would state the type of monster instead.

The chat log is set to the General tab, which currently shows that the player has looted some items recently. The value of the item is shown by the colour of it's name. The blue text indicates that they picked up a rare club, and the white text indicates common items that may have some use. In this case, one is a common cloak, and two are items for crafting items. Had the player picked up junk items they would have been grey. In the case of even rarer and more valuable items, the value goes from lower → higher: Rare (Blue) → Epic (Purple) → Legendary (Orange).

Where the quest log shows the objectives and the quest description as long as the player has the log open, the quest tracker shown on the right side of fig. 4 is an extension of the quest log, showing the objectives continuously while playing. From this, we can see that the player is defeating ghouls as part of a quest, rather than randomly fighting monsters.

The minimap is similar in function to minimaps in almost any game, however this one has some added features. The magnifying glass along the ring of the minimap allows users to customise what is tracked on the minimap, such as vendors, mailboxes, or if they have the appropriate skill, beasts or monsters. There is also a calendar attached to the minimap, which can be clicked on to bring up a larger calendar window with information about in-game events. There is also a clock showing what the time is in the server's time-zone, as well as plus-minus buttons for zooming in and out on the minimap. Aside from this, distant objects of interest, for example a city, are pointed out with arrows. The player is depicted at the center of the minimap as an arrow, and their current target as a red (meaning hostile) dot with an added gold border. In addition to this, the blue field marked on the minimap is the area in which the player can find the ghouls they need to defeat. These blue fields appear to aid players in locating the objectives for their active quest, indicated in the quest tracker by a highlighted yellow, as opposed to a brown one. A quest that is ready to be turned in is signified by a question mark. The name of the geographic zone or subzone that the player is in is displayed above the minimap. This also helps them identify where they are relative to their quest objectives or other goals while playing.

Once again, the most dynamic and contextually important information is displayed in or around the center of the player's perspective, with the more static and constant information displays being gathered around the edges of the screen, so it can be said that this is a fish-eye visualisation type
design scheme. WoW however, does offer a lot of customisability to the user in regards to the interface. The base interface options allow players to scale all elements of the interface to be larger or smaller, according to their preferences. They can add or remove skillbars and even unlock frames to place almost any element of the interface in a position of their choosing. Aside from this, players can also install add-ons to further modify the interface, how it looks, how it functions, add features and more. This does give players the power to control how information is visualised, and greatly enhances the information visualisation capabilities of the game.

![Fig. 5 – A player has modified the interface with addons](image)

Fig. 5 is an example of a heavily modified user interface in WoW. The player has added a meter to track the performance of the group, their damage done, healing done, etc. The cast bar has also been altered, to increase visibility. Important, high-value skills have been separated from, placed above the skillbar, and been enlarged for extra visibility and emphasis. Timers have been added for skills used by the boss-monster, so that the player can know when they need to take special care. The scrolling combat text has also been moved to scroll on either side of the player, along with icons to show which skill the text was caused by, and is filtered to either side based on criteria set by the player, leaving the middle open for particularly interesting information, such as a critical hit or critical heal, more powerful instances of their respective action type.

Modifying the interface is relatively simple, but planning the information visualisation of it can be much harder. Inexperienced players may find the increased information available from a modified interface to be too much at once, unable to make sense of it all. Even experienced players may become confused when the interface has been altered improperly.
Fig. 6 – A heavily modified interface

Fig. 6 shows an interface which has been more heavily modified, with its own graphical style. In this one, the “unit” frames of the character and their target have been placed at the bottom of the screen together with the skillbars. Even the minimap has been moved to the bottom center of the screen, a change that would be quite significant for many players.

Fig. 7 – A modified interface that would likely be hard to grasp

In fig. 7, the player has modified their interface and seems to have created a lot of visual noise. The skillbars overlap in some places, the frame showing the larger group of players is obscuring some other elements of the interface. While this player might be comfortable with how they have arranged their interface, another player might have a hard time understanding what was going on due to the clutter.

Returning to the framework of Bowman et al. (2012), many of the features and elements of the WoW interface share similarities with those of Battlefield 4. The minimap serves the same purpose, for example. There is a bit more interactivity with the minimap in WoW, but the function is ultimately the same. Scrolling combat text has the same purpose of the hit marker and blood overlay, health and mana bars the same as the hp and ammunition counters, and so on.

Where WoW really differs from Battlefield 4 in terms of information visualisation is the freedom the player has to alter the interface. Battlefield 4 is locked in the first-person perspective, and the interface cannot be freely moved around. In WoW, the users can move, resize or completely replace various parts of the interface. They can add or remove information from the display as they wish. The potential for view transformations are much larger, but this also adds the risk of players disrupting the visualisation techniques in place. The modifications frequently do
not share an immersive aesthetic with the game and original interface, and are more informational in nature.

Overall, the base elements of the interface fit the techniques of fish-eye view and layering and separation. Micro-macro readings appear across the interface in almost every element. Health is shown as numbers, but also bars. Each individual skill and its cooldown is visible together with all the other skills the player has on their skillbar. The Magic lens technique is implemented when the player places their mouse-pointer on a skill, object, other player or nearly anything in the game as it brings up a tooltip with detailed information on that object. With the customisability of the interface, players may even add their own visualisation techniques that aren’t already in the game by design.

5.3 The study
In this section I will present the findings in the study that I conducted with the gamers and non-gamers. The reason I chose two groups with different experience was because I expected there to be a difference in how the players with experience and those with none would interpret the visualisations in the game. I will begin with presenting the non-gamer group.

Non-gamers
The participants in this group were largely inexperienced with games, either having played videogames only once or twice, or having only seen someone playing before. All participants in the group said “I don’t play games” or “I am not good at games” or something to that effect.

When viewing the videos of Battlefield 4, the non-gamers identified different elements of the interface within moments of pressing play. While they did recognise the most obvious functions of some, more subtle visualisations were harder for them to identify. They also recognised the theme of the game fairly quickly as a “military game”.

The minimap and ammunition counter were found and identified almost immediately. The health-counter went unmentioned and perhaps unnoticed for the duration of both Battlefield 4 videos. When the player in the first video placed a recon drone and switched view to the drone, the non-gamers did not realise the connection between the drone and the view-change, but they noticed that they changed from a first-person view on the ground to a first-person aerial view. They also noticed that the player was shooting at something with a light on it, but were unable to identify that it was the glare off of an enemy sniper's rifle scope. The action feed in the top right was noted as showing who killed someone.

The minimap and its purpose were obvious to the non-gamers, as they knew what maps are and that they display geographical areas, in this case they identified it as showing the battlefield of the game. Some of the non-gamers felt that the minimap was too hard to understand since they felt it was cluttered with icons and the ground wasn’t shown clearly. They were able to identify the objective-markers as some sort of goal or target, as well as that they had a different shape when held by the enemy and when held by the player's team. From the information above the minimap they found that the player was part of the team playing as the U.S. Army, against the Russian army. They were also able to see that the more objectives one team held, the faster the enemy team’s numbers would decrease, giving them an idea of what the objective of the game was.

There was some confusion about why the player’s colour was green, and that some other players were also green, but the majority were blue or red. Eventually they realised that green signified the player and his team, blue signified other teams that were on the player's side, and red was the
enemy. They never really figured out that players who were identified as green were part of a squad with the player, despite the numerous messages about being “Last Man in Squad” or other references to actions in concert with squad-mates.

The non-gamers had trouble identifying the various icons in the player's field of view that depicted a range of different objects, such as enemy and allied vehicles, teammates, objective locations, and so on. Eventually they did get some idea of what they represented as “pins, showing what is what”.

Some of the non-gamers realised immediately that the player had been shot when blood “flew up in his face”, while others completely missed this event. They all noticed when the player was killed though; the game has a “killcam” that shows how and where the player died, from a third-person perspective.

They noticed that when the player stood near an objective, a bar started filling up that said “flag status” and guessed that their goal was to capture the objective, and defend it from the enemy. At the end of the videos, what they said when asked about what the goal of the game seemed to be, their responses varied but in essence they said, “Capture the area and shoot away the invaders”.

Next I showed them the videos of WoW gameplay which they identified, among other things, as “some sort of fantasy game”, “mutants” and one non-gamer said it was “role-playing”. Once again the minimap was identified quickly, along with the player's representation as an arrow. Following this, they saw the blue area on the minimap (the quest guide), saying it really grabs your attention and guessing that it was some sort of objective, maybe it had the biggest monster and the goal was to capture the blue spot. When the “blue spot” disappeared, they figured it was some kind of objective that they had to accomplish, and once they had done it the blue spot on the minimap disappears. They saw that the things the player were attacking “really look like bad guys”, that they looked like monsters, and that they were carrying a cage on their back that opened up and released green energy when they died. From this they guessed that the player had to kill these monsters to gain what was in the cage, and while it was true that the player's objective was to kill the monsters, they incorrectly identified the reason; The player was just defeating the monsters to fulfil the quest objectives, the releasing of energy from the cages was nothing more than a cosmetic death effect meant to enhance immersion into the fantasy.

They also found the unit-frames in the top left showing the player's health and resources, and the frames showing the player’s target. The non-gamers were able to identify the healthbar as the green one, but had trouble identifying the purpose of the second bar, though they had suspicions that it might have to do with the powering up of the player, or maybe a special skill.

When the player was turning in and accepting quests, the non-gamers were able to identify it as the player receiving objectives to complete, though they weren't sure because the player was accepting and closing the windows too quickly. A cutscene was shown in the video, which the non-gamers identified as “a little movie thing” that showed a little about what the player had to do next.

The second video was of raid-dungeon gameplay, with many players acting together to defeat a larger boss-monster. The non-gamers realised this was something that was bigger than usual because of the way the boss entered the arena, and the amount of players present.

They noticed that the icons at the bottom of the screen were flashing, and identified this as skills being locked for a period of time, although some thought that the icons were the skills of all the players, not just the one whose view they were watching. They thought the player was attacking the boss, but when they examined the video closer they noticed that the player was casting healing spells and realised that the player's role was that of a healer. They saw that the rings and graphics
on the ground were spells cast by the player and others, and that they were likely some kind of protection or healing spell since the attacks from the boss seemed to be deflected.

The large amount of players on the screen obscured the vision of the player's character and the non-gamers lost track of where “they” were, despite the character always being in the center of the screen, with the camera following it.

When asked how they would play the game after having seen the videos, one said they would probably never play it, and others said they would go to the blue areas and clear the objectives, and actually read the quests instead of just accepting them without looking so they could understand better why they were doing anything.

Gamers

The gamer group consisted of people who were more experienced with games and/or played games regularly, possessing a familiarity with game-interfaces and more knowledge of what kind of information they would need to be able to play a game.

The gamers noticed the minimap immediately, pointing out that it contained a lot of information on allied movements and positions and about the objectives on the battlefield. One gamer expressed that they were used to minimaps being in the upper right corner (like in WoW), it felt strange to see it in the bottom left and it took more time to look at it as a result. Additionally, it was seen as crowded and that it might be hard to see some details.

When the player placed the recon drone and switched to the aerial view, one gamer noticed that there was an altimeter showing how high above the ground the drone was, as well as the distance to objects that the drones could detect. Likewise, when the player aimed through their rifle-scope the range-finder and drop-off marks were pointed out. Additionally, the glint of enemy rifle-scopes were correctly identified.

The gamers noticed that green text signified squadmates and blue was for the team, and mentioned how important colours were for distinguishing friend and foe, especially in the heat of the moment.

When the player was trying to capture an objective the gamers immediately noticed the capture progress bar, noting that the player was first “de-capturing”, removing the enemy's ownership of the objective before capturing it for their own team.

They noticed that the player was shooting and hitting the enemy because the player was receiving points at the bottom of the screen, and the hit-marker that appeared around the crosshairs was appreciated. They also noticed that the player was repairing a broken helicopter by “shoving a blowtorch at it”, and remarked that “it used to be just smacking it with a wrench”.

The position of friendly players was obvious to the gamers because of their blue markers, as well as where players had died due to the skull icons. They also noticed that someone had thrown a grenade near the player because a flashing grenade icon appeared.

Some gamers expressed uncertainty about the objective-markers above the minimap, thinking that the difference in shapes (Squares vs. Diamonds) was to aid colourblind players in identifying which team has possession of an objective.

When showing the videos of WoW, the gamers were able to immediately identify it as World of Warcraft, even though some of them hadn't personally played it much, if at all. The Health and mana bars, skillbars, quest tracker, and the minimap were pointed out almost as soon as the video started. The theme of the game was noted as fantasy, supported by the visual effects of the magic the characters used, as well as the environmental design and monsters seen in the game.
The quest guide on the minimap was noticed and the purpose guessed at, then confirmed as it disappeared when the player completed an objective.

The skill cooldowns were pointed out, and some of the gamers felt that the scrolling combat text was irrelevant for more than pointing out that you are in combat, since if you didn’t know exactly how much percentage of health you were damaging the monster for, it wouldn’t give you an accurate picture of how well you are doing. They noticed that the damage text was yellow when the damage was done by a skill, because when the skill started recharging the damage text that scrolled by was yellow.

When shown the video of the boss-fight, all the gamers knew that it was going to be a boss-fight, and that the large group of players were a raid, players playing together to defeat the boss. They noticed that there was a big button below the player's character, which they assumed was a special skill granted to the player during the boss-fight since it took up more space on the screen than the other skills, was placed directly under the character and had attention-grabbing graphics around it. They also pointed out a damage-meter the player had added on the right side of the screen, which they thought was strange since they had noticed that the player was healing the other raid-members and that the player should probably be tracking healing done per second instead. They saw that the player had the role of healer because of the green combat text with plusses next to the numbers, indicating they were adding health rather than removing it, and they also saw from the casting bar that the player was casting healing spells.

When the time came for the raid to change which platform they were standing on, the gamers noted that the fight had moved on to the next “phase” or step of the fight. When the boss was using special skills, the gamers pointed out that a warning appeared above the player’s character.

Some of the gamers returned to discussing colour as a powerful indicator of whether something was good or bad, such as healing or damage, indicating that the game would be much harder if colours were not used to distinguish different information. For example, they knew that the monsters in WoW were enemies not just because they looked like monsters but also because their names and healthbars were red. Likewise, in Battlefield, the Flag Status bar was red when de-capturing and blue when capturing. They also commented on the layout of the information and their preferences regarding where information should be located. Some expressed preferences for a layout that corresponds to a fish-eye view, with important information being placed as close to the center as possible without obscuring the view. Others felt that spreading the information out across the view, but grouping similar information in the same location was easier to understand and would cause less clutter around the center of focus. None of the gamers liked when there was too much information overlapping in focus, for example in Battlefield 4 when the player looked at the center of the battlefield from the edge, all the icons were jumbled together and made no sense to them. The minimap was mentioned as a necessity for developing an acceptable level of situational awareness, as the cues and senses we would use in reality are difficult to reproduce in games.

6. Discussion

How is information visualisation used in games? How does Information Visualisation help the player understand what is going on within the game? Within this thesis, I have searched two games for information visualisation techniques and asked gamers and non-gamers what they can see and understand from looking at these games.
The two games I examined were of completely different genres, they had different player perspectives, different paces. Battlefield 4 was a first-person shooter, action game. World of Warcraft belongs to the role-play genre, played from a third-person perspective and together with millions of other players. One might think that these would employ very different visualisation techniques, but in reality they were very similar. The interface of both games had an overall design that fits into the fish-eye view visualisation technique, with the most important momentary information placed in and around the center of the screen, which is the focal-point in both games. In real-time strategy games, the focus is spread out over the entire interface and the user directs their own attention more freely. This would suggest that, from an information visualisation perspective, one could classify games by their focal-point instead of by their genre or perspective; whether it's first-person or third-person, the focus is always around the center. In contrast, in a management or strategy game the focus is diffused around the screen. I would then call both Battlefield 4 and World of Warcraft “Center-focus games”, which would have similar information layouts.

That said, there are several elements in both that are simply common to most modern games, such as the minimap and differentiation of teams by colour. The type of information that is required in each game does depend on the genre though, as well as the setting. WoW is an rpg, where characters use magic and skills to fight monsters. Thus, they require information about how and when they can use their skills, which is provided by showing the resourcebar and cooldowns, and if the skill can't be used it will turn grey or red. In Battlefield 4, the players use weapons to fight the enemy. Weapons use ammunition, not rechargeable skills, and so require an ammunition counter instead of cooldowns (although there are some rechargeable items and perks in Battlefield 4 as well).

In both games, I noticed a difference in the information that the non-gamers and gamers payed attention to most. The non-gamers were attracted to the more dynamic information, such as the action feed, the ammunition counter and the icons moving around on the screen as other players moved within the players field of view. Whether the player was shooting or had been killed were also big events in the eyes of the non-gamers, these events often interrupted their vocalisation and took over their train of thought.

The gamers seemed to look more at the static, “organisational” information than the non-gamers. In Battlefield 4 they spent a lot of time talking about the minimap, the team information above it, the colours of squads vs. team vs. enemy, objective-markers, and the way icons display friendly players in the field and on the minimap. They noticed such things as the ribbons and points for actions, but placed no more importance on it than signifying the player had done something successfully. They also noticed other information such as the numerical data about distance when looking through a sniper-scope, or the altitude when flying the recon drone, which the non-gamers didn't mention at all. In WoW, when asked to decribe what they were seeing on the screen and what they understood about the game, they started by describing such things as the healthbar, minimap, quest guide, quest tracker, and skillbars. The non-gamers once again first noticed the information that was dynamic and changing, such as the minimap as the player moved, the recharging after the player used a skill or the scrolling combat text while the player was fighting.

The non-gamers seemed to have difficulty understanding what an element of the interface was for if they couldn't find that it changed depending on how the player was acting in the gameworld. First they thought that maybe the quest guide on the minimap showed where the biggest monster
was, until they saw that it disappeared when the player interacted with an object and realised it must be something that shows where objectives are. Likewise, they never quite figured out what the resourcebar was for (indicating the amount of times a player can use a skill), just that it changed sometimes. When shown the video with the raid-boss, they felt like there was too much going on, presumably because their attention was mostly drawn by the dynamic information in the gameworld, such as all the other players moving around and casting spells, along with the large boss that took up considerable screenspace. The gamers on the other hand looked around at the static information in order to get their bearings, with the events in the gameworld being secondary- but important.

The gamers felt that placing the player’s focus in the center was important for the immersive feel of “being in the game”, but also helping players manage the amount of information they have to take in at once. Some preferred to have more information around the center, for example in WoW they would position their bars and unit-frames closer to the center, while others preferred to have a clearer view of the gameworld, so as not to obscure information coming from there such as traps or dangerous environments. This was described as preferring to keep focus on information regarding the player’s personal position in focus, rather than data about such things as group members. In Battlefield 4 however, none of the gamers wanted to have extra information around the center, more than what was necessary to be able to play the game.

I believe that the apparent preference of the gamers towards organisational, static information over the fast-changing dynamic information like the non-gamers is because the gamers’ experience with games has made the processing of the dynamic data much quicker, perhaps even automatic, leaving them free to focus more on the slower static information.

What I mean by this is that the dynamic information changes so quickly that non-gamers’ attention is continually directed towards it because they don’t have the time to process it and understand what it means before it has changed again. Non-gamers might not know the importance of different information in the game, thus making them focus on dynamic information so they don’t miss any changes (Rensink, O’Regan, Clark, 1997). The gamers, due to their experience with games, might already have an idea of what the information is trying to tell them and as such can spend less time on those elements of the interface. What this might mean is that experienced gamers have a better understanding of the ways in which games visualise information to the players, such that they are more efficient at taking in the information and understanding the game.

The literature about Information Visualisation lists many different methods of visualising multidimensional information, such as fish-eye view, perspective wall, magic lens, and more. In my analysis of Battlefield 4 and WoW, I found many of these methods, or at least elements of them, and the participants seemed to follow the patterns of visualisation described in the literature of these methods. This tells us that games are multidimensional, and the methods that fall under this category would be the most common ones used to visualise information in games.

7. Conclusion

This thesis has aimed to apply the lens of Information Visualisation to videogames, to discover how information is visualised within games and how players understand the game through those visualisations. The study sought to answer the questions: How is Information Visualisation used in
games? How does Information Visualisation help players to understand what is going on within the game?

The main findings of the study were described within the Results section, regarding visualisation in Battlefield 4 and World of Warcraft. With the research questions in mind, these findings were:

**First Question: How is Information Visualisation used in games?**
This study found that the two games that were examined appeared to use a fish-eye view to display information, with information appearing closer to the center the more relevant it was to the player's current focus, which was directed to the center of the display.

From this, we can conclude that Information Visualisation can be used to predict and plan where and how the player can most effectively receive and comprehend the information presented by the game.

**Second Question: How does Information Visualisation help players to understand what is going on in the game?**
When and how information is displayed, along with how it is separated from other information is important in allowing players to comprehend events in the game. This was shown by such things as the non-gamers being able to understand the events based on the colours and visual cues displayed as the player completed objectives and performed actions, as well as the gamers being able to tell the meaning of different events and objects based on their colour.

The main contributions of the thesis are in the following areas: the thesis presents and defines how Information Visualisation is used in games, it describes various visualisation techniques and methods that can be found in games, it gives a glimpse into how players comprehend games based on their visualisations, as well as that genre might not be as large a factor in what visualisation methods are used as one might think. These contributions aim to answer the research questions (presented in bold above), about how Information Visualisation is used in games and how it helps players understand the games they play. Following this; The key points that can be taken away from this study are:

- Information Visualisation can explain and be useful for the planning of game-interfaces
- Information Visualisation is important for players to be able to understand not only what is happening, but also the meaning and significance of events in the game.
- The layout of the interface can affect how visible certain information is, and to some degree determine its importance to the player
- Visualisation techniques help players keep focus on their own actions while allowing them to comprehend the larger situations beyond their local area within the game

Given the lack of published research around Information Visualisation in games, a few limitations were encountered in this study. Most of the knowledge in the Information Visualisation field is concerning scientific information, which is very different from the information that games present to the player. This led to a lack of established frameworks and theories with which to approach the subject. Though I would have liked to include interviews with game developers on their thoughts regarding the subject, I was unable to convince any to take the time to speak with me. I would also have liked to examine more games, but due to the limited time I had to limit myself to just two.

Future work should be able to use this thesis as a stepping-stone into researching Information Visualisation in video-games, perhaps developing a new classification system for games from an Information Visualisation perspective, such as “Center-focus games” and “Diffused-focus games”.
Future research could also examine more games for visualisation design patterns that appear across genres in order to produce a theoretical framework of how to plan Information Visualisation for games.

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