

**Imageability and Intelligibility in 3D Game
Environments Examining Experiential and
Cultural Influence on the Design Process**

by

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A thesis submitted in partial fulfilment for the requirements of the degree of
Doctor of Philosophy at the University of Central Lancashire

June 2014

Student Declaration

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

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Type of Award:

Doctor of Philosophy

School:

Computing Engineering and Physical Sciences

Abstract

The games industry has developed online multiplayer three-dimensional game worlds that allow players from different geographical locations to engage in competitive and cooperative gameplay together. This has enabled players from different cultures to inhabit the same virtual game world, bypassing any geographical or cultural boundaries found in the real world. These 3D game worlds ask the player to use the basic principles of spatial awareness and movement from the real world, and are often virtual representations of real world environments. These spaces are designed for players from all nationalities to inhabit concurrently. There is now a need to determine design considerations for these multicultural multiplayer game worlds but any investigation must consider the historical evidence from the games industry of cultural differences in gameplay preferences.

This thesis discusses the effect of cultural knowledge on the spatial design and interpretation of three-dimensional game environments that are based on real world affordances. A new methodology for the comparative analysis of the design of three-dimensional game environments is established using Space Syntax metrics. This facilitates the discussion of cultural models applied to design thinking for the implementation and interpretation of game environments. Through spatial metrics the analysis of the intelligibility underlying three-dimensional game environments is correlated to the imageability of the projected two-dimensional screen image.

The application of this methodology to internationally popular, and culturally specific, game environments establishes new knowledge on tacit cultural influences within game design processes. The analysed intelligibility of the environments indicates cognitive differences between Eastern and Western cultures, already recognised in the interpretation of two-dimensional imagery, also exist within the design and interpretation of three-dimensional game spaces.

This study establishes a new methodology through the analysis of intelligibility for design research into game environments. The resulting evaluation of tacit cultural influences within the design of the environments establishes new cultural differences and commonalities. These design characteristics can inform future game design methodologies within industry for the design and implementation of multicultural game environments.

Acknowledgements

This research question was originally formed during my Masters studies in Game Design in 2002. During my subsequent travels as a design educator I was constantly reminded that I had not found how cultural differences I encountered might determine differences in game worlds. I am thankful to my supervisory team for having the faith in me after our first meeting to consider that I might be able to resolve at least some element of this question.

I would like to thank my Director of Studies Dr Gareth Bellaby who has offered guidance and support on this journey through a wide range of academic subject areas. I am grateful to all of my supervisory team. Professor Lik-Kwan Shark whose rigour developed my confidence to push methodologies into more mathematical areas that I would normally back away from. Professor Simon Robertshaw who saw the potential in the problem and offered encouragement throughout bringing different design viewpoints to bear on the study. Professor Chris Meigh-Andrews who led the discussion into digital arts and cultural practices that helped balanced the maths and keep me sane.

Finally I would like to express my eternal love and gratitude to my wife who has offered me nothing but patience, support and understanding through the trials and tribulations of this study.

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Chapter 1: Introduction

1.1 Background

The games industry has developed online multiplayer three-dimensional (3D) game worlds that allow players from different geographical locations to engage in competitive and cooperative gameplay together. This has enabled players from different cultures to inhabit the same virtual game world bypassing any geographical or cultural boundaries found in the real world. These 3D game worlds ask the player to use the basic principles of spatial awareness and movement from the real world, and are often virtual representations of real world environments. The levels of visual realism that are now possible enable players to transfer their experiential knowledge of the real world into the virtual environment consciously and subconsciously. Cultural differences in encounters and interactions, that are expected when travelling in the real world, are now possible when playing in an online game world.

There is now a need to determine design considerations for these multicultural multiplayer game worlds. Any investigation must consider the differences in cultural behaviour of players when in the real world and the historical evidence from the games industry of cultural differences in gameplay preferences.

Online 3D multiplayer game spaces are a common element within a range of current game genres and have formed specific genres, massively multiplayer online role-playing game (MMORPG) and more recently massively multiplayer first-person shooter (MMFPS). They allow from two to several thousand players to play alongside each other in individual or cooperative gameplay. A battle in the game *Eve Online* (CCP Games, 2003) involved 7548 players from around the world in one 3D space (Moore, 2014).

These spaces may be designed for players from all nationalities to inhabit concurrently, or may delineate player access to multiplayer spaces via game servers in, and for, specific geographic regions. Even with the use of regional servers, evidence indicates players are frequenting game spaces intended for players from different regions to that of their own geographic location.

In the development of the Chinese adaptation of the MMORPG *World of Warcraft* (Blizzard Entertainment, 2004) separate servers for Chinese players were created. Yet some players continued to access foreign servers after the games launch in China (Lindtner, Mainwaring, et al., 2008).

Players often prefer to access different regional servers and with the yet to be released game *Everquest Next* (Sony Online Entertainment, TBA) the President of Sony Online Entertainment, John Smedley, responded to the desire for this functionality

Clearing up a few misconceptions about EQN in Europe and UK. All players including ones from Prosieben [the European supplier] can play on all servers (Smedley, 2013).

A desirable requirement for multiplayer gameplay is a fast network connection to the game server to ensure there is no delay in the transfer of information between the players. Any delay in the updating of game information between players is detrimental to the multiplayer gaming experience. Feng hypothesized the ideal geographic placement of the computer server that runs a game space would closely match the geographic distribution of the players. When running a multiplayer game server to test this hypothesis it was found that 45% of players connected to the server from overseas (Feng and Feng, 2003). This correlated with the geographic time of day in a player location. If there are no other players to play against on the multiplayer game server then the geographic location of the server is not a consideration.

If designers cannot be sure a multiplayer space will not become a multicultural space, then determining design requirements for facilitating multicultural gameplay becomes useful knowledge to inform future game design.

Play has been discussed as a human trait that crosses cultural boundaries by Huizinga (1938) and Caillois (1958). The play of a child is considered anterior to culture, without cultural influences determining behaviour within play. These multicultural multiplayer game spaces contain older players. In America the average age of a game player is 30 and 68% of players are over the age of 18 (ESA, 2013). In this context Huizinga considers play as superior to culture because cultural elements will influence their forms of play. In the multicultural multiplayer space, each player brings his or her cultural influence to bear on the form of gameplay the designer has intended for that game space.

Culture is a complex concept with many different ways of defining it, in this deployment it will be considered in its anthropological form often used in a social sciences context. This form examines the shared values of how social life is constructed and the ideas and practices that form from this shared viewpoint. To quote Stuart Hall a major contributor to this reading of culture:

Culture, it is argued, is not so much a set of *things* – novels and paintings or TV programmes and comics – as a process, a set of *practices*. Primarily, culture is concerned with the production and the exchange of meanings – the ‘giving and taking of meaning’ – between the members of a society or group ... Thus culture depends on its participants interpreting meaningfully what is happening around them, and ‘making sense’ of the world, in broadly similar ways.

(Hall, 1997)

These cultural ‘meanings’ structure our social practices and behaviours, the way we interact with each other. In a multicultural multiplayer game space any cultural differences for players in ‘making sense’ of the space must be considered in its design in order to facilitate cooperative gameplay.

These ‘meanings’ are also conveyed through made artefacts where the artefacts are representations of a common viewpoint. This is the ‘social constructionist approach’ where the production of artefacts is conceived as a cultural practice, the artefact is representative of the shared viewpoint. Salen and Zimmerman discuss games in this context as reflecting culture.

Games reflect the values of the society in which they are played because they are part of the fabric of that society. Any game designer or game scholar who doesn’t engage with games on the level of cultural representation is missing out on a very important part of the picture.

(Salen and Zimmerman, 2006).

A game is reflective of society because a game designer is subject to the cultural influences of their society. Therefore consideration of gameplay in a multicultural multiplayer game space must involve an understanding of the cultural viewpoint of the designer that built the space. The cultural influences of players within the game space should be considered for shared viewpoints with each other and the designer.

There is a history of anecdotal evidence from the games industry of cultural differences in Eastern and Western gameplay preferences. The assertion that certain forms of gameplay, specific to game genres, are more popular with players dependent on their

cultural origin continues to influence the games industry. Naoki Aoyagi, CEO of Japan's largest mobile social games network stated in 2011

some content like sports games they are popular in the worldwide, but some contents are very local -- like Japanese RPGs [Role Playing Games], or the FPS [First Person Shooter] in the U.S. and Europe

(Nutt, 2011).

The game industry has developed this viewpoint over time and it is important to contextualise it within the current market place for games. Historically game sales figures reinforce this viewpoint. In 1999 the First Person Shooter (FPS) *GoldenEye 007* (Rare Ltd, 1997a) was the number two best selling game in America yet failed make the best selling top five games in Japan (IGN Staff, 1999). Ten years later in 2009 the FPS *Call of Duty: Modern Warfare 2* (Infinity Ward, 2009) sold over twice as many units in America than the traditional character based game *New Super Mario Bros Wii* (Nintendo EAD Group No. 4, 2009). In Japan in the same year *New Super Mario Bros Wii* sold over ten times as many units as the FPS game (Parfitt, n.d.).

Game development costs are recognised as constantly increasing (Cerny, 2011) and with any increase there will be the inherent business risks if a game is a financial loss in a particular region. Records of previous sales of games in the same genre in that region cannot be discounted as influential in any industry decision to develop or localise a game.

Other regional factors to consider would include; localisation costs to translate the game, marketing and distribution costs to get the game to retailers and players, the size of the player base or platform ownership that the game has been developed for.

Historically games were developed for a specific game system and the competition between game consoles is well documented in (Kohler, 2004; Sheff, 1994). The early console manufacturers were predominantly Japanese; *Nintendo*, *Sega*, and *Sony*. The American company *Microsoft* released the *Xbox* in 2001. Game analysts have discussed the poor sales of the *Xbox* in Japan. The discussion of gameplay preferences are contextually linked to a focus on America versus Japan, as these have been the dominant forces in the games markets.

The distribution of games has changed with the advancement of communication technologies and the accessibility of Internet access. Downloadable games are now

available for console and computer platforms. These require no consideration of physical packaging and transport costs to distribute them to players in different regions. The free-to-play distribution model is now being used for games on consoles and is used across regions. This requires no initial purchase fee in order for a player to try a game that may be a different genre from a player's previous purchases and perceived cultural preferences.

The free-to-play model is bringing cultural game preferences into question with the South Korean developed FPS *Special Force* (Dragonfly, 2004) accumulating over four million users in Japan. (Korea Game Watch, 2010)

Games are now released concurrently across consoles and computers ensuring all game platforms are reached, distribution models allow free-to-play to attract new players, Asian regions are demonstrating different gameplay preferences to the historical Japanese preferences for gameplay. Historic notions of genre led cultural gameplay preferences can now be questioned in the context of changes to the global market for games.

The adaptation of games is discussed as integral within current game production processes (Chandler and Deming, 2011). The initial industry method is localisation, concerned with the translation of text and dialogue. This ensures any user interface elements or game instructions will be in the specific language for the player. With localisation each player in a multicultural multiplayer game space will see their game interface in their own language. They will still understand instructions from the game and with players from the same culture.

The multicultural MMORPG *Eve Online* (CCP Games, 2003) takes this approach with one game world for all players and localisation of the game interface. The only exception is for Chinese players who play in a separate game world.

Localisation has moved to a deeper understanding of adapting games through the methodology of culturalisation. This is the examination of the game from the shared viewpoint of the players in the specified country or region. This involves changes to a range of game content including art assets, storylines or dialogue ensuring there is nothing to disrupt the game's context, or offend a player within a specific local market.

Culturalization is going a step further beyond localization as it takes a deeper look into a game's fundamental assumptions and content choices, and then gauges their viability in both the broad, multicultural marketplace as well as in specific geographic locales.

(Edwards, 2011)

Localisation and culturalisation methods were originally offered as services to the game industry dealing with games or content already produced. They are now part of the game production process but they are historically a post-production process. They apply specific cultural knowledge to inform an understanding of where cultural issues may be problematic. A question arises that if a multiplayer function, within a culturalised game, enables players to access game spaces intended for the use of players with different geocultural preferences then are those locale-specific enhancements compromised?

Specifically designing a multicultural game environment will require a consideration of culturalisation within the design process. This involves cultural knowledge applied before or during the production of assets. In interviews for the release of the game *Binary Domain* (Sega, 2012), the producer Toshihiro Nagoshi stated his desire to purposefully produce a game that met different cultural game preferences.

What we're trying to do with Binary domain is... third person shooters are obviously a very popular genre in western markets, and increasingly Japanese-developed titles are not received well in western markets. So what we're trying to do with Binary Domain is break through this barrier.

(“AusGamers Toshihiro Nagoshi Binary Domain Interview”, 2011)

To do this he has considered the viewpoints of the cultural groups of players he is targeting and embedded this consideration within the game.

So on first look it might seem quite Western, the characters are mostly Westerners, but once you play a little bit it looks a little Japanese, because it's based in Japan. But if you go deeper and you get to know more about this game it's totally something else. It's not particularly Western or Japanese.

(Jenkins, 2011)

Toshihiro Nagoshi has considered culturalisation as a part of the game's design process, influencing narrative and environment design decisions. This is indicative of a game design methodology embedding culturalisation within the design process. A design methodology in this form would consider how cultural knowledge informs the design methods of game assets during the creative design and production stages of a game. This is as opposed to applying cultural knowledge retrospectively to the assets at a post-production stage.

Current cultural knowledge formed from historical evidence of gameplay differences, or the analysis of statistical data from game sales, may be useful to inform such a methodology. The evidence discussed in this section indicates its use would require careful consideration within the context of the current global games market. Whether it can be considered as starting point to develop multicultural design methods requires further deliberation.

The current multicultural multiplayer game spaces, designed intentionally as multicultural or not, offer a different possibility to inform this methodology, and subsequent design methods. This direction will require the development of a method for analysing these game spaces, for both the cultural reflection of the designer and the cultural viewpoint of the player. In theory an analytical method that can determine cultural influence within game assets may then be used as a method within a multicultural game design methodology.

1.2 Structure of the Thesis

The structure of the thesis is led by the two-stage reflective design research methodology of the study. The first stage is a mapping of the design problem from an interdisciplinary perspective. Then the second stage is the development, testing and application of the design method.

The model for this design research is considered in chapter two to ensure discipline in the development of an understanding of the problem and possible methodology for its investigation. The underpinning methodological assumptions of experiential knowledge and spatial embodiment in games are discussed. Then the theories of imageability and intelligibility are introduced.

In chapter three frameworks for the discussion of the problem from an industry, academic and design led perspective are established. The anecdotal evidence and perceived notions of cultural differences in industry are discussed. Then, recognising the lack of specific materials for this subject study and the interdisciplinary nature of game design, relevant literature from other academic disciplines is considered.

Chapter four discusses initial interpretations of 3D environments and how to analyse virtual space. It considers how the user and designer use tacit knowledge and cognitive mapping in game spaces and other 3D environments. The replication of real world architecture in virtual spaces informs the development of a methodology through the use of common spatial elements identified in urban studies by Lynch (Lynch, 1960) and correlated with spatial measures (Conroy-Dalton and Bafna, 2003).

Chapter five considers how the development of Space Syntax theory and spatial metrics is relevant to the analysis of game environments through the methodology of imageability and intelligibility. Spatial metrics known to correlate with how people interpret real world environments are considered. The determination of specific spatial metrics applicable to game design and how players interpret environments are explored in control environments.

Chapter six applies the methodology to specific game environments establishing statistical differences between game environments. Environments from Western and Asian games are compared defining cultural differences through specific spatial metrics linked to cultural theory. The characteristics of game environments popular across cultures are established to enable comparative studies of their metrics with other game environments. Environments developed from replication of real world environments are examined to consider the transfer of real world knowledge and design rules into game environments.

Chapter seven discusses how the results of cultural investigations may be applied to the design process. Game patterns are analysed for the correlation of game design principles with spatial metrics. How these can be applied within game design methodologies is then discussed in order to ensure a designer can consider both the imageability and the intelligibility of their design.

Chapter eight concludes the study with the establishment of new knowledge and a new methodology for games design practice. Future applications and further research directions are also discussed.

Chapter 2: A Design Research Methodology

The previous chapter introduced the context of this study, framing the design problem of how developing a methodological approach to multicultural game design will first require an appropriate analytical design method. This chapter first explains the interdisciplinary approach of design research and the two-stage reflective methodology used to understand the design problem. Next key assumptions that underpin the study are discussed, and then lastly the specifics of the methods involved in stage 2 that determine the resulting method for cultural analysis in 3D game spaces.

This study situates itself within the field of game design, and subsequently the broader academic subject area of design research. Its aim is to inform creative practices within this field of knowledge.

This research follows a constructivist approach to design research and the creative process recognising a design investigation often has to consider what has been termed ‘designerly ways of knowing’ (Cross, 2007). Gedenryd points out that while a designer is expected to solve a problem, in fact “producing the problem is the [significant] work that the designer must do” (Henrik Gedenryd, 1998). Lawson considers that, “it seems more likely that design is a process in which problem and solution emerge together” (2005).

This methodology recognises the reflective nature of design research and so the study uses a two-stage research methodology enabling reflection in order progress to the second stage. It is this form of reflective methodology that enabled the determination of where different theoretical positions meet in order to develop the hypothesis for the analytical method.

Two methodological assumptions underpin the study throughout and are discussed in more detail later in this section. First is that experiential knowledge is transferred into the game space when designing or playing in a game space. This experiential knowledge must be considered for what is common explicit knowledge to all players and designers, and when it becomes culturally specific to designers or groups of players.

The second assumption is the spatial knowledge of the player within a 3D game space. This study considers player interactions within spaces that enable player movement on

the three axes, x, y and z, of a Cartesian system. The player in a 3D space interprets the space through an implicit understanding of those movement planes in the real world. As opposed to 2D game spaces or isometric game spaces that may pictorially represent 3D space but only allow a player to move on two axes. The visual representation of 3D space and the player within it is important in order for the transfer of an implicit understanding of the use of real world movement

Stage one has two elements that are not independent of each other, but within the design research process enable a continuous process of reflection. One element is a review of interdisciplinary literature, considering its applicability to game design and understanding where cultural influence might be evident in game production. The second element is a spatial investigation considering experiential and cultural knowledge within current online 3D environments. This is to consider cultural affordances of objects in virtual environments and where an analytical method may be appropriate within the design and production of those objects. Reflection of these two elements enabled the hypothesis for the method of analysis in stage two.

Stage two develops and explores this hypothesis. Using investigative design practice to determine the validity of the analytical design method for use in determining cultural influence in 3D environments. Then considering how it may inform the design of those environments.

The reflection after stage one was the ‘designerly ways of knowing’ element where practical investigation and application took many forms. The use of drawing as visual thinking, experimentation with analytical software from the Space Syntax community, and building an understanding of statistical analysis and its application to this design problem. This active reflection determined the methodology for stage two to develop the analytical method for detecting cultural influence in game spaces.

This reflection took the following form and is at the centre of the study.

- Investigating spaces to look for cultural affordances in objects within the spaces led to the hypothesis that cultural affordances might be evident in the space if it is considered as a single object. A game space is designed as a single object, not as the sequence of design actions over time that will have formed the real world environment it may be emulating.

- Theories of cultural differences in the cognitive perception of a two dimensional image, and the cultural theory of proxemics, led to the consideration of imageability. Put simplistically, this is the designer or player's cognitive map of a space and will be influenced by these two cultural areas as discussed later in the study.
- Designers and players form cognitive maps of space, and designers also draw their cognitive maps of game spaces as physical 2D maps. As this physical 2D map influences the designer's construction of a 3D game space then cultural influences could be evident in the form of that space.
- The game space can be measured for cultural influence through Space Syntax. This uses the structure of the space to determine its intelligibility. This form of analysis would give an indication of the cultural affordance of a space to look for common and distinctive measures.

It is important to contextualise these theories underpinning the investigation within the two stages so the next sections discuss them within the context of the design research methodology. First is a discussion of the epistemological assumptions of the broader context of design research, and the relationship of theory and design practice within this study. Then the rationale for the use of experiential knowledge and spatial knowledge is considered as this informs the initial investigation of both literature and 3D environments. The theories of imageability and intelligibility are then explained in order to introduce the hypothesis of a space syntax method for correlation to cultural theory in stage two. The analytical method is then discussed in terms of testing, cultural analysis of game environments and its application within a game design methodology.

2.1 Design Research

The design research problem is: A multicultural multiplayer design methodology first requires an analytical method to formulate it that may then theoretically become part of the solution. In design research this is called a 'wicked problem'. Described as those problems that cannot be said to be understood until a solution has been resolved (Rittel and Webber, 1973; Buchanan, 1992; Rust, 2006). This is indicative of the problematic relationship between creative practices and scholarship. The 'problem space' for design

research may be devoid of evidence, but this in itself indicates to the designer that there is an area worth exploring. In this study this 'problem space' is the multicultural multiplayer methodology, but to discuss this with its intended users, the games industry, it has to first be identified through an analytical method.

Creative practice and research is a complex academic debate that this study touches upon in different forms due to the different epistemological positions within design research. Essentially there are three main positions in creative practice and research that correspond to subjectivist, constructivist and objectivist epistemologies (Feast and Melles, 2010). Those who consider design making as research practice and argue the knowledge produced through practice can be read in the artefact take the subjectivist position. Those who consider reflection as part of the process of designing take the constructionist position. Lastly, those who consider the logical construction of design theory through empirical facts take the objectivist position. This is an incredibly simplified description and the true complexity of the discussion surrounding this debate is seen in international design conferences and publications. To compound this simplified delineation it is broadly recognised that interdisciplinarity is an important aspect of design and this occurs frequently in this study.

Interdisciplinarity is a useful starting point for design research investigations. In this design study it is justified by the introduction containing theoretical standpoints for culture, quantitative game sales statistics and qualitative personal viewpoints from industry practitioners. Designers construct the problem space from the appropriate research material in what academia call a literature review or in industry it is often called a scoping study. This takes the form of the literature review but additionally involves the investigative and reflective design practices of drawing and practical design experimentation. This enables the mapping of the space and the construction of a clear definition, or redefinition, of the design problem and takes the form of stage one in this study.

Crotty (1998) discusses the hierarchical nature of the four elements of knowledge within the research process. Epistemology, theoretical perspective, methodology and methods are presumed to contain within them the primary element that connects them. This leads to epistemological assumptions based on one element in the hierarchical chain. The analytical method resolved in this study is a statistical analysis of game environments determining cultural preferences. A distinctly objectivist method but led

by Halls 'social constructionist approach', a constructivist epistemology. The statistical method constructed in this study is intended for use in a multicultural multiplayer game design methodology. The statistical form of the final design method does not mean that the resulting methodology should be objectivist in its approach. This is not the author's position on game design.

The recognition of the interdisciplinary research required to form the 'problem space' for a multicultural multiplayer design methodology places this research study in a constructionism framework of knowledge. The resulting method of analysis of game spaces uses statistical analysis, but this is an example of the complexity of design research and the requirement to take into account different perspectives on knowledge in order to construct a design solution.

2.2 Experiential Knowledge

Game designers often replicate real world locations or reference real world objects and built environments. A designer can use the player's real world knowledge in the virtual game space to immerse the player in the environment. The player's experiential knowledge of the game space is presupposed by their knowledge of the form the space takes, and any game elements such as narrative, that are experienced prior to encountering the space. This relies on specific knowledge from the real world and an understanding of the games narrative and this is where cultural differences may occur.

Tim Willits, a level designer for id software, states in *Game Design Secrets of the Sages*

A designer must make the level look the way the player expects it to. If the designer calls a map a *warehouse*, then there better be some crates lying around, because players will be looking for them. (Saltzman, 1999)

Referencing the experiential knowledge of the player enables game designers to create environments that are easily interpreted by a player. This informs a fluid and natural flow to gameplay. The theory of flow is "the state in which people are so involved in an activity that nothing else seems to matter" (Csikszentmihalyi, 1991). To create *flow* the player interactions with the environment must be without any unexpected

inconsistencies that detract the player from their immersion in the game world. It is important to *flow* that cultural differences do not create those inconsistencies

Experiential knowledge of the interaction with objects informs *affordance*. Originally defined by the perceptual psychologist J. J. Gibson (Gibson, 1979) it refers to the actionable properties between objects and users. For Gibson these affordances did not have to be visible or known to the user but could be implicit as well as explicit. Affordance is often used in the fields of Human Computer Interaction (HCI) and interaction design. It aids in the analysis of a users interaction with an interface, or element of, and the users physical abilities, intentions and their experiential knowledge.

Norman used the term affordance in his book *The Psychology of Everyday Things* (1988) to consider the design of objects and the way people interact with the world around them. Norman later elaborated affordance to a relationship between the perceived affordances of an object and the actual affordances of an object in order to deal with misinterpretations of the terminology (Norman, n.d.).

Perceived and actual affordances offer a method for the analysis of game environments and the objects within them. The perceived affordance of the object would be that of the same object in the real world while the actual affordance is that enabled by the game designer. The perceived affordance of the environment might be where the player expects to be able to travel to but is actually prevented from reaching by the design of the environment.

Ito and Nakakoji (1996) discuss the impact of culture on perceptual and actual affordance of an object using a two phase model of listening mode, where the user perceives the objects affordances, and the speaking mode, where the interaction with the object enables understanding of the actual affordances. In this model the effect of culture on the experiential knowledge of the player increases with the move from perceptual to actual affordances, illustrated in Figure 1: Levels of cultural dependence in interaction.

An example of this is the recognition of the representation of a car in a game environment, eliciting the player's basic experiential knowledge of the real world object as a means of transport. Therefore the perceived affordance of its representation within the game world is that it can offer transport within the game. Interacting with the car increases the cultural dependence considering which side of the car the player tries to

enter in order to drive it. The cultural experiential knowledge of the designer is used in determining which side of the car to put the driving seat. Actual affordance is whether it can be used in the game for transport.

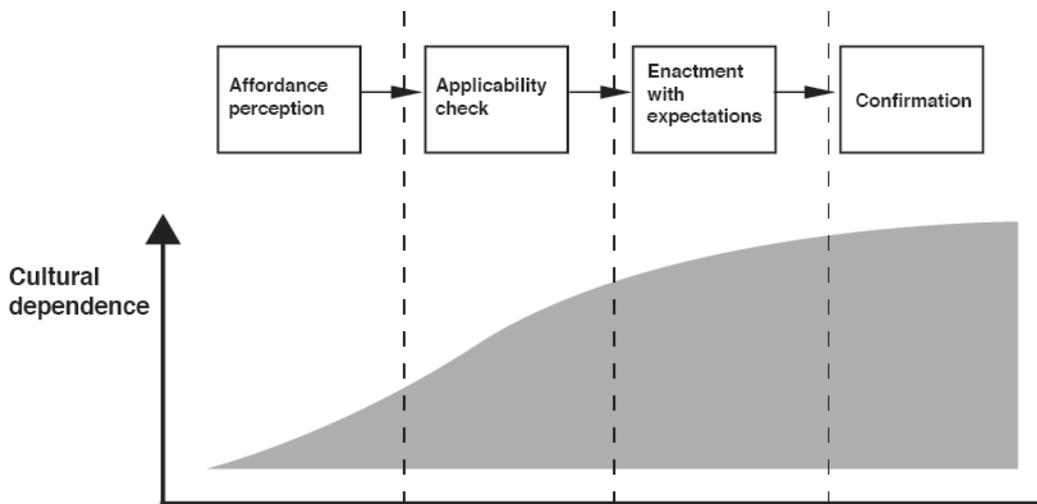


Figure 1: Levels of cultural dependence in interaction

Game players expect the visual realism of an environment to be reinforced with the expected interactions and responses they would expect from the real environment.

This supports a general hypothesis of a level of common explicit knowledge for players and their perceived affordances of real objects replicated in game environments and that cultural knowledge is used when engaging with those objects.

Defining implicit cultural knowledge requires the elimination of primary explicit knowledge and common affordances in order to determine where cultural individualities are occurring. The basic functionality of a door or window is the same across cultures but when analysing environments and the objects within them the question is at what point does cultural dependence affect interaction and thus affect gameplay.

The experiential knowledge of the player can be broken down into explicit knowledge, implicit knowledge and tacit knowledge. Explicit knowledge is that which they know they know and can be fully revealed. Implicit knowledge is unexpressed knowledge but is capable of being understood through something else. Tacit knowledge is in their head but cannot be codified or committed to language.

Tacit knowledge has been defined as that body of knowledge that is implicit and subconsciously affects decision making, first discussed by Michael Polanyi (1958). It

can be loosely defined as knowing how but not knowing why. This is the theory that a body of subconscious knowledge underpins particular cognitive processes and behaviours but that the individual cannot easily communicate it as it is habitual or cultural and we do not recognize it in ourselves.

In conclusion the analysis, and subsequently the design, of a game environment requires consideration of the different levels of knowledge. The primary explicit knowledge of a player learning specific game functions, the common explicit knowledge of the function of objects, the specific implicit or tacit cultural knowledge of a group of players and the deepest level of tacit knowledge, anterior to culture, that of play. These are listed for reference in Table 1: Spectrum of knowledge in gameplay.

Table 1: Spectrum of knowledge in gameplay

Primary Explicit Knowledge	Individual knowledge based on the outcomes of events as they are experienced, such as a new object in a game environment that requires interaction before its use can be determined. This is led directly by the game designer.
Common Explicit Knowledge	Knowledge assumed to be common to all players and designers such as simple environmental functions e.g. the function of a door handle. This is led by the game designer but may be affected by specific implicit knowledge of both the game designer and the player.
Specific Implicit Knowledge	Implicit knowledge specific to groups of players or designers. For example the cultural knowledge of which side a driver should enter into a car. Cultural knowledge that is specific implicit knowledge may be codified.
Specific Tacit Knowledge	Specific knowledge that cannot be codified such as specific social behaviours dependent on cultural background.
Common Tacit Knowledge	The common tacit knowledge within player and designers such as the knowledge of play anterior to implicit or explicit cultural influences.

2.2 Spatial Embodiment in the Game Space

A game space is both observed and engaged with, in a form of engagement that changes the observed space or elements within it. It can be discussed as an experiential space where the level of immersion into the game space is how integrated that experience of interacting with the space is. An immersive experience in a 3D space will be when the player feels they are acting *within* the space and not simply *upon* it. They become embodied within the space and not an onlooker of the space.

The visual representation of the space the player sees is important to consider if embodiment is to occur. 3D game spaces offer the closest representation to a player's real world movement. This knowledge of movement within 3D space can be considered common experiential knowledge across culturally different players. The visual representation of this movement within the space is essentially a 2D image as the 3D image is projected on a flat screen. The designer, through their choice of camera viewpoint and the design of the environment, establishes the form of the 2D screen image. The player then constructs the 2D representation of the space as they interact with the space.

When it comes to videogames, movement designates the dimensions of the image. What defines the so-called 3D game is not the image itself—2D games may and often do represent a third dimension as well—but the possibility and necessity to explore all the three dimensions. Consequently, the reception of visual art in 3D games is never merely a static examination of an image but also an active exploration of space (or more correctly, place).

(Karhulahti, 2012)

The visual positioning of the player within the game space, and the form this takes in the game display is important to create embodiment in this exploration of space (Nitsche, 2009; Taylor, 2002).

In the first-person-point-of-view players see through the eyes of the character in what may be considered a natural optical perspective. In this way the player will perceive the game space as the character would. This is a direct embodiment of the player in the game space. This viewpoint does limit the immediate contextual view of the

surroundings and so a player has to be more active in viewing the game environment in order to understand their spatial relationship within it.

In the third-person-point-of-view the player is presented visually as an embodied character within the game environment. A camera, often controlled by the player, facilitates the spatial relationship with the game environment. Stephen Poole considers this view to be a disembodiment of the player as it is looking at the player (Poole, 2001). This study's methodology disagrees with this viewpoint and takes Taylor's view of the third-person-point-of-view that viewing a representation of the player in the space is in fact an embodiment of the player in the space.

the player is given an embodied representation in the space with all that an embodied representation entails, including the physical relationship of the character to the space and objects around the character and a contextualized presence in the game space

(Taylor, 2002)

First or third person viewpoints are integral to the game tasks required of the player. Accuracy in shooting usually requires a first-person view but platform games often require third-person to offer a perspective view so the layer can judge obstacles and puzzles. Some games will implement both views depending on the tasks within the game or allow the player to change it dependent on personal preference. Both views allow the player to decide on their position in the game space and have a conceptualised position of their embodied space *within* the game.

This study will look at game worlds considering both first and third person viewpoints and the positioning of the player within the active exploration of the 3D game space and the resulting 2D image.

2.3 Imageability and Intelligibility

Imageability is the term developed by Kevin Lynch and presented in his book *The Image of the City* (1960), to cover the criteria for the legibility of an environment. Intelligibility is defined by Hillier as the connection and integration of the spaces that form an environment (Hillier and Hanson, 1989).

The two methodologies were considered as unrelated by their respective fields until the paper *The syntactical image of the city: A reciprocal definition of spatial elements and spatial syntaxes* by Conroy-Dalton (Conroy-Dalton and Bafna, 2003) explored the relationship between them.

It can be seen why they were considered different if their approaches are considered. Imageability focuses on the visual qualities of an environment elicited from the users of the environment. Intelligibility is concerned with the mathematical analysis of the underlying structure of an environment, in correlation to observable behaviour of users in the environment.

In order to analyse the design and implementation of game environments both of these methods are applicable. Intelligibility can be considered to relate to game architectural functions of the structure of the space and control of player movement. Imageability is in line with the subjective response to an environment affecting player movement.

A brief description of both of these systems and the relationship between them establishes a better context to the development of the analytical method used in stage two of this study. The relevant metrics are explained in more detail in chapter 5.

2.3.1 Imageability

In *Image of the City* Lynch describes a five year study using city environments from Boston, Los Angeles and Jersey City to discover what was important to the people who live there and how they interpret their environments. The innovative approach by Lynch was to use what he termed ‘place legibility’ which is how people understand the layout of an environment. He used this to isolate the features of a city that people use to create their mental maps, the mental representation, of the layout of their environment. These features were determined as five characteristics of an environment.

Paths: The lines by which people move around the city.

Edges: Walls, barriers and other lines not within the paths group.

Districts: Areas that have an identifying character about them.

Nodes: Points where there is a focus or concentration of features such as junctions or squares.

Landmarks: Physical objects that are used in way finding and orientation.

These five criteria offered Lynch a method for the quantifiable analysis of space that could be correlated with the descriptions and sketched maps that subjects from each city produced. Through the subjects feedback Lynch found areas in cities that were hard to distinguish and lacked distinctiveness in order to navigate them, and areas people found to be vivid and distinct. Areas he rated as having high imageability had distinctive landmarks, clearly defined edges, often with major nodes where busy paths joined. Low imageability was marked by a lack of landmarks with vague and indistinct paths and edges. He concluded that a well-formed and highly imageable environment would be instantly recognizable, easy to navigate and give its inhabitants a sense of emotional security.

This has been discussed as relevant by game design practitioners and theorists for some time (Adams, 2002; Bartle, 2003; Dieberger, 2000; Jenkins, 2004; Nitsche, 2009).

The five characteristics used by Lynch; paths, edges, districts, nodes and landmarks are consistent with the design of game spaces. As Bartle expresses in *Designing Virtual Worlds*

Obvious nodes, paths, edges, districts, and (especially) landmarks should be provided to give players a sense of where they are and how to get to where they want to go; a sense of place, in other words.

(Bartle, 2003)

The influence of these characteristics upon the navigation of a game environment is the same as in the real world; they break environments up into recognisable spaces for way finding. In a game these characteristics form memorable places, imageable, instantly recognisable, that then form the player's cognitive map of the space, just as they would in the real world.

The cognitive map for a player experiencing a 3D game space is built from the 2D image they can see on the screen. The most important consideration is that this is not a static 2D image this is an active 2D image. The player's understanding of their embodiment in the 3D game space is built from a 360-degree viewfield from their current location. It doesn't matter whether it is first person or third person they will build a cognitive map through actively looking around the space considering their embodiment in it.

Game designers use many methods to formulate game spaces but mapping a space on paper is a common method, "After the initial design discussions, maps were sketched out by the design group, and then built by the level designers" (Hodgson, 2003), "annotated maps...is a method widely used throughout the games industry" (Kremers, 2009). These 2D maps consider the player's 3D location in the future game space with the designers visualising how the space builds the player's understanding of the game space.

Level design maps represent a future game space while player cognitive maps represent the interpretation of a current game space through the imageability of the screen representation of that location. Neither map has Lynch's five characteristics directly defined on the map, but they will be present.

The paper map of the designer and the 360-degree viewfield of the player, that builds their cognitive map, demonstrate imageability. How to quantify the imageability and cross-reference and compare them for cultural influence is where intelligibility becomes useful.

2.3.2 Intelligibility

In his book *Space is the Machine* Hillier states that

The property of ‘intelligibility’... means the degree to which what we can see from the spaces that make up the system - that is how many other spaces are connected to - is a good guide to what we cannot see, that is the integration of each space into the system as a whole. An intelligible system is one in which well connected spaces also tend to be well-integrated spaces. An unintelligible system is one where well-connected spaces are not well integrated, so that what we can see of their connections misleads us about the status of that space in the system as a whole. (Hillier, 2007)

This is essentially the relationship of the local properties of a space—such as paths to other spaces—to the global properties of the paths within the whole environment. An unintelligible space fails to assist the user in their navigation through the environment, as there is not a strong relationship between the properties visible to the subject and the overall system of spaces that make up the environment.

In order to determine intelligibility the spatial structure of an environment is examined using metrics formed from lines of sight; axial lines, isovists and visibility graph analysis (VGA). The representative metrics factor is visibility across the environment in terms of the visual integration of one location in a single space against all the possible locations in the spaces that form the environment. The main metrics are:

Axial lines: These represent the fewest and longest lines of sight that pass through every space in an environment these are not used in this study.

Isovists: This is the viewfield from a single point in an environment drawn as a polygon, usually at eye level and represents a 360-degree viewfield.

VGA: This is the calculation of the relationship between isovists drawn at regular points across the navigable space and their visibility to each other.

These are abstract spatial descriptions based on visibility as an obviously recognisable factor in human way finding and producing metrics that may then be statistically analysed. For this study the metrics generated by using the isovist, which represents a single 360-degree viewfield from the position of a player are important.

The isovist corresponds to the imageability of the player’s cognitive map, as it is the shape of their viewfield. The isovist form indicates complexity of the map, size of the

space, maximum line of sight, occluded edges indicating further spaces. These will affect the player's cognitive map of their position in the larger 3D game space.

2.3.3 A Method for Capturing the Qualities of an Environment

The issue a multicultural multiplayer method of analysis has is the difficulty in applying a consistent evaluation of different environments. There is a need for a method that can distinguish between game architecture in terms of geometry and the more subjective forms of elements such as narrative textures. Imageability and intelligibility offer a method that can bridge this area. As methods applied to real world environments they are both proven within their respective fields and correlate to the experiential knowledge a person uses to navigate real world environments. This fits this study's investigation of the transfer of experiential knowledge into game environments in terms of how players and designers interpret the game space.

In comparing the two systems Dalton-Conroy (2003) concluded there is a relationship between imageability and intelligibility but it is not a direct mapping of one to the other. The dependencies connecting them were not mutual but the elements from Lynch's imageability were dependent on the elements of space syntax. No such dependence was reversed. The hypothesis was that an imageable city is also intelligible, but an intelligible city does not have to be imageable.

A very simplistic explanation is to say that an underlying structure in a game environment may be seen within the visual differentiation of the elements of imageability but a structure itself is not dependent on these elements indicating it.

To this purpose an analytical method for this study can be based initially on space syntax in order to consider the structure of an environment. Imageability elements can be used when observing environments but not relied on wholly to indicate what that structure might mean.

In conclusion intelligibility is a method for the analysis of game environments based directly on spatial metrics that are statistically testable. Yet within this method there is correlation to the subjectivity of imageability and the interpretation of the player's viewpoint in the space.

Chapter 3: Frameworks for Design?

The previous chapters introduced the context of the study and the methodological assumptions for investigating the design problem. This chapter reviews relevant interdisciplinary literature to define the ‘problem space’ in more detail. It considers current cultural knowledge on games and cultural models establishing what is relevant to inform the development of a multicultural multiplayer design methodology.

3.1 Geographic Markets and Cultural Preference

This study does not intend to statistically analyse historical sales data in depth but it is wise to consider where, when and possibly why some cultural preferences became so pronounced and still resonate in today’s marketplace.

In order to begin to consider cultural differences and market divisions in games the games published by a single company Nintendo, for their globally successful *Nintendo 64* console, offer a starting point. The *Nintendo 64* console was able to deliver what was considered at the time to be high quality 3D graphics. This allowed game developers to produce games with 3D environments, as applicable to this study. The five best-selling *Nintendo 64* titles in Japan and America by December 1999 according to Nintendo (IGN Staff, 1999) are shown in Table 1 and Table 2.

It must be noted that *Pokemon Stadium* (Nintendo, 1999) was not released in America until February 2000 so must be discounted. *Super Smash Bros* (HAL Laboratory, 1999) was not released in US until April 1999 so is also weighted in favour of the Japanese market in these tables. *Diddy Kong Racing* (Rare Ltd, 1997b) was released in both Japan and America in November 1997 and *GoldenEye 007* (Rare Ltd, 1997a) was released in America and Japan in August 1997.

Considering the games that were released concurrently across both market sectors, or had enough time to reach peak sales, these figures are indicative of some of the possible early cultural boundaries in games publishing. *Super Mario 64* (Nintendo EAD, 1996), *Mario Kart 64* (Nintendo, 1996) and *Legend of Zelda: Ocarina of Time* (Nintendo EAD, 1998) are games with strong character placement unique to Nintendo and do well

in both market sectors. The First Person Shooter (FPS) *GoldenEye 007* sold in large volumes in America but failed to repeat those sales in Japan.

Table 4 shows sales figures for the top 5 video games titles sold globally ten years later in 2009. Now the sales figures indicate that the FPS *Call of Duty: Modern Warfare 2* (Infinity Ward, 2009) is more popular in America than traditional Mario games while in Japan the Mario game easily outsells the FPS game.

The FPS genre has traditionally been seen as a popular Western game with Role Playing Games (RPG) as more traditional to the Japanese market. Even though this traditional view is still evident (Nutt, 2011) game designers are intentionally or unintentionally questioning these historical market boundaries through their implementation of multicultural multiplayer online play.

Initial developments in multiplayer games used server technologies that kept players from different geographic regions from encountering each other. With the increase in data transfer speeds multiplayer gameplay genres can allow thousands of players to access servers in any part of the world and play competitively or cooperatively within the same game environment. Figure 2 shows the server choice menu from *Counter-Strike* (Valve Corporation, 1999) where the player can choose from servers based on geographical delineation irrespective of their location.

The first person shooter (FPS) genre uses 3D environments representative of real world space making it an easily accessible form of gameplay requiring only basic experiential knowledge to establish gameplay parameters for movement. The recognition by the player that they are able to move forwards, backwards, left, right and jump or crouch means that there is a direct correlation of experiential knowledge to the real world spaces the game space may be representative of. In a game space where there is no narrative factor affecting a player's movement, such as gravity on an alien world or game objects that enhance movement then any cultural affordances are from gameplay preferences rather than cultural knowledge.

Table 2: The five best selling Nintendo 64 titles in Japan by December 1999

	Game Title and Release Date	Units Sold
1.	Mario Kart 64 (Dec 1996)	2,060,000
2.	Super Mario 64 (1996)	1,800,000
3.	Super Smash Bros. (Jan 1999)	1,520,000
4.	Legend of Zelda: Ocarina of Time (Nov 1998)	1,450,000
5.	Pokemon Stadium (April 1999)	1,370,000

Table 3: The five best selling Nintendo 64 titles in America by December 1999

	Game Title and Release Date	Units Sold
1.	Super Mario 64 (1996)	9,040,000
2.	GoldenEye 007 (1997)	6,980,000
3.	Mario Kart 64 (Feb 1997)	6,230,000
4.	Legend of Zelda: Ocarina of Time(Nov 1998)	5,720,000
5.	Diddy Kong Racing (1997)	3,780,000

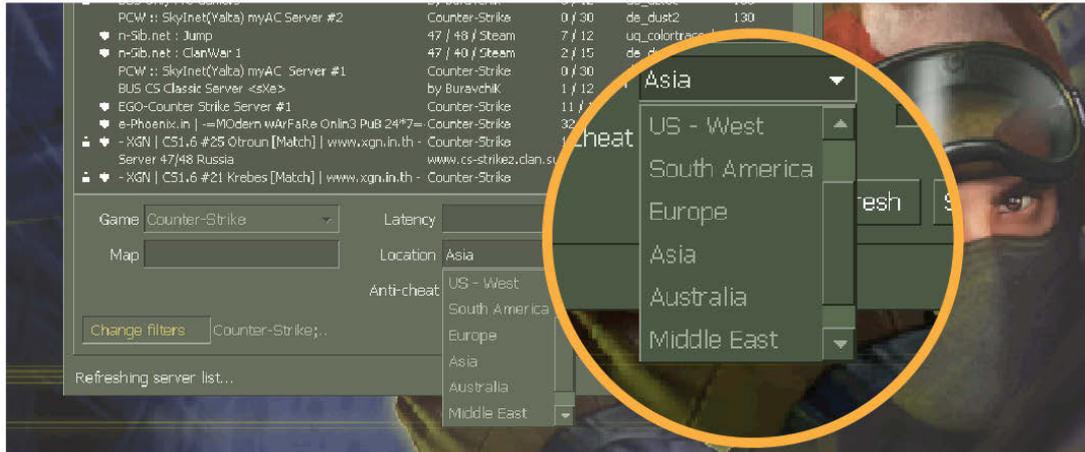
Table 4: Unit Sales figures for the top 5 video games titles sold in 2009

2009 Titles	Publisher	Total	US Retail	Japan Retail	UK Retail
Call of Duty: Modern Warfare 2	Activision	11,860,000	8,820,000	237,500	2,800,000
Wii Sports Resort	Nintendo	7,570,000	4,540,000	1,540,000	1,490,000
New Super Mario Bros. Wii	Nintendo	7,410,000	4,230,000	2,490,000	687,000
Wii Fit Plus	Nintendo	5,800,000	3,530,000	1,300,000	968,300
Wii Fit	Nintendo	5,440,000	3,600,000	588,300	1,250,000

Source: Top Global Markets Report / Retail Tracking Service

Unit sales figures rounded – due to rounding, the sum of the individual countries may not equal the Total for certain titles. (Parfitt, n.d.)

Figure 2: Screen shot of Counter-Strike server menu.



The FPS genre led multicultural gameplay opportunities through its role in the development of e-sport tournaments. These are held internationally with teams from across the world competing against each other. This area of e-sports is recognised in academic studies (Rambusch et al., 2007) as having been given little academic attention. This subject is a possible future area of study to develop multicultural game studies to inform game design.

Statistics from the World Cyber Games official web site, www.wcg.com indicate in 2001 thirty-three countries took part in the World Cyber Games and by 2011 it had risen to fifty-seven. In 2001 of the six games played competitively three were First Person Shooters created by Western developers; *Counter-Strike*, *Unreal Tournament* and *Quake III: Arena*. In 2011 there were fourteen games played competitively and still three First Person Shooters but two of these are developed by South Korean developers; *Cross Fire* and *Special Force*. The third was *Counter-Strike* that had since been localised for the Asian market by a South Korean developer. Why South Korea had become a preferred developer of FPS for players from across the globe at the World Cyber Games is a cultural game design question.

The PC based multiplayer game *Counter-Strike* (Valve Corporation, 1999) by American developer Valve Corporation is an FPS set in a simple representation of a real world environment and has been extremely successful in Western markets. It has since been produced for the Asian market as an online FPS *Counter-Strike Online* (Nexon Corporation, 2008) and as a multiplayer arcade game for Japan *Counter-Strike Neo* (Namco, 2003). That the game has been developed for alternative markets made it important for this study especially as *Counter-Strike Online* (2008) was originally

developed as an online model for Asian markets by local developers and was not originally for distribution in Western markets.

Increasing accessibility to the FPS genre through the online free-to-play game mode has meant an increase in the number of players globally. The South Korean developed FPS *Cross Fire* (SmileGate, 2007) reached three million concurrent users in China in September 2011, according to its publisher Neowiz Games (Press Release, 2011). The FPS *Special Force* (Dragonfly, 2004) also developed in South Korea accumulated 4 million registered users in Japan identified by industry as not a historically or commercially significant market for FPS (Korea Game Watch, 2010).

The genre of the Role Playing Game (RPG) in Japan was traditionally seen as a single player console game, with only a small percentage of consoles being used for online multiplayer games. The Korean developed game *Ragnarok Online* (Gravity Co Ltd, 2002) for the PC disproved this with its entry into the Japanese market in 2002. It matched sales of console based online RPG's in half the time (Hall, 2003) and Japan now has a thriving PC based online RPG market of multiplayer game environments.

The genre of Massively Multiplayer Online Role-Playing Games (MMORPG) offers insight into multicultural game environments as it uses server technologies to create persistent worlds where thousands of players may inhabit the same environment. Initial MMORPG development used separate servers for different geographic locations but the game *Eve Online* (CCP Games, 2003) uses a single game universe for players from around the world except for China.

The globally successful MMORPG *World of Warcraft* (Blizzard Entertainment, 2004) eventually developed separate servers for its Chinese players, and of interest to this study is that Chinese players continued to access foreign servers after the games launch in China (Lindtner, Mainwaring, et al., 2008). The use of separate regional servers during the international expansion of *World of Warcraft* demonstrated cultural gameplay differences and the transfer of cultural knowledge into the game world. Chinese players transferred the use of the cultural practice of *guanxi* from their real world into their game world. This Chinese cultural practice of personal connections between two people prevalent in Chinese society would not have been considered when developing the game for the Western market. It is evidence of the transfer of cultural experiential knowledge of groups of players into multiplayer environments and

indicative of the need for more understanding of cultural differences in game design practices.

Korea and China are already important games markets while Russia and South America are recognised as offering the games industry major opportunities and relevant gameplay preferences are already being discussed by industry.

It also helps to know what sort of games Russians like: “Don’t expect a fishing game to sell more than a few units,” says Baryshnikov. “The same goes for golf and baseball games.” War games and first-person shooters top the list of favourites. (Hyman, 2011)

The distribution model of free-to-play is also becoming a common feature.

People there love PC games, especially free-to-play (F2P) games. So if you’re in that sector, there’s practically a guarantee of success. If you’re in a different market, Russia may not be as interesting for you. (Hyman, 2011)

While free-to-play makes it difficult to establish clear game sales statistics in Russia there is also the piracy factor.

If your game is released here one week later than in the rest of the world, expect to lose 20-30% of your sales. If it’s two to four weeks late, expect to lose 50% of sales. Local gamers won’t wait for a game; they would rather download a pirated version.

(Hyman, 2011)

In conclusion it can be said that traditional sales charts no longer offer a true statistic to base cultural gameplay preferences upon, as the games industry does not have a singular picture of global sales figures. Examining only game sales figures to try and establish current cultural preferences is obviously problematic if figures do not include new distribution models like free-to-play. What is of importance to the development of an analytical method to understand multicultural gameplay is the popularity of the first person shooter genre of games.

3.2 The Academic Study of Games

This study is focussing on game design methodology and methods for multicultural game design. How to approach methodological approaches and methods in previous academic studies and game design texts are useful to consider, as well as findings. Materials must first be considered as to how they inform a design process relevant to the methodological assumptions of experiential knowledge and spatial embodiment.

There is an ever-increasing body of academic research on games approaching the subject area from a variety of academic fields outside of the discipline of game design practice. The different aims, methodologies and epistemologies of these disciplines mean that they might not be understood by practitioners as applicable to inform game design. A key text on level design by one industry practitioner states “There are many sizeable books and academic studies devoted to games and gameplay but they often contradict each other and in some cases even attack each other” (Kremers, 2009). This is a possible reference to the high profile academic debate of narratology versus ludology. This debate did not appear to have any effect on industry practices.

As the academic subject area of game design expands new research methods directly related to game design practice are being used for academic studies. Playing games to understand games is recognised as an important method to understanding gameplay (Aarseth, 2003). Using experimental games or the game building process, to question game theory through applied research, is a more recent industry facing research practice. It is also a recognised design methodology, *research through practice* (Feast and Melles, 2010).

There are now some extremely successful and respected academic studies that have taken this approach. Jenova Chen’s masters thesis *Flow in Games* (Jenova Chen, 2006) resulted in the game *Flow* (Chen, 2006). It won Best Downloadable Game at the Game Developers Choice Awards 2008. Dan Pinchbeck’s thesis *Story as a function of gameplay in First Person Shooters* (Pinchbeck, 2009) was written while acting as the writer for the experimental first-person art game *Dear Esther* (Briscoe, 2008). It was nominated for five awards at the 9th British Academy Video Game Awards (“British Academy Games Awards Nominees Announced”, 2013).

In these studies the academic thesis proved to be of suitable timescale for a full game development method to be possible. Smaller studies using research through practice are also possible producing conference papers including *Build It to Understand It: Ludology Meets Narratology in Game Design Space* using “a simultaneous process of research and artmaking in the construction of the interactive drama *Façade*” (Mateas and Stern, 2005). While *Experiential Modes of Game Play* (Appelman, 2007) is one of the few offering directly applicable methodologies to this study in terms of analysis and proven frameworks, although not within multiplayer environments.

Games industry professionals have produced key texts on game design, level design and designing virtual worlds. These texts are of the utmost importance to learning game design as they deliver information on game design as practiced by professionals. Comprehensive texts discuss both design theory and industry practice. Referred to in this design research are *Designing Virtual Worlds* (Bartle, 2003), *21st Century Game Design* (Bateman and Boon, 2005), *Level Design Concept Theory and Practice* (Kremers, 2009), *Fundamentals of Game Design* (Adams, 2009), *Game Design: Secrets of the Sages* (Saltzman, 1999). These industry texts are crucial in informing this body of research of relevant industry design practices, experiential knowledge, player embodiment in the game space and multiplayer design. But none of them discuss multicultural gameplay or culturalisation.

Texts on cultural practices that target industry are evident with *The Game Localization Handbook* (Chandler and Deming, 2011) and *Game Localization: Translating for the global digital entertainment industry* (O’Hagan and Mangiron, 2013). Both deal with localisation and culturalisation but do not deal with multiplayer multicultural scenarios in any form directly affecting this study.

The literature areas of multicultural knowledge in games are focussed more on historical analysis of games, predominantly dealing with Japan and the West. *Power Up* (Kohler, 2004) and *Game Over* (Sheff, 1994) are useful historical texts but reveal little in how to move forward with multicultural game design, as they heavily reference Japanese aesthetics.

Differences in the Japanese and American game markets and game preferences are the most deliberated and the most historically justified as discussed in sections 1.1 and 3.1. Some of these studies are setting out design directions for games to cross this specific

cultural divide (Ngai, 2005) while others discuss in detail the player experience and preferences (Cook, 2009; James, 2010; O'Hagan, 2009). Of importance to this study is the findings in *Cultural Differences in Game Appreciation: A Study of Player Game Reviews* (Zagal and Tomuro, 2013) that there was no bias for or against specific game platforms in either culture.

In conclusion it can be stated that the body of knowledge on game design, multiplayer practices, game research methodologies and cultural findings are informative for this study. But there is no directly applicable research methodology or methods for the design of multicultural multiplayer game spaces and no conclusive literature on multicultural multiplayer environments. This indicates this study will form new knowledge to inform game design practices.

3.2.1 Theoretical Models of Games

The analysis of current debates within game studies for this study's purpose requires consideration as to the relevance from the context of both the player and or the game designer. Game theorists discussed the transfer of knowledge from the real world into the world of play long before the advent of video games. Huizinga (1938) and Caillois (1958) both explored the concept of play and culture where play can be considered a common human trait crossing cultural boundaries. Caillois examined play across cultures and recognised both commonality and cultural identity in the forms and mechanics of play as a social function within society. If culture can be said to influence a game player's notions of play then this will in turn affect their gameplay decisions within that game environment. Digital game environments are offering the chance to transcend common cultural boundaries. It is where these commonalities and cultural identities manifest themselves within the forms and mechanics of gameplay that will inform game design processes

Huizinga's theory of 'The Magic Circle' (Huizinga, 1938), representing a boundary between the real world and the world of the game, has been discussed in terms of digital games by many theorists (Juul, 2005; Salen and Zimmerman, 2004; Sniderman, 1999) Sniderman discusses the unwritten rules, social contracts and cultural influences players may bring into a game world recognising a player transfers knowledge across the boundaries of the magic circle in terms of their experiential and cultural knowledge.

Cultural contexts of players are recognised as important. Sniderman states in *The Unwritten Rules*, part of the rules a player follows are those were they “ Intuitively understand and respond to the ‘real-life’ context in which the game is being played i.e. social, cultural, economic, political and moral consequences of the result”. A player bases their decisions on their knowledge of the game but also on their experiential knowledge from other aspects of their life.

Rules are the defining element that moves the pure play of a child into the realms of gameplay. The consideration of rules within digital games enables the understanding of current game design and gameplay practices through the use of taxonomies for distinguishing gameplay types. A single game environment may be used for different types of gameplay simply by changing the rules, as is common with first person shooter games where capture the flag, deathmatch and other individual or team based games may be played in the same game space.

Rule systems within game design work at different levels within the player experience. Game designers may create strict rules for a player to adhere to whether the player realises or not. Importantly these rule systems may be dictated by the environment enforcing the player into gameplay sequences through the nature of the space. These rules are easier to discern and evaluate, as the geometry of the environment is indicative of the game designer’s intentions. Some environment rules may be deemed to be tacit knowledge, such as the player in a track and field game knowing to run round the track, not across it, to the finish line.

Salen and Zimmerman discuss in *Rules of play: game design fundamentals* (2004) the player becomes the final designer in their personal interpretation of the game rules. As discussed by Neumann and Morgenstern (1944) Juul and others rules must be distinguished from strategies. Strategies are the player’s interpretation of how to act within those rules, or if possible breaking them.

Juul (2005) points to the gameplay in a game coming from the need to reach the goal of the game while working within the rules of the game. The tension between goal and rules is often evident within the spatial design of the environment where the player will see glimpses of the goal to create that tension.

Salen and Zimmerman define a schema for the analysis of games as:

Rules: Determines the game structure and its logic.

Play: Analyses the player's experiential, social and representational aspects with the game and other players.

Culture: Assesses the larger cultural context of the game and the game design.

In terms of culture Salen and Zimmerman (2006) discuss a games ability to “reflect culture, depicting images of gender... as well as portrayals of race and class”.

As games have become recognised as reflecting culture many debates by theorists on how to read games have developed. A particularly strong debate for game theorists is that between ludologists focussing on the mechanics of gameplay and narratologists concerned with games as storytelling devices. This study does not intend to debate scholarly theory on games but to use applicable theory to explore cultural practices within the use and design of multiplayer game spaces. Important within the narratology ludology debate is *Game Design as Narrative Architecture* by Henry Jenkins (2004). This stands out in its relevance to the study as introducing the idea of spatiality within the debate.

Game designers don't simply tell stories; they design worlds and sculpt spaces. It is no accident, for example that game design documents have historically been more interested in issues of level design than on plotting or character motivation. (Jenkins, 2004)

This study is concerned with both interpreting and informing the design of game spaces through developing an understanding of experiential and cultural knowledge of both the player and designer. Spatiality is the simplest form of experiential knowledge; the awareness of where you are within a space and the movement options available to you and this is discussed this study's methodology. Jenkins earlier work includes seminal texts on console games being virtual play spaces replacing the disappearing physical play spaces (Jenkins, 2000). The discussion of virtual game spaces facilitating classical conceptions of play for children, in terms of exploration and identity formation, poses a key question for this study: How does a game space form, facilitate or reflect identity?

Jenkins describes the narrative within the space as a spatial story “held together by broadly defined goals and conflicts and pushed forward by the character's movement across the map” (Jenkins, 2004). The player moves across the map as they determine the relevant goals to the overarching narrative and the relevant game mechanics to

unlock access to those goals. The game designer aims to control the rhythm of the player's movement through the environment with specific gameplay features and events.

Spatiality and narratives are discussed in four useful forms; evoked, enacted, embedded and emergent.

- Evoked narratives use the design of the game space to immerse the player in a familiar world drawing on the experiential knowledge of the player.
- Enacted narratives structure the story around the movement of the player through the game space.
- Embedded narratives use the space to hold the clues to the narrative that must be deciphered.
- Emergent narratives the space is designed to be full of narrative potential for the player to construct their own narratives with.

These indicate that the spatial design of the game space will evidence game elements such as narrative and game mechanics.

In conclusion if narrative, game mechanics and rules are designed as part of the geometry of the environment, then the design of the environment will be useful in indicating cultural preferences. Rather than looking for cultural preferences by analysing game narratives, rules or game mechanics, all of which often categorise games or genres, the spatial element of the game can be more indicative of cultural preferences than genre.

3.2.2 Cultural Studies of Games

If games, players and designers are to be situated in terms of cultural knowledge and boundaries, then cultural studies inform design principles through relevant cultural theory.

Said defines culture as “...those practices, like the arts of description, communication, and representation, that have relative autonomy from the economic, social, and political realms and that often exist in aesthetic forms, one of whose principal aims is pleasure.” (Said, 1998). Therefore games, whose principle aim is pleasure, fit part of this

description but the question arises as to whether they have autonomy from economic, social or political realms in terms of being a commercial commodity.

The Frankfurt School of cultural theory suggests that popular culture is intrinsic to maintaining capitalism and the oppression and exploitation of the masses. Games are an economic product and therefore the pressure from industry for commercial success drives any larger cultural aspects of games. It is the industry's reluctance to try new approaches for particular markets that will flavour cultural aspects for this study of games. In terms of this study it is essential that the work of amateur or modding game designers, who have no economic goal to their game design, be considered. They offer commercially independent game spaces when investigating cultural influence within game design.

The study of cultural influence within game environments requires an approach encompassing the different contexts of the word culture used with video games that can create confusion within literature searches.

It is not the intention of this study to address current debates about defining culture or the culture of games, on-going within cultural studies, as they are beyond the scope or immediate design relevance of this study. There is a range of debate into how cultural studies should discuss and analyse games with techniques borrowed from other interpretations of media such as literature or film theory (Kücklich, 2006) (Atkins and Krzywinska, 2007) (Murray, 1998) again drawing on the ludology versus narratology debate. These areas prove to be distracting in how to analyse gameplay and cannot proffer immediate relevance to design processes and cultural identity for this study.

The discussion of games as cultural reflections goes right back to the first distributed video game *Spacewar* (Russell, 1962), developed by Steve Russell at MIT in the USA. This is essentially the beginning point of the history of distributed video games, and *Spacewar* was created at a time when America was gripped by the space race that escalated in 1961 with the Russians beating America to put the first man in space.

Using Said's Orientalist concept Western games can be said to have a history of orientalist depictions of Arab enemies from *Desert Strike: Return to the Gulf* (Electronic Arts, 1992) to *Call of Duty 4* (Infinity Ward, 2007) with the Middle East having been an area of military interest for America since the end of the cold war.

This cultural reflection in the content of games with military narratives is recognised by many game scholars (Höglund, 2008) (Shaw and Warf, 2009) but the US Army developed FPS game, *America's Army* (United States Army, 2002), turns this around and puts the nature of conflicts in the Middle East directly into their game as a realistic representation. Cultural reflection now becomes recruitment propaganda.

These forms of cultural reflection are where the current practice of culturalisation is working to ensure cultural reflections in a game so not offend other cultural markets for the game.

Games as with other forms of visual media, are often read as cultural artefacts informing cultural understanding through their inherited cultural influence. Götz asks whether other cultural artistic movements might affect game design aesthetics.

Do the technological and artistic signals that promote realistic storytelling come from the software industry? Representative realism is widespread in the USA, where most game design software is produced today as most photorealistic art was in the 1960s. Perhaps the cultural preferences of the USA are reflected in the game industry. (Götz, 2007)

This is an interesting question and there are studies discussing specific Japanese aesthetics in games such as flatness (Chan, 2007). Investigating these would limit this research study to specific cultural aesthetics.

In conclusion the cultural study of games often interprets games from a position that is informing current culturalisation practices specific to the cultural origin of the game. The cultural origin of the game is of interest to this study but only in so much as questioning it if it is free of commercial cultural practices.

3.3 Cultural Models and Game Design

In discussing games this study recognises the argument put forward by Shaw (2010) of how video game culture is often seen as separate to other forms of mainstream culture and this separating of games has shaped, and limited, how games are studied. This separation of games from mainstream culture is not commensurate with this study as it is the very nature of cultural identity and its relationship to games that defines this study. The linking of research into cultural identity outside of areas of games research with practical research into the culture of games informs the design research methodology of this study. For this reason cultural models and the discussion of culture outside of games and other forms of cultural media will be discussed.

There are many cultural models discussing different dimensions of cultural knowledge in order to enable the classification of human behaviour. There is no definitive model used across academic disciplines so it is the applicability to the design process that is important for this study. Of the many cultural models those of Hall, Hofstede and Nisbett have been considered as offering the most useful frameworks for informing a cultural design method.

3.3.1 Cultural Models: Hall

Hall explored the model of units of culture in order to enable the measurement and comparison of cultures across nationalities in his work as an anthropologist and in teaching culture to those outside of his field. Analysing culture as a set of behaviours that are learned and shared between a group influencing the way they communicate, contextualise and relate to each other and the rest of the world. This reading of culture is at a tacit level according to Hall (1989) and is a form of communication that is subconscious, its participants unaware of their behaviour.

Hall defined the concept of high-low context cultures examining messages and the flow of information within a culture. High context cultures use messages that are expressly implicit where information is contained within the context of the message. Low context cultures use explicit messages and the meaning of the message is clearly realised within the message itself with little or no hidden meanings.

The concept of low-high context messages can be considered within games as the design of goals within games requires different levels of context in order to pass a

message to the player of what gameplay actions they should take. A fast paced first person shooter requires low context messages easily read while moving around the environment at speed. Role playing games generally use high context messages where the clues for players to act upon are less obvious. The message in RPG games may be contained in visual clues and knowledge gained from players completing earlier game quests and referenced within subsequent game environments.

Countries with low context cultures include North America, England, and Germany while countries of high context culture include China, Japan and Korea. There is not a clear distinction for this study of Eastern and Western cultures as some European cultures are regarded as high context—French, Italian, and Spanish—but this may offer some insight if considered against overarching nationalities of game developers.

If historical game sales statistics and boundaries were considered then this would support the early preference of FPS over RPG games in Western game markets.

The study of perception and use of space, proxemics was defined by Hall as “the interrelated observations and theories of man's use of space as a specialized elaboration of culture” (Hall, 1988). Hall separated proxemics into two areas, personal space and territory. Personal space is the immediate space surrounding a person and is broken down into reducing circles of distance from public distance, social distance, personal distance and then intimate distance as the smallest.

Territory is derived as public, interactional, home and body. These equate to open spaces, meeting spaces, an owned space and the immediate space surrounding a person. Hall notes that personal space is different depending on culture and the interaction of personal space and territory is culturally characteristic.

The game space establishes the nature of the space between players and the function of the space. The analysis of game space can consider proxemics in terms of the cultural influence of the designer upon the space. How to consider proxemics within the design of the game space and relate this to cultural influence is where the theory of imageability and intelligibility are useful.

3.3.2 Cultural Models: Hofstede

Geert Hofstede created a model for classifying national cultural characteristics that is commonly used in studies across different disciplines. Discussing culture as a collective phenomenon where the “collective programming of the mind ” (Hofstede, 2003) differentiates groups or categories of people Hofstede has produced studies at national and organisational levels.

Hofstede subdivides culture into layers, the ‘onion’ model, with values at the core then rituals, heroes and at the outer layer symbols. Values are the deepest layer and the most difficult to influence while rituals, heroes and symbols are in every day life and more observable but also most prone to influences. It is the core area of values that Hofstede measures and uses to classify nationality and culture through his Value Survey Module (VSM) questionnaire exploring 6 dimensions. The six dimensions are:

Power Distance (PDI): This expresses the relationship between the individual in society and the distribution of power. High values mean an individual accepts there is a strong societal hierarchy and inequalities of power. A low value pertains to a society where the individual can strive to equalise the distribution of power.

Uncertainty Avoidance (UAI): This property expresses how uncomfortable an individual in society may feel about uncertainty and ambiguity. Low values mean people are more relaxed about what may or may not happen while high values mean people hold strong codes of belief and are intolerant of unorthodox behaviours or ideas.

Individualism Collectivism (IDV): High vales of this property indicate a society where the individual is responsible for themselves and immediate family only while low values mean society is more important than the individual.

Masculinity Femininity (MAS): This is not to be confused with gender as with this property a high value represents a preference for assertiveness and rewarding success while a low value stands for a more caring and cooperative approach.

Long-term Short-term Orientation (LTO): This can be interpreted as a societies search for virtue. Low values indicate a propensity for quick results and a short-term orientation. High values indicate societies where truth is governed by context, situation and time demonstrating perseverance in achieving results.

Indulgence versus Restraint (IVR): High values indicate a society that allows individuals to enjoy life and gratify natural human drives while a low value indicates restraint and regulation through expected social behaviours.

Currently data that can be used to discuss 110 different countries national cultural characteristics is available through his website (Hofstede, n.d.). The Values Survey Module questionnaire is also available to download and it may partly be this generous accessibility that has made this model so highly referenced.

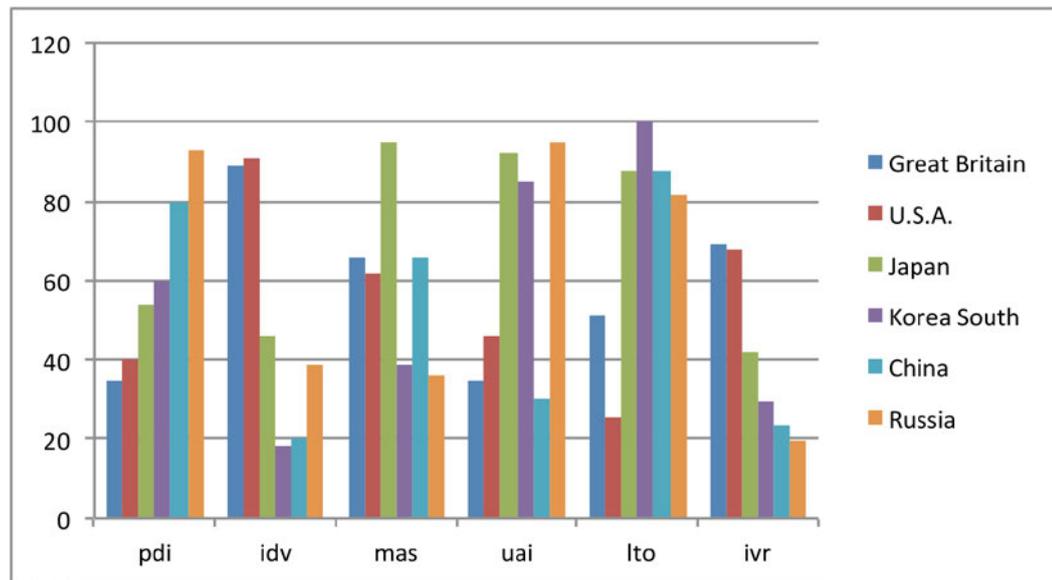


Figure 3: Hofstede attributes for cultural characteristics of six countries retrieved 2012

Figure 3 compares cultural characteristics using the Hofstede model of six countries already mentioned within this study.

In all properties except long-term versus short-term orientation the USA and Great Britain exhibit similar values. The significantly higher individuality values (idv) indicate a preference for looser social frameworks while the higher Indulgence versus Restraint values (ivr) relate to enjoying life and having more fun. This could relate to the success of the FPS genre within the USA and Great Britain as this genre has inherently more freedom in fast competitive games with less need for structure within team play.

Japan has a higher individuality than South Korea and China with a much more significant difference in Masculinity Femininity (mas) representing a preference for heroism and reward. This could relate to the success of narrative based heroic RPG's that have been hugely successful in Japan but not fared as well in other markets. The

higher Long Term Short Term Orientation (Ito) also indicates a possible propensity for greater context in game narratives that comes with RPG's. The higher MAS property alongside the high uncertainty avoidance property could indicate an avoidance of FPS with their quick fire and random team play.

South Korea and China are more restrained than Japan but they do not have the same propensity for achievement, MAS, or individuality that may account for the success of FPS in these markets.

Interestingly Russia has more similarities to the Eastern cultures than to that of Great Britain or the USA and is developing similar game industry models through online play.

These cultural characteristics appear to offer some insight into cultural preferences for games though this data is not without its critics as to the depth and richness of a national culture being reduced to six dimensions.

3.3.3 Cultural Models: Nisbett

Nisbett's model of culture does not offer key measurable dimensions with nationality as with the previous models but concerns itself with how Eastern and Western cultures differ. Mental processes including areas of thought, perception, attention, organisation of knowledge and understanding are used to define Eastern and Western cultural differences (Nisbett, 2004).

Nisbett suggests that Westerners are analytic and see their world in terms of goals and individual elements, looking for the rules that govern these in order for them to control events. Eastern thinking is holistic considering inter connection, where everything is in a state of constant change and has an effect on others so to understand a part you must understand the whole. As Nisbett evidences that these cultural cognitive differences affect the way a subject interprets images then the interpretation of a game environment, a two dimensional display of three dimensional data, will also be affected.

Static, moving and interactive elements on screen combine to make a game narrative required for the interpretation of game objectives and therefore Nisbett's evidence of cultural differences will mean these elements are interpreted differently by players from different cultures.

Nisbett concludes the goal led thinking process of Western cultures and the holistic approach of Eastern cultures directly affects the interpretation of the visual field and objects within it. Nisbett proffers questions in terms of cultural differences that directly affect gameplay mechanisms. Categorising his questions into several areas there are three that directly affect gameplay thinking.

Attention and Perception: Why are East Asians better able to see relationships among events than Westerners are? Why do East Asians find it relatively difficult to disentangle an object from its surroundings?

Causal Inference: Why are Westerners so likely to overlook the influence of context on the behaviour of objects and even of people? Why are Easterners more susceptible to the “hindsight bias,” which allows them to believe that they knew it all along?

Reasoning: Why are Westerners more likely to apply formal logic when reasoning about everyday events, and why does their insistence on logic sometimes cause them to make errors? Why are Easterners so willing to entertain apparently contradictory propositions and how can this sometimes be helpful in getting to the truth? (Nisbett, 2004)

Gameplay mechanisms such as; play on rails, open gameplay and sandbox theories all weave together narrative and logic in order to build a functional and understandable game environment that would be informed by answers to these questions.

It may be considered from this initial starting point that a Western player would be more goals driven within a game world while an Eastern player may be more concerned with understanding the narrative in order to make sense of the gameplay. As game design balances player goals within an encompassing holistic narrative then this may result in cultural differences in gameplay within the same game. Therefore market differences may be the result of different interpretations of a game leading to perceived cultural preferences in game sales.

Building on Nisbett’s early findings Nisbett and others (Chua, 2005; Goh et al., 2009) have continued in determining differences in how subjects from Western and Eastern cultures perceive and interact with a two dimensional visual field. Subjects from different cultural backgrounds perceived the relationship of objects within test images in different ways offering different narratives for the structure of the elements within the image. Nisbett’s original study has evolved into studies using single images, photographs of city environments, animation and web sites.

Faiola suggests from a study using web pages, a mix of pictorial and textual information, that web design should be carried out according to Nisbett's cognitive theory in order to enhance perception and usage (Faiola and Matei, 2005). Users perform better when using a website developed by a designer from their own cultural background than a comparable website designed by a designer with a different cultural knowledge. Just like a web site a game screen contains pictorial information, the environment, and textual information the user interface, both to be interpreted by the player in order to make gameplay decisions.

These results demonstrating cognitive differences in the interpretation of images indicate the need for the investigation of possible design issues for the design of multicultural game spaces in order that they will be interpreted with parity by players from different cultures. The findings of cultural preferences dependent on a designer's cultural origins demonstrate the requirement to investigate cultural influences in current game environments to establish possible cultural characteristics within the design process.

A starting point for game design research into these cultural cognitive differences with the visual field can be begun with the findings of a study by Boduroglu et al (2009) which offers a practical issue for the design of screen composition.

They demonstrate that East Asians are better than Americans at detecting colour changes when a layout of a set of coloured blocks is expanded to cover a wider region and worse when it is shrunk. East Asians are also slower than Americans are at detecting changes in the centre of the screen. The data suggest that East Asians allocate their attention more broadly than Americans (Boduroglu et al., 2009).

Nisbett's cultural model of differing Eastern and Western cognitive processes relating to the visual field has led to research directly affecting the design of the visual field for multicultural game environments.

3.3.4 Cultural Models: Conclusion

Hall's high–low context and Hofstede's VSM can be used to correlate nationality characteristics, organisational characteristics and the individual level to some extent in relation to game sale statistics. This is more retrospective than moving forward to a new design methodology.

Nisbett's model indicating cultural differences in the interpretation of the visual field is directly applicable to design practices and possible cultural differences in the interpretation of images on screens. If it is possible to analyse game environments for the elements that construct a player's visual field, extrapolating visual parameters such as areas of complexity within the image, then a design theory may be determined in order to be able to balance the visual field as seen by players from different cultures.

Hall's model of proxemics indicating cultural differences in spatial relationships is also directly applicable to the game space. As designers build the spaces that can determine spatial relationships then evidence of culture may be in the geometry that makes up the gamespace.

Each cultural model offers possibilities to inform or analyse games and game data. Nisbett's model offers a direct influence upon the design process due to its investigation of differences in the interpretation of the visual field. Hall's proxemics offers a design understanding of the 3D space.

3.4 Conclusion

In this chapter literature relevant to the development of a multicultural multiplayer game design methodology has been discussed in order to inform a design research framework for moving forward with the study. As there is no definitive literature on multicultural multiplayer game design this study is moving into the realms of new knowledge but the direction should be informed by the following conclusions.

It is clear that sales figures and historical notions of gameplay preferences are not a solid basis on which to build the design investigation. Game distribution models have changed and a simplistic Western versus Japanese preference model is not appropriate.

The first person shooter format is a form of gameplay that was perceived as specific to certain cultural markets. It is now evident in other cultural markets but through different distribution models so it will be a format useful to investigate further.

Game rules and mechanics are discussed as part of the architecture so this may indicate cultural influences for gameplay. An analysis of the game space, the architecture within it and the design rules game designers apply to it is required. These cultural influences may also be more evident in 3D spaces that are not tied to economic constraints.

Cultural models are applicable to two areas in game design. First the use of the 2D visual field as determined by Nisbett and others through differences in Eastern and Western cognitive perception of 2D images. Second the use of space as determined by proxemics the understanding of spatial behaviour.

The next chapter will carry these conclusions forward while investigating 3D spaces and the rules used to construct them.

Chapter 4: Spatial Investigation

This chapter deals with the direct investigation and interpretation of game spaces, 3D worlds and the rules used to construct them. It examines the game methods and theory used to construct spaces, including the transfer of real environments into games. The cultural interpretation of real spaces transferred to the game space is also considered. Then the examination of 3D spaces and the implications of these for a design methodology and creating an analytical method are discussed.

The complication to interpreting 3D game spaces is that a player views a game space on a 2D visual display and the designer also builds the game space using a 2D visual display. This visual display frames the composition of the 3D space and may be used by the designer to create fixed viewpoints through specific design techniques. This may involve ensuring every player moves through the space via a particular route. Game designers also understand that the player is embodied in the space and can make their own choice to frame elements of the space within their viewfield. Therefore both the designer's spatial rules and the player's behavioural rules have to be recognised in order to understand where both use implicit knowledge.

Nisbett's cultural model indicates differences in the cultural interpretation of 2D visual fields, including those seen on a computer monitor (Faiola and Matei, 2005). Therefore the framing of the 3D game space as a 2D image is subject to cultural interpretation. The player is constantly subject to this as they are only ever analysing the game space through the frame even as their awareness of the 3D space develops through gameplay. This is not the case for the designer of the space as they have an instant understanding of the overall layout of the space through their design process, as well as the framing of the space when considering small elements of a larger space.

Game designers will map out game spaces considering the player movement and actions within the space. They may consider when they wish to reveal environmental or narrative information to the player, or aim to control how the player uses the space within gameplay. Therefore the spatial analysis of a game space may be considered in two ways.

- Considering player movement through the overall 3D space and the constraints applied to this by the designer. This considers the design of the whole space holistically often visualized as a 2D map of the space.
- Considering individually the interconnected 3D environments making up a game space. This considers the immediate view field as seen by a player and any particular viewpoints the designer may have composed within the individual environments.

Therefore analysis of player decisions may be based on their immediate field of view while analysis of design decisions can be based upon fields of view and the overall layout of the space.

Expanding this to consider the transfer of real environments into this framework and therefore where the use of experiential and cultural knowledge is apparent, several areas must be considered. There are the inherent cultural values in the real world environment being replicated. What level of prior knowledge do the designer and the player of the replicated environment have? What design decisions did the designer make when replicating the environment?

To begin with the practice of transferring environments into games is considered in section 4.1. This discusses the cultural interpretation of environments and architectural theory as relevant to games through game design theory and practice. Then in section 4.2 the application of this knowledge to interpret virtual environments leads to the reasoning behind the study's analytical methodology.

4.1 Transferring the Real to the Virtual

3D game spaces offer the closest representation to a player's real world movement and often replicate real world locations or reference real world objects and built environments. This replication of real world elements creates a considered virtual architecture for a game's functionality, or ensures an aesthetic empathy with the player enhancing the game's narrative. As the game designer Määttä suggests

It's much better to take certain amount of detail directly from real environments and not to try use your imagination to invent it (somebody has already designed certain machinery for certain purposes, so why not use that information?)

(Määttä, 2002)

As is suggested the real world elements have been designed for a purpose so the transfer to the virtual world replicates that design knowledge that has dictated the visual form even if the functionality is not required. Any design rules used for a real world space are transferred to the virtual space through the intended simulation or representation of real world elements.

Jim Brown, lead level designer at Epic Games, when discussing level design at the *Level Design in a Day* seminar at the Game Developers Conference 2013 stated.

Ultimately, however, I think the best way to get good results here is to have an understanding of real world architecture and psychology -- if something looks "real" or appears "normal" people will subconsciously accept much more than you'd think.

(Seifert, 2013)

It may be surmised that the creators of real world environments utilize common explicit knowledge in order to ensure an understanding of the space and successful navigation within it. In simple terms architects know entrances need to be clearly indicated and stairs or lifts are the expected methods of moving around an environment with different levels. Ladders are recognised as possibly dangerous and a possible hindrance to movement within multilevel environments. Aesthetic decisions made by the architect of a space are balanced with the knowledge of what the user may or may not be able to do, or wish to do, while navigating the space.

The ladder in both the real and virtual world is recognised instantly through common explicit knowledge, or the affordance of the object, as a means of moving to a different

vertical level within an environment. A player navigating a virtual space will not be overly concerned about the requirement to use a ladder as much as when encountering a ladder in a real space where the understanding of the dangers of a ladder is more pronounced.

The designers of real world spaces recognise that common explicit knowledge has implications for the functionality of the space and cannot let aesthetic decisions override this. The understanding that a person's tacit knowledge states that a ladder is inherently more dangerous to use than a staircase will, in most cases, override any appreciation of the aesthetic minimalism of using a ladder instead of a staircase. In a virtual world this knowledge is still present but it will not prevent the use of the ladder as it might in the real world.

The replication of larger real world environments to game spaces, such as large sections of London in the games *The Getaway* (Team Soho, 2002) offer different issues for the use of tacit knowledge by the player and designer. A direct representation of geometric form means the transfer of layers of cultural information built over many years in the real world that is now remediated into the game space. Layouts for cities are affected by many elements, for example the age of the city. Older cities have evolving street patterns while modern cities often use grid systems. In building virtual representations of real world elements a designer transfers these cultural references implicit to those elements that may then affect player interpretation dependent on the player's cultural knowledge.

The cultural references in the landscape of a city or in the layout of a city will be familiar to some and completely alien to others, who will feel like a tourist in another culture. Iconic cities such as London, New York, Paris, Rome and Tokyo are commonly used in game environments but whether a designer lives in the city to be referenced or visits it to collect the required information affects the design process and the transfer of specific tacit knowledge.

In an interview, with Iain Simons, Martin Chudley Managing Director of Bizarre Creations, the developers of the Project Gotham Racing series of games, discusses the design process for developing a city based racing track and the tension between reality and playability.

“The artists, particularly in the old days, wanted to make the setting pristine – every corner, every bollard, every lamppost had to be in exactly the right place. From a design perspective, we were going ‘no, no, no! – we’ve got to make this more playable!’ Always we would be trying to remove that bollard, shave a little from that corner – to make it better from a gameplay perspective. There’s always been a compromise. We wanted to make sure that the city is completely recognizable. We saw so many games after MSR that made half-hearted attempts at that – ‘there’s the Eiffel Tower, so therefore this is Paris’ – but didn’t actually try to replicate the location. If you stood on any corner in our game, you would see exactly the buildings and landmarks that you would if you stood there in real life. That’s a big thing for us, putting reality into the game. It’s hugely gratifying for us to get comments like, ‘I bought PGR2 from the very shop in Edinburgh that’s in the game.’ Players can actually drive past, in the game, the very shop from which they bought the game in real life.

The fact is, it’s very difficult to just make up a city. Cities have evolved over hundreds of years with thousands of different architects and styles, so to get one artist to sit there and fabricate a city from imagination that looks believable is an impossible task. Our approach is to let history do the work for us and remake what we see. It’s far easier.”

(Simons, 2007)

This perfectly illustrates the tension of realism and playability while also indicating the cultural expectations of the player, as it is not Paris by simply placing the Eiffel Tower somewhere in the environment. He goes on to describe how they replicate the environment of a known place.

We usually start out as a skeleton team, with maybe three of us doing all the research. We walk down every one of those streets and take reference pictures of every single building...

We found a company that does high-res satellite photography, which was what we used most for New York. All we do with this is cut around the basic footprint – once the city is divided up into blocks.

The designers are replicating the individual buildings in the city directly upon the layout of the city. Both individual buildings and the layout of the city have layers of cultural information built up over time that is intentionally being transferred to the virtual environment to create a believable experience.

Chudley is discussing a racing level set in New York, so the route the player takes through the city is circular, repetitive and goes past at speed. Games where whole sections of a city allow a player to walk around and get up close to the architecture only amplify these design issues.

In summary a game designer may knowingly use architectural theory from a real world environment to inform the creation of virtual spaces or, if not knowingly, then they may be using tacit knowledge gained from their every day interaction with a real space. Within this tacit knowledge there will be common explicit knowledge of real world environments and of designing gameplay but also the specific cultural knowledge of the designer will affect the gameplay decisions they make. It is how the game space reflects this implicit cultural knowledge of the designer and the cultural specificity within the original source of the environment that is important.

To do this first establishing the form and function of architecture in games then considering the cultural interpretation of environments is important and then to consider where architecture and games converge.

4.1.1 Architecture in Games

When discussing architecture in games, unlike in the real world, it considers both the structural elements and the landscape that contains them. Even if the landscape is a representation of natural forms these are still created by the designer and therefore subject to tacit knowledge within the design process.

In order to consider how tacit knowledge may transfer through architectural forms in the game world we must first consider the use of architecture in game worlds. Adams states this succinctly in his Gamasutra column discussing a lecture he gave on the role of architecture in video games

... architecture tells you where you are. But more than that, it also tells you what might happen to you there, and even sometimes what you ought to be doing.
(Adams, 2002)

Architecture when discussed for game environments in is an integral part of the game narrative. If the overall environment the player moves through is considered then architecture will locate the player within the narrative as they reach certain goals and may also allow them to see where they are aiming for. Architecture within the immediate player environment offers the player indicators for what they might be required to do or contain gameplay elements to be discovered.

Adams breaks down the function of architecture in games into primary and secondary functions where the primary function is to support gameplay through; constraint, concealment, skill tests and exploration. The secondary is to inform the player through familiarity, allusion, new forms, surrealism, atmosphere, comedic effect, and architectural clichés.

This primary and secondary taxonomy establishes an important consideration for this study as it differentiates the primary architectural function as the geometry that makes the game space and then the implementation of narrative through the application of secondary architectural functions.

The primary functions of architecture in terms of constraining movement, creating areas for concealment and creating a game space where players may test their skills and explore the environment are common explicit design functions across games. The addition of the secondary functions, particularly the concepts of familiarity or knowledge of cliché, may be specific to a player due to their implicit cultural knowledge.

Primary and secondary architectural functions can be mapped to a relatively consistent design process evident in published game design documents. Game designers will normally first consider a game level holistically on an environmental scale determining the gameplay mechanics in sequential stages through the level. This can involve teaching the player the game skills necessary to overcome later obstacles. It may mean the distribution of equipment or game objects that enable the player to deal with later more dangerous or complex geometry. These are the design decisions that affect the speed and rhythm of a player's movement through the level determining the flow of the game. This may be directly linked to an overarching game narrative. As stated by Jenkins

The organization of the plot becomes a matter of designing the geography of imaginary worlds, so that obstacles thwart and affordances facilitate the protagonist's forward movement towards resolution. (Jenkins, 2004)

The secondary architectural functions add the aesthetic qualities to the geometry that make up the level. These will involve the aesthetic structure of the geometry so a kitchen environment contains geometry that establishes it in the player's mind as a kitchen through familiarity. Copying architectural references from real world architecture will give the player the allusion or emotional response required for the

game narrative. Creating unfamiliar geometrical forms will give the player a sense of an alien world.

Geometry, texture and lighting qualities are all elements within these secondary architectural functions. The designer makes the decision on the age of an object through the choice of texture, aged flaking paint or a smooth fresh painted texture. Even shadows creating dark corridors may be faked through shadows that are baked into the texture image as opposed to created by the combination of lighting and geometry.

The secondary architectural functions are akin to *mise-en-scène* discussed within film theory as the placement of all elements within the camera frame establishing the look and feel of scene or particular camera shot. The difference for the game designer is that the player does the framing as they look around the environment; so secondary architectural functions must establish a holistic look and feel to the environment rather than the single composed viewpoint chosen by a film director.

Within the analysis of game spaces both primary and secondary architectural functions shall be considered independently and holistically.

4.1.2 Cultural Interpretation of Environments

The significance of culture in the interpretation of environments has been discussed in the academic fields of architecture and the built environment. A built environment is considered to be constantly transmitting messages to people conveying cues from which they may determine their personal behaviour or make judgments about other occupants. As people behave differently in different settings, often according to behaviour defined by culture, then the built environment can be seen to be a non-verbal form of communication (Sanoff, 1991). The environment transmits nonverbal messages through social, cultural and symbolic information that elicit appropriate behaviours (Wagner, 1972). Effectively the cultural identity of an environment is a secondary function to its primary function, that which the architecture is designed for.

Rapoport (1990) discussed a study by Duffy in 1969 of the offices of British civil servants reporting how they were laden with signifiers of the status of the occupant including, size, number of windows and furnishings. Sanoff (1991) continues this discourse by considering how designers and researchers can and should learn how people decode their environments in order to be able to construct more desirable and

meaningful environments. Though he acknowledges that perceiving and interpreting physical environments is a complex process requiring the understanding of physiological, experiential and cultural values.

Norman argues whether culture matters for the design of objects any more in current society (Norman, 2012). He considers this through the homogenisation of department store environments in different countries as common environments due to the common objects within them. Using photographs of department stores, restaurants and street scenes he asked his students where the photo might have been taken demonstrating a lack of cultural differences between Asia, Europe and America in these environments. It should be considered that his initial studies proved more about the homogenisation of department stores than of all real world environments.

In contrast Miyamoto et al (2006) examined the holistic and analytic perceptual affordances of real world environments in a study of external environments. This used street scenes from Japanese and American cities with schools, hotels and post offices from a range of different sized cities for a comparative study. They concluded that Japanese scenes contained more elements than American scenes and that “culturally characteristic environments may afford distinctive patterns of perception”.

This means that common environments across the world such as department stores may now be culturally similar while external environments may be deemed not to be. As game environments are often based directly on visual research from real world environments, both internal and external, the homogenisation of cultural individualities in environments has to be recognised by this study and by game designers.

The game designer creates a 2D screen representation of a 3D virtual world that in turn represents a real world environment. Then the screen image is a remediation of the real world environment. This can be considered to be much like an artist painting a landscape. The 2D painting is a remediation of the artist’s visual field and the artist may remove or enhance objects within the artwork. Hall states that if an artist is successful and the viewer has a common culture to the artist then the viewer replaces anything they identify as missing in the artwork (Hall, 1988). The emphasis here is on a common culture between artist and viewer in the shared cultural understanding of affordances within the objects composing the image. That commonality facilitates the viewer’s

replacement of objects through specific implicit knowledge. This is the secondary architectural function of games, the allusion and familiarity discussed by Adams.

When considering culture and primary architecture in games there is the larger layout of the real world environment to be considered. Americans have become used to the uniform grid pattern of American towns and cities while European cities have grown organically over longer periods. Though more organic the grid and the radiating star are still prevalent organisational hierarchies in European cities. Hall discusses how American travellers will often get lost due to the lack of the simple grid structure in which to orient themselves (Hall, 1988). He also states that the language of a traveller often indicates their affront with the architecture as though the town is victimising them due to their cultural differences.

The structure of a Japanese town does not conform to either form. Where a grid or a star pattern stresses the lines or roads that will be named, the Japanese stress the intersections and name them. The Japanese system emphasises hierarchies by numbering houses as they are built so the relationship of space to time can be read in the landscape.

Hall considers that all spatial structures from an office to a town will reflect the spatial modalities of its builders so whether a designer takes their inspiration from a real world environment or not there will be some form of specific implicit knowledge evident.

In conclusion at the level of primary game architecture, considered when mapping a game environment, a player encountering a virtual environment based on real world architecture from another culture can be considered to be in the same predicament as the visitor to a city where the spatial structure is not the norm. The difference in expected navigation hierarchies, grids, radial lines or intersections all point to issues for player navigation due to their cultural knowledge of differing real world spatial hierarchies. If the hostility discussed by Hall, found in real life encounters, transfers into the game world then it can be expected that the player is unlikely to continue with the game.

Game environments have to be read for cultural implications at both the level of the immediately viewable environment but also at the level of the overarching structure of the environment. Both levels can carry cultural influence that may affect a players understanding of the environment.

4.1.3 Games and Architectural Theory

Game and architectural theory converge at the point that the user of a real or a virtual space experiences a narrative informed through the exploration of the form and the function of the space. The form and the function of either form of space are conceived through a design process that is intended to fine tune the user experience, enhancing the usability and intended function of the designed space. The anticipation of the user led inquiry of space, and the paths through it, means that the two design disciplines; architecture and game design, have common ground in the design skills required to shape three dimensional spaces.

Design theory relevant to both game design and architecture has been recognised by many game scholars; Adams (2002), Licht (2003), von Borries et al, (Borries et al., 2007) and Nitsche (2009) amongst others. Licht trained as an architect before working as a level designer at Lucas Arts and discusses design methodologies learnt while studying architecture in his Gamasutra article *An Architect's Perspective on Level Design Pre-Production* (2003). He explains how useful they are in the level design process mapping them to a level design process looking at primary architectural functions.

Götz discusses this convergence of architecture and game space practices in his paper *Load and Support: Architectural Realism in Video Games* (2007).

As both game designers and architects experience similar problems in the construction of space, it is not surprising that they use similar working methods in their planning and development phases.

Further discussions in (Borries et al., 2007) concern what both disciplines can learn from each other and the new typologies of space where the physical and the virtual overlay each other. As games move out of virtual spaces and combine with real architectural spaces these become interesting theoretical areas for both disciplines as common design considerations cross the boundaries of Huizinga's magic circle. There are architect practices, such as HKS, working with Unreal game technologies and as digital realms offer a freedom from real world constraints there is evidence of architects moving into digital spaces within communal worlds to explore architectural possibilities discussed in the next section.

This study is focused on the replication or parody of real world spaces in virtual spaces but recognises that these are not simulations of the real world space. The design of game space often replicates real space and the game world designer seeks to recreate, with considered levels of realism, the architecture of a real space. This will not normally be an exact transfer of the space but the game designers interpretation of the real world. Though as Hall states, anything the designer leaves out will be replaced by the user of that space if from a common cultural background to that of the designer.

This replication enables the transfer of player knowledge into the game world informing narrative or game functions. There is an inherent reliance on the player recognizing and using their tacit knowledge of the functions of a real space within the virtual space whether the player is utilizing primary or secondary knowledge of the real environment.

The function of a space, the artistic vision of those involved in the commissioning of the space and material and construction capabilities, all lead the design of real world spaces. None of these affects game designers when reproducing a real world space. They have no need for the specialist training to understand and deconstruct the design of a real space in terms of materials and construction techniques. They are simply engaged with capturing an aesthetic of a space for a function particular to the game world. Thus in replicating the real world the game designer copies the constraints and limitations the architect of the real space was subject to even though these may not be relevant to the virtual space.

Form and function may differ for architecture when replicated within game worlds as game architecture is influenced by the games primary and secondary architectural functions that may differ from the real world function. Doorframes are doorframes in both worlds and players know to walk through them yet the supporting beam duplicated through geometry or texture has no purpose in the virtual world where gravity does not exist and buildings have no weight. The question may be asked how much the designer recognises the original function from the replicated visual form to ascertain where real world knowledge ends and game world possibilities begin.

An area of theory discussed within architecture and recognised as implicit in all forms of spatial design is that of human instinct. It is often cited as shelter theory derived from Maslow's hierarchy of human needs. This states that once we have our physiological needs satisfied such as breathing, food, water we then consider safety. This need for

safety is implicit tacit knowledge across cultures as it is derived from the most basic of human instincts. Architecture initially was mainly concerned with satisfying this need for shelter and the spatial experience and it was only later that architecture made form important.

In considering human instinct in terms of spatial design the Gamasutra article by Christopher Totten, *Designing Better Levels Through Human Survival Instincts* (Totten, 2011) offers excellent spatial analysis. Breaking down elements of human instinct into three areas; size of space; prospect and refuge; shade, shadow and survival. These areas of tacit knowledge are useful in interpreting game spaces and are discussed when considering spatial design rules later in this study.

Size of space deals with three simple groups: narrow spaces, intimate spaces and prospect spaces.

Narrow spaces create a sense of vulnerability as the occupant feels confined and realises that movement is limited. Regularly used in horror games due to their ability to elicit fear, the proximity of danger and the lack of escape affect the emotions of the player.

Intimate spaces offer the player instantly recognisable accessibility to elements within the space, even if some consideration is needed to access them. The space is neither too small nor overly large and the player feels they have a control over them.

Prospect Space is considered to be the opposite of narrow space while producing a similar effect. This is an architectural theory proposed by Grant Hildebrand (Hildebrand, 1999) describing a spatial condition that is a wide-open space where the occupant feels exposed. The implication is that humans feel uncomfortable in a large open space where there are few places to hide relating back to early instincts for shelter from predators or the elements.

The theory of prospect and refuge builds on the notion of prospect to include the idea of refuge spaces where the occupant of the space feels safe within an intimate and enclosed space. Level designers use the alternation of prospect and refuge to pace a level or offer respite within a dangerous area. Often refuge enables the occupant to view goals while anticipating the prospect space between them and the goal.

Shade, Shadow and Survival concerns the human instinct of fear and the dark space. Shadow is a traditional effect used in the horror genre using dark spaces to increase fear that something may be lurking within the shadows. Moving between shadow and light is often perceived as uncomfortable in the real world but has added effect when there is the possibility of something waiting in the shadow.

Shade is used as a way of obscuring elements to create mystery rather than outright fear. Shade in this instance can provide hidden bonuses for players, possible refuge or hidden enemies and keeps a player guessing until they approach.

This set of principles explained by Totten considers both the primary and secondary functions of architecture in game spaces. It offers a spatial method for analysing game design that also underpins theory of real architectural spaces as Totten discusses referencing the architectural work of Corbusier and Frank Lloyd Wright.

The work of Corbusier has been described as prospect-based due to his common practice of placing of buildings were they would rise above nature. Within the architecture he would use ramps, raised pathways and wide-open spaces common features in first person shooter maps.

The work of Frank Lloyd Wright is described as refuge-based as his designs often incorporate intimate spaces and he based many of his designs around the hearth as the centre for warmth and safety in the home. His buildings would often be set within the landscape as integral and not apart from nature giving them an intimate but still exploratory feel.

The direct link of architectural theory and virtual spaces is discussed further in section 4.2.1 as Falling Water, considered to be a classic example of Frank Lloyd Wright's architectural design practice, has been replicated in virtual worlds.

This conflation of architectural theory with the design of game environments reinforces game designers using the real world experiential knowledge of the player in the game world to reinforce the player connection with the virtual environment. It also means there is a language for the analysis of game environments led by a qualified approach used in another design discipline.

4.1.4 A Conclusion on Transferring the Real to the Virtual

In considering how to analyse game environments the two considerations where:

- Consideration of player movement through the overall 3D space and the constraints applied to this by the designer.
- Consideration of the individually interconnected 3D environments making up a game space.

These can now be considered within a framework of architectural game principles that underpin game design at both the level of complete environment and the immediate environment as seen by the player.

The overarching layout of a game environment can be discussed in terms of human spatial instincts as seen to underpin elements of architectural theory. Theories of prospect and space also apply to primary architectural game functions of constraint and concealment. This must also consider the familiarity of the layout dependent on the cultural origins of the environment and the cultural background of the player as to their familiarity with an overall street pattern.

The cultural implications of a single area in an environment can be discussed in terms of secondary architectural game functions, such as allusion and familiarity. It should also be considered whether the environment was culturally homogenised before it was replicated within the game.

4.2 Investigating Real World Replication.

This part of the study explores two 3D areas. Professionally developed game environments and communication worlds in which the development of the virtual environment by individual users is actively encouraged. This enables the comparison of game environments led by professional design techniques with environments built by non-professionals with no commercial incentives.

First the exploration of individual buildings directly replicated in virtual worlds with no specific game function offers insight into the differences of the direct transfer of real world architecture to virtual architecture. Then the discussion of an individual building transferred directly as a game level enables the consideration of its use for gameplay. Buildings transferred into professional game environments are then considered as to how they are adapted for gameplay.

Landmark buildings are often used to define architectural movements but as yet there seems to be none feted as such within online communal worlds or game worlds. Virtual spaces are more often celebrated as whole environments defining key realisations of form and function in terms of gameplay. Examining the replication of landmark buildings within digital worlds offers the possibility to examine key points of transfer between the real and the digital realm. This enables the critical analysis of the common and the specific tacit knowledge used in understanding the remediation of reality based architecture.

Amateur and professional built environments, in both communication worlds and games, are then considered in order to develop the methodology for analysing and comparing digital environments containing individual buildings.

4.2.1 The Replication of Farnsworth House

Farnsworth House designed by Ludwig Mies Van Der Rome in 1951 is recognised as a classic expression of the Modern Movement in architecture and has been recreated within *Second Life* (Linden Research Inc, 2003), shown in Figure 4.

The original design of the house is as a place of transparency and almost weightlessness as if it is suspended within the environment using large areas of glass and eight single steel I-section beams to lift the house above the flood plain of the Fox River. The form of the house recognises the environment and when viewed from within attempts to frame the environment to bring nature, architecture and the user together. This implied vision of weightlessness and the contemporary use of large spaces of glass with minimal brick and mortar construction offer an aesthetic design that transfers easily to the virtual world through its simplicity of form and function. In *Second Life* the form of the house has been recreated exactly to scale and the contemporary aesthetics of the house fits the simplified geometry this virtual world is limited to.

The Farnsworth House proved controversial in real life through the complaints of the owner Dr Edith Farnsworth who declared the house impractical in terms of heating and as a living space and tried to sue the architect. The digital version proves to be just as impractical as a virtual living space as the low roof causes the virtual camera to fly through walls destroying the original's sense of light and buoyancy. A virtual user in *Second Life* does not see everything from the first person but often views through a third person context enabling them to situate their virtual self within the environment. This means any architectural design must ensure suitable head room for the ever-present virtual camera or in this case the user spends a lot of time sitting down in order to look around the environment.

The ethos of viewing nature from the original house has meant the careful digital landscaping of the replicas surroundings but the limitations of the technology mean that the user cannot fail to see the landscape as anything other than manmade. This defeats the aesthetic function of the real world form as the user explicitly knows this is not a real landscape and there is no narrative to engage the user to believe otherwise.



Figure 4: The Farnsworth House in *Second Life*

The translation of the real life architecture to *Second Life* changes the original context of the structure even though it is a carefully considered architectural replica. The remediation of the form within its new world allows the user to experience the same interpretation on every visit unlike the original form that sits within a constantly changing environment. That environment has since flooded the house twice proving the form to be less than functional but this, to the author's best knowledge, has not happened to the virtual build.

The visitor to the digital Farnsworth House experiences a stylised and neutral version of the real world devoid of the environmental factors that led the architectural principles of its construction. It feels like a remediated experience that is only geometrically similar and not the holistic experience of architecture and landscape that the original possesses.

4.2.2 The Replication of Falling Water

Falling Water is a house designed by the renowned architect Frank Lloyd Wright and built so that it is partly suspended over a waterfall in the south west of Pennsylvania in America. Completed in 1937 it used cantilever technology and reinforced concrete yet due to its aesthetic detail and sensibility it is applauded as a building that creates a harmony between man and nature.

Frank Lloyd Wright is considered to be an exponent of refuge-based architecture and Falling Water offers a cave like experience of safety or refuge in the form of its low ceilinged interior spaces looking out through broad expanses of glass windows. The natural landscape intrudes into the spaces and is integrated with the structural form of the building. Boulders appear through walls and windows are recessed into the natural rock. Interestingly for this study Wright had a passion for Japanese architecture and this is reflected in the design of Falling Water. Japanese architect Tadao Ando considers its spatial sensibilities to be similar to those of Japanese architecture (Hyatt Foundation, 2008).

An architecture student Kasperg, made falling Water into a Counter-Strike map in 2006 (Kasperg, 2006). Originally intended as a demonstration of mapping skills and as a tribute to Frank Lloyd Wright. The map was later adapted to allow a hostage rescue gameplay as *cs_fallingliquid* (Kasperg, 2007) for the *CounterStrike: Source platform* (Valve Corporation, 2004a).

Screenshots are shown in Figure 5 and the attention to detail is very high and commensurate to someone studying architecture appreciating the subtleties of Wright's design. The general consensus from gamers in the comments from sites where this map can be downloaded is an approval of the detail and the level of reality that the map demonstrates. They recognise the building from its use in other games, films and television programmes.

The building is set into the landscape as to be a part of it in the refuge-based architectural style Wright was known for. The virtual version has trees placed in the exact locations as those in the real world with realistic lighting and a strong audio of running water to set the context of the building. The designer of the virtual environment has understood the context of the building in the real landscape and attempted to emulate that landscape as well as the building itself.



Figure 5: Images of CS_fallingliquid a virtual version of Falling Water a house designed by Frank Lloyd Wright.



Figure 6: cs_parkhouse in the style of Falling Water



Figure 7: cs_fallingliquid a virtual replica of Falling Water

In *Counter-Strike: Source* the player is presented in the first person camera view. With Falling Water being to scale the cave like refuge feeling from the spatial qualities of a low ceiling with broad expanses of windows in key rooms is felt immediately. The narrow stairways and corridors elicit claustrophobic prospect feelings but then they open up onto the large rooms with expansive views of the landscape. These are where the player feels more control over the environment.

This individual building suits the primary architectural gameplay function of hostage rescue, and the secondary architectural game functions generate an allusion of reality and familiarity with the recognisable style. The theory underpinning the design of the original building has transferred to the virtual and offered particular gameplay characteristics. The Prospect Refuge sequence while moving around the space gives an ideal gameplay sequence to the hostage rescue gameplay that has been added to the map.

In the 6 years since it was made publicly available it has been downloaded over 5900 times as of the end of 2012. In several searches on www.game-monitor.com, a web site that can list Counter-Strike: Source maps being played on servers around the world, `cs_fallingliquid` never appeared. An earlier map called `cs_parkhouse` (Cc_NIPPER, 2006), in the style of Falling Water, as opposed to replicating it, has been downloaded over 65,000 times and does appear on www.game-monitor.com site on servers in America and Germany.

Over a 6 year period Cc_NIPPER the designer of `cs_parkhouse`, has submitted 64 maps to the web site www.gamebanana.com of which 45 are rated above 9 out of 10. Kasperg has submitted 7 maps all rated above 9 over the same period. While quantity does not presuppose quality it can be considered that the Cc_NIPPER is a more experienced designer and that this experience may affect how the building in `cs_parkhouse` has been constructed.

The comparison of these two similar maps now becomes problematic to pinpoint the factors that may make one more popular for gameplay than the other. It is known one designer has an architectural knowledge and is using this in their designs while the other does not appear to be a professional game designer but is drawing on experience. The secondary principles of game architecture using texture and lighting can be seen to be subtler in the map designed by someone with architectural skills. But the first

principles of architecture for games would appear to mean the gameplay experience is more successful in *cs_parkhouse*, if downloads are used as evidence.

A method to compare these two similar maps in order to measure the differences in their design will facilitate the discussion on why differences in design have occurred.

4.2.3 Buildings in *Second Life*

Architecture within a game world is led by the game function and form in order to enhance the immersion of the player. Within communication worlds there is the ability for the player or user to build their own architecture. Using in world functions or separate world editors there is no remit other than that of their own interest.

In-world building is often complicated to the novice user, but in worlds such as *Second Life* the user may build complicated structures. There are pre-designed elements that make construction easier for the novice but limit form. The use of predesigned building materials lead the amateur digital builder down routes that relate back to similar forms in the real world.

This user built architecture in many worlds can be compared to the classic form of sheds on English allotments made out of multiple doors and window frames. Shantytown like structures are created in a way that extends no definitive consistent architectural or aesthetic form other than functional. This structural form is easily recognised within the real world and has inherent contextual implications of poverty, lacking the economic ability to purchase structures pre-designed with both form and function in mind. But it is also adaptability and human ingenuity to fashion a structure required out of materials at hand.

Architecture carries a cultural context established over many centuries and tacitly understood by most players yet the shanty town aesthetic evolving in most digital suburbs within *Second Life* appears not to tarnish the neighbourhood in the same way a physical shanty town would. Form triumphs over function in *Second Life* as the function is irrelevant in a world that does not rain, or temperatures drop. This is the complete opposite to a real world shantytown where every element is used to enhance function and aestheticism is secondary.



Figure 8: User builds in *Second Life*

The question may be asked whether there is a natural cultural homogenisation of architectural aesthetic when players and users are left to devise their own environment out of predetermined materials. At present there is not enough evidence of cultural differences within *Second Life* to draw any firm conclusions.

Iconic structures often appear within game environments though the ability to interact with them is rare. This maybe that game developers are aware of the breaking down of engagement with an environment if the replicated architecture does not replicate the experience of reality. There are many landmark buildings replicated by amateur builders in worlds such as *Second Life* where this is exactly the issue. Recognisable architectural landmarks such as the model of Big Ben found in *Second Life* act as a landmark from a distance where the model works effectively, but as you move closer to it the lack of detail and the amateur nature of the model becomes apparent.



Figure 9: User built landmark in *Second Life*

The construction of iconic landmark buildings indicates a prior knowledge of their significance but this form of architectural replication is the equivalent of the experience of visiting the remediated versions of the Eiffel Tower, Pyramids or Grand Canal within the casinos of Las Vegas. The shape and form may be representative but there is a cultural resonance that cannot be replicated. The textural and aesthetic values do not replicate those of the original to the point of the viewer suspending belief. The Vegas Sphinx is brand new in comparison to the original. Hall suggested the viewer fills in the spaces in the cultural picture but in these the spaces are too large to evoke a sense of the

original, you explicitly know it is a replica and implicitly know it does not match the original.

In conclusion the replication of individual buildings creates digital architectural geometry that may be construed as an aesthetic replica but not a contextual replica unless there is an understanding of the original context. The direct transfer of an individual building requires an understanding of the landscape the building sits in and how it draws function and form from that relationship.

The architecture's relationship with the landscape is the *mis-en-scène* of the film director. It is the contextual framing, not of a single view as with film, but of the space in a holistic approach that means the viewer is constantly framing the architect's vision. When architecture is only replicated to demonstrate aesthetic form it becomes a form of hyper-reality where the reality of form and function is re-mediated simply for aesthetic principles and any cultural resonance is lost.

4.2.4 The Transfer of Environments into Digital Worlds

Game environments are constructed as a complete environment with design considerations on how structures fit together to form a complete gameplay space, rather than the construction of individual buildings over time as in the real world. To examine environments holistically offers more insight into their transfer from the real world to the virtual.

Iconic cities offer the virtual architect chances to embed game narratives in real life locales and to engage the player with locations that maybe exotic or familiar, but are recognisable to some degree. London has been used as an environment for many games, often within the genre of racing where iconic architecture is commonly used as a visual aid to location. This form of architecture is not accessible to the player but works as a landmark to help players to locate their position on a track. Of greater interest is where representations of cities are accessible to both the virtual pedestrian and driver. This complete access to a representation of a city can be found with London in the game *The Getaway* (Team Soho, 2002).

The Getaway version of London is interesting as it is a direct geospatial representation of Central London and driving or walking around the streets offers a comparable spatial experience of driving in London. The production of a representative landscape built to the scale of the real world offers the player a direct experiential transfer of the spatial characteristics of London.

The compromise in this spatial replication is that for the player to remain engaged with the narrative and gameplay structure they need to drive freely at speed. This is unlikely in the real central London due to the density of traffic and so the environment is not populated with a realistic number of other vehicles on the roads. This offers a better gameplay experience, as a realistic experience of driving around London would be frustrating.

In this environment the primary architectural game functions are more reliant on the mission scenarios located within buildings and the larger environment enables timed driving or getaways as part of missions.

In *The Getaway* driving around London is a key element of the game narrative and the environment design has had to reflect real driving time within the gameplay due to its realistic spatial characteristics. This has enforced a possible compromise of a player's explicit knowledge of London traffic. This may be led by experience or by information channels such as news, movies or other entertainment media where London traffic is portrayed realistically.

As discussed a primary function of game architecture is to establish gameplay with skill tests, exploration, constraint and the secondary functions then include familiarity, allusion and atmosphere. The use of a direct replication of an iconic city is firstly familiarity and allusion along with atmosphere specific to the location. The primary function then has to adapt to this environment, as in this case with the traffic balancing in order to keep the flow of gameplay within exploration and skill tests.

The replication of a city structure was discussed as having cultural implications for those players unfamiliar with the structure of the city. This was not just about a lack of primary experience of the city but that players might find the underlying structure alien to them if they may be used to a city laid out on a grid structure.



Figure 10: The game map of London distributed with *The Getaway*

London has a historically evolved street structure with little in the way of regular grids as can be seen by the map of the game in figure 7. If a player from another culture were to find navigating this environment confusing in the manner a tourist might upon visiting London then this might affect sales.

Table 5: The Getaway sales figures

Region	Total Units	
North America:	1.23m	34.6%
Europe:	1.77m	50.1%
Japan:	0.05m	1.4%
Rest of the World:	0.49m	13.9%
Global	3.54m	

www.vgchartz.com/game/2382/the-getaway/

The sales figures for *The Getaway* indicate a European preference having sold more in Europe than other regions. It is listed at VGsales as having sold over 600,000 copies in the UK, which is nearly a third of all European sales. This is by no means a positive identification of cultural preference as there are other navigation indicators in the game narrative.

The user built version of London in *Second Life* offers a combination of iconic architecture and formulaic architectural forms to try to assemble a representation of London. It is not a direct simulation but a representation of a group of individual designers' visual thoughts of London as a cultural locale. This interpretation of London is more interesting from a design research direction as it is the interpretation by individuals demonstrating a perceived notion of place rather than an exact geometrical representation, as with *The Getaway*.



Figure 11: Buildings from the user built London in *Second Life*

The use of iconic forms or architectural styles derived from the most common elements used within real life locales offer environment designers formulas for the construction of architecture, evoking player's limited knowledge of particular cultural locales. These are essentially an aesthetic myth, as described by Barthes (1993), and not real world knowledge but the hyper-real knowledge of a cultural aesthetic. The design rules for an aesthetic myth offer the possibility of a common cultural interpretation of an environment. As opposed to a direct replication that may not be recognised as truthful by players who have never visited the real world location.

Barthes discusses the concept of architectural grammar within *Mythologies* (Barthes, 1993). His theories of semiology and myth discuss Basque architecture as a unity of style that can be recognised when seen in their original context within the Basque country. It is when seen out of context, for Barthes this is the Basque house in Paris, that the simplification of an architectural style becomes an amplification of the mythology of the form that may be then critically analysed. This mythology of the form equates to the idea of reading the architectural text but takes the concept forward. It considers that the text or myth may not be true to historical fact but may now be of a larger cultural concept. This is signified by many objects in a manner that is highly relevant to game design and this study.

The use of iconic form or architectural style derived from the most common elements used within a real life locale, offers the digital designer a formula for the construction of architecture. This may evoke player's tacit knowledge of the myth as described by Barthes and not the real world knowledge but the hyper real knowledge of a cultural aesthetic.

These aesthetic formulas are evident in both professionally built environments and those created by amateurs, where the amplification of certain elements such as geometrical shapes or the aesthetic textures applied to the shapes, create a stylised hyperrealist environment. Figure 9 shows a building from *World of Warcraft* aesthetically styled to be recognisable as a human medieval house. Figure 10 shows the area called Caledon in *Second Life* where users must meet the steam punk Victorian aesthetic enforced by other users if they are to be allowed to build in that area of *Second Life*.

In *Second Life* an area described as Chinatown, figure 11, uses iconic architectural elements to construct virtual architecture representative of historical Chinese forms but they appear formulaic and lack cultural context when compared to real world structures that now sit alongside modern architecture offering a context of time and history.



Figure 12: A human dwelling in *World of Warcraft*



Figure 13: A user built house in Caledon a designated area in *Second Life*

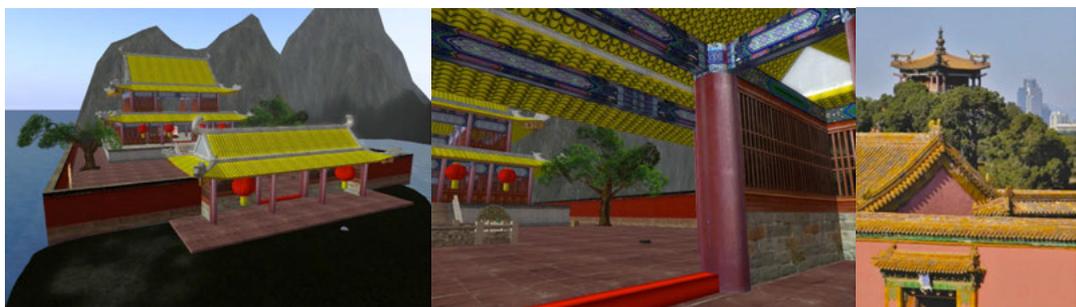


Figure 14: Chinese buildings replicated in *Second Life* and a photo of the rooftops of the Forbidden Palace in Beijing

In *Assassins Creed* (2008) the mediaeval architecture of Jerusalem offers a highly detailed aesthetic that the player interacts with in very close proximity. This is while climbing up buildings and using rooftops to traverse the large virtual environments. A criticism levelled at the game is the repetitive nature of the gameplay and this is also reflected in the environmental architecture. Common elements are repeated when viewing the city from a high enough viewpoint, unfortunately a common element of the gameplay. The environment when viewed in close proximity demonstrates a historical element used by the game designers to enable gameplay features but also remediated for the gameplay function. Mediaeval masonry was often covered with putlog holes where scaffolding would have been supported, these consist of square gaps left between blocks and can still be seen today. Game designers in *Assassins Creed* have remediated these into decorative forms and used them as part of architectural aesthetics that while appearing to reside comfortably within the virtual architecture are now of little use for their original function. Where the environment does contain scaffold there appears to be no evidence of the use of putlog holes and where there are putlog holes the player cannot use them when climbing.

This is a preliminary examination of the transfer of real world elements into game worlds. User built environments and professional built environments demonstrate repetitions in the geometry that break the narrative a player engages with. According to Adams the narrative is a secondary principle, but this makes analysing the geometry that dictates the primary function, difficult to establish. Narrative is a secondary function as narrative can make an environment welcoming but geometry has a primary function that means it can prevent the player from entering a welcoming area.

4.2.5 Architecture as Narrative

Mythology and formulaic architecture are commonly used in game environments wishing to set up a narrative and evoke particular tacit knowledge from a player. *Republic: The Revolution* (Elixir Studios, 2003) was set in an imaginary post revolutionary Russian state and developed by a UK developer. The aesthetic environmental style copies intrinsic features of Eastern European architecture in an attempt to elicit authoritarian, Eastern European contexts. *Half Life 2* (Valve Corporation, 2004b) deals with an Orwellian 1984 environment and again uses an

Eastern European architectural style but with an aesthetic of deterioration and economic hardship to set the scene for the gameplay. This proves to be more effective because of the use of constrained viewpoints and a lack of large cityscapes to break engagement.

The producers of the game are a Western company, Valve Corporation, based in Seattle and use both standard retail distribution and a bespoke digital distribution method called Steam to retail the game. As of December 2008 over 6.5 million copies of *Half Life 2* had been sold through standard retail and though digital sales figures were not announced it is known that digital sales surpassed retail outlet sales in 2008. The figures sold outside of Western markets are not published. Due to its digital distribution overcoming physical and cultural barriers this game offers interesting aspects, as it is also the originator of the *Counter-Strike* mod used extensively in the later stages of this study.

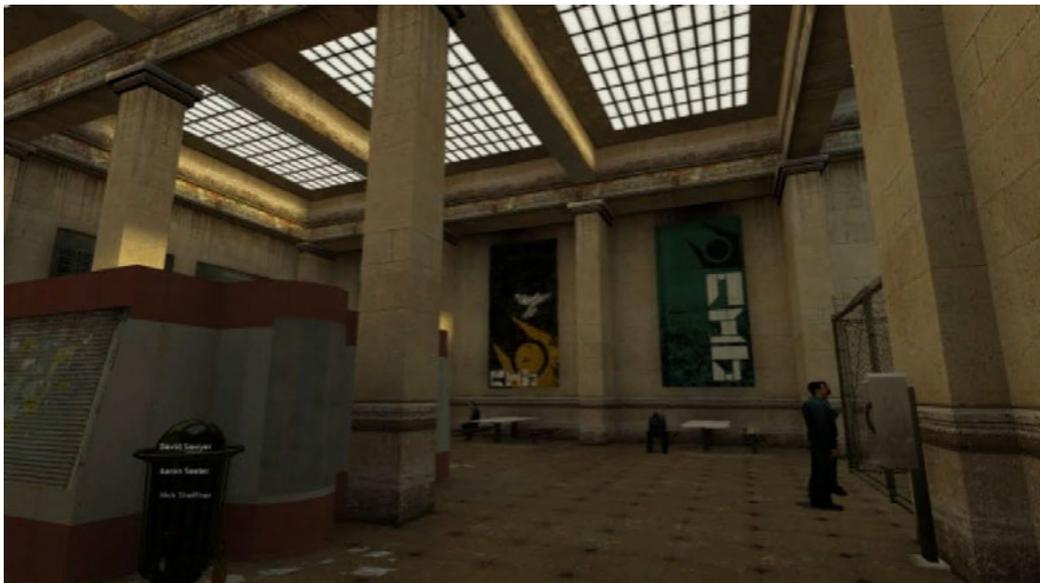


Figure 15: *Half Life 2* the station, the first environment the player encounters

The player introduction to *Half Life 2* uses the format of arriving by train to introduce the environment and the narrative. An effective use of environment and experiential knowledge understanding a player may feel disoriented in an environment they have never visited yet. It offers a real world connection to reassure the player they can find their own way, as if they were on a real world travel experience. The use of shabby soviet style architecture to set the foreign context offers another familiar experiential message establishing narrative context.



Figure 16: Caledon in *Second Life*

Caledon is an example of a consistent, self-governing, narrative within an area of *Second Life* where rules dictate behavioural and aesthetic codes of practice. The architectural forms relate to a neo Victorian, 19th Century aesthetic based loosely around the steam punk movement. The themed architecture is crucial to the narrative of the environment.



Figure 17: London in *Second Life*

Second Life London fails to offer a consistent narrative as it is poorly observed and key landmarks, such as Big Ben, may be efficiently modelled the narrative breaks up in the details such as cars and other objects that are immediately recognisable as out of context. Their form offers American signifiers more powerful than those related to London.

When dealing with a virtual game world of completely fictional constructs the narrative within the architecture is not that of layers of society and cultural significance, as it has no exact real world context to connect experiential knowledge to. This narrative becomes a form of myth, as described by Barthes, that of the constructed narrative from

the forms and their significance that surround the player. This changes depending on the forms that surround the player and is therefore subject to cultural differences.

Myth is a second order semiotic system constructed from first order signs. An individual sign consists of the sign and its component parts the signifier and the signified but myth is composed of multiple signs that become themselves signifiers of the myth.

The myth of a game such as *World of Warcraft* is created through the environment design and every virtual creation from buildings, objects and landscapes must build the myth to the level of instant empathy for the player.



Figure 18: The city of Ogrimmar in *World of Warcraft*

Ogrimmar in *World of Warcraft* is a major Horde city built by fictional races so the architecture is required to reinforce the sense of history and context of players who have chosen to live in the game world as members of these races.

The use of rough timber, large stone block, rope and defensive spikes of either timber or animal origin offer a transitory aesthetic of semi permanence, the invading horde that has built an encampment now turned into a city of sorts.

The buildings within Ogrimmar appear distorted and have a cartoon perspective to their geometry taken to an extreme of both form and aesthetic. Textures are almost abstract with minimal reflection of appropriate scale. Function is not foremost in the mind of the Ogrimmar architect, floor space at ground level would be minimal compared to the first floor and then reduced again above in a form built with extreme aesthetic in mind. Ogrimmar is built holistically, not as individual components, with architectural grammar utilised to abstraction.



Figure 19: A building in Ogrimmar

The human races within *World of Warcraft* demonstrate a more recognisable form to their architecture with form and function representative of real world similarities. Farms offer traditional buildings such as barns and within structures areas such as kitchens and dining areas are clearly delineated even though the virtual player has no use for them.

The aesthetic is not as distorted as with the structures of non-human races but is also not a direct real world representation looking more like a fairy tale stylised form of architecture in the manner of Barthes's Basque house in the middle of Paris.



Figure 20: Human dwellings in *World of Warcraft*

Within *World of Warcraft* there is the crucial mix of ancient history that aids in the narrative led gameplay of quests and treasure hunts. The player regularly encounters the remnants of other races still living within the ruins of their cities and temples hidden within pockets of the landscape for the intrepid adventurer to discover. These areas are

used to signify the myth of *World of Warcraft*, the artificial history of a fictional world the player must empathise with if they are to engage with the narrative led gameplay.



Figure 21: A ruined temple in *World of Warcraft*

The architecture of encountered ruins do not play much more of a function for the player than signifiers of historical remains and landmarks for way finding. The form of the ruins often resemble the ruins of real world Mediterranean civilisations, drawing on the players tacit knowledge of real world history and associating a deeper level of myth to the digital environment.

World of Warcraft has seen considerable success in China and Asian countries and offers possible insights into multicultural gameplay mechanics. The completeness of the myth within massive environments though means it is difficult to see how to analyse primary and secondary architectural game functions to establish what might make this game so popular across cultures.

4.4 Conclusion on Architecture in Virtual Environments

A primary function of game architecture is to establish gameplay with skill tests, exploration, constraint, and the secondary functions that include familiarity, allusion and atmosphere. The use of a direct replication of an iconic city is firstly for familiarity and allusion along with atmosphere specific to the location. The primary function then has to adapt to this environment as the secondary function is prioritised.

Analysing environments that are constructed using an aesthetic formula based on real world elements, then reinterpreted to fit gameplay specifications requires a consistent methodology to reduce it to its component parts. The component parts consist of the geometry and its narrative shape, primary function influencing player movement, narrative textures applied to it, and other secondary functions alluding to familiarity.

The visual field experienced by the player is a 2D image on a screen of a 3D form visible from the player location. This frames the geometry and the narrative through the decisions of the player, but overarched by the design decisions on the environment structure. A method for the deconstruction and comparison of the elements that form the field of view from locations in the environment is required in understanding the influence of geometry or narrative on gameplay decision-making.

In conclusion a method is required to separate geometry from the narrative texture in analysing an element of an environment and also to analyse the overall structure of the environment geometry. The field of spatial analysis based on early work by Lynch (Lynch, 1960) and the academic field of Space Syntax both consider how people make way-finding decisions in urban environments and offer a way forward to build this method.

Chapter 5: Space Syntax as a Method

In this chapter space syntax methods and relevant metrics will be discussed for their applicability to inform game design and indicate where cultural differences occur in the spatial design of game spaces.

First the isovist and its relevant metrics will be considered, then the visibility graph analysis (VGA) is discussed. For each of these the graph theory and maths behind the metric is also discussed. This is important as it allows the discussion of its implementation into game design methodologies and practical implementations.

Two slightly different control maps are used to apply the method to and consider how each metric visually informs the designer of small changes across a game environment.

The consideration of how to process game environments is discussed in section 5.5.

Lastly as this method is not usually used to compare multiple environments a known issue with the scale of the VGA is tested to ensure the validity of future results.

5.1 Space Syntax as a Method to Analyse Game Worlds

In order to understand how a player interprets game environments representative of real world environments, research into how a person interprets real world environments is a logical step. The transfer of basic spatial experiential knowledge means cognitive maps used for way finding in the real world can be assumed to be used in the game world that is representative of a real world environment. Research in the subject areas of architecture and the built environment has established methods, through the work of Lynch (1960) and his theory of imageability, that helps to understand these cognitive maps. This has been noted as discussed by game design theorists (Adams, 2002) (Nitsche, 2009).

Exploring the influence of the visual field upon the navigation of an environment breaks environments up into quantifiable spaces based on the field of view of the player and not individual architectural structures.

Initial investigations of architectural forms in virtual environments correlate with Lynch's interpretations of how to read the image of a city. Virtual environments contain the same elements; paths, edges, districts, nodes and landmarks as do real environments.

Professional game design uses many of the elements observed by Lynch to contain and direct players around an environment, as they are the features in the real environment being replicated. Key elements such as landmarks are used in amateur environments as again these correlate strongly to the experiential knowledge of a real world environment.



Figure 22: The use of landmarks by amateur users in *Second Life* and professional designers in *Half-Life 2*.

This correlation of Lynch's criteria for reading an environment with the virtual environments examined in this study makes sense when considering Lynch has identified the most important elements a person uses consciously or subconsciously while navigating an environment. These will be the elements both a professional or amateur designer will at some point focus on when recreating a real world environment in a virtual world.

Theories set out by Lynch are explored in the paper *The syntactical image of the city: A reciprocal definition of spatial elements and spatial syntaxes* (Conroy-Dalton and Bafna, 2003). This examines the relationship of city elements defined by Lynch and spatial descriptors used by space syntax research. Discussed in more detail in section 2.3 the conclusion was the relationship is such that space syntax is an underlying structure present whether Lynch's indicators are present or not.

Earlier space syntax research by Conroy-Dalton in her PhD thesis *Spatial Navigation in Immersive Virtual Environments* (Conroy, 2001) concluded movements in virtual environments can be considered to be equivalent to movements in real environments in order to further space syntax research using virtual environments.

Space syntax is a set of theories and methodologies concerning the social use of space based on the work of Hillier and Hanson at University College London in the mid 1970's (Hillier and Hanson, 1989). It has become a recognised technique for urban analysis and quantifying the interrelationship between the built environment and social use. It has been used to correlate pedestrian movements and a range of other social activities with environment configuration and has progressed to be used as a simulation framework to support the work of architects and designers.

To build a methodology for this study of real world knowledge influencing player and design decisions for virtual environments it can be stated that:

- Lynch's theories are recognised as relevant to game design.
- Space syntax underlies Lynch's theories of imageability.
- Space syntax is indicative of people's movements through environments.
- Virtual environments are valid for exploration of space syntax practice.

From this line of reckoning it can be hypothesised that the investigation of how player movements in game environments, as influenced by experiential knowledge from the real world, could be informed through space syntax as:

- Chosen game worlds are virtual environments based on real world parameters.
- Players use their experiential knowledge of the real world to make movement decisions.
- Space syntax uses and predicts the movement of people in virtual worlds correlating with the behaviour of people in the real world to inform the design of real world design environments.

Therefore space syntax can inform the design of game worlds based on real world environments and the consideration of how players navigate within them.

This area of spatial analysis developed from initial topological measures of lines of sight to the examination of the space between buildings, the holistic space the user interprets. Importantly it is not the individual architectural structures that form the space. This directly links to game design as game environments are constructed as one

space, and not as in the real world a series of buildings built over a period of time to create a space.

Space syntax has developed various parameters to anticipate the interpretation of space and how a user navigates through it. These are not accepted without question and the arguments for these must be considered (Ratti, 2004). Though first the discussion of imageability and intelligibility linking Lynch and space syntax will be discussed further.

In conclusion space syntax parameters applied to virtual environments offers this study a possible method for the comparative analysis of corresponding real world and virtual environments. This can lead to an understanding of the geometry that creates the aesthetic myths used by designers through the use of spatial parameters for the interpretation of that geometry independent of narrative textures.

This deconstruction of environments can determine through comparative studies any elements of cultural interpretation in the design of environments. As space syntax is used to interpret how people move through real world environments this enables direct comparison of game environments and a player's real world way finding skills also enabling cultural differences to be compared.

This study was given access to the *Depthmap* (2009) software, first developed by Alasdair Turner in 1998 at University College London within their Space Syntax Laboratory. This facilitates a range of spatial methodologies including axial lines, isovists and visibility graph analysis. The requirements in order to choose methodologies were the application to game design, the ability to quantify real world and game environments and the application to human behaviour and cultural investigation. In these first explorations with space syntax measures the methodologies chosen as most appropriate for application to game design were isovists and visibility graph analysis. These are now explained in more detail with reference to game design and this study's aims.

5.2 The Isovist as Applied to Games

The initial Space Syntax measure that offers the most potential to inform the design process is the isovist. An isovist is a polygon forming the player's viewfield within an environment, and so directly correlates to the image a player sees on screen. This offers the possibility of understanding the transformation of 3D structures into 2D images. Isovists are calculated by creating a 2D polygon of the visible area from a single location, which may then be used to calculate individual isovist properties.

Isovist theory quantifies the view field formed by the geometry of a virtual environment from a particular point in that environment. As it is measuring the space the geometry forms this enables the separation of the geometry from textural aesthetic. It is therefore a controlled method of establishing the influence of geometry as a component of the virtual environment.

In Figure 23 the position of player 1 demonstrates a complicated isovist viewfield, marked in green, with occluded edges in red. Player 1 is unaware of player 2 within the arena as player 2 is not within the isovist but the occluded edge of the isovist means player 2 can step out into the viewfield thus posing a threat to player 1.

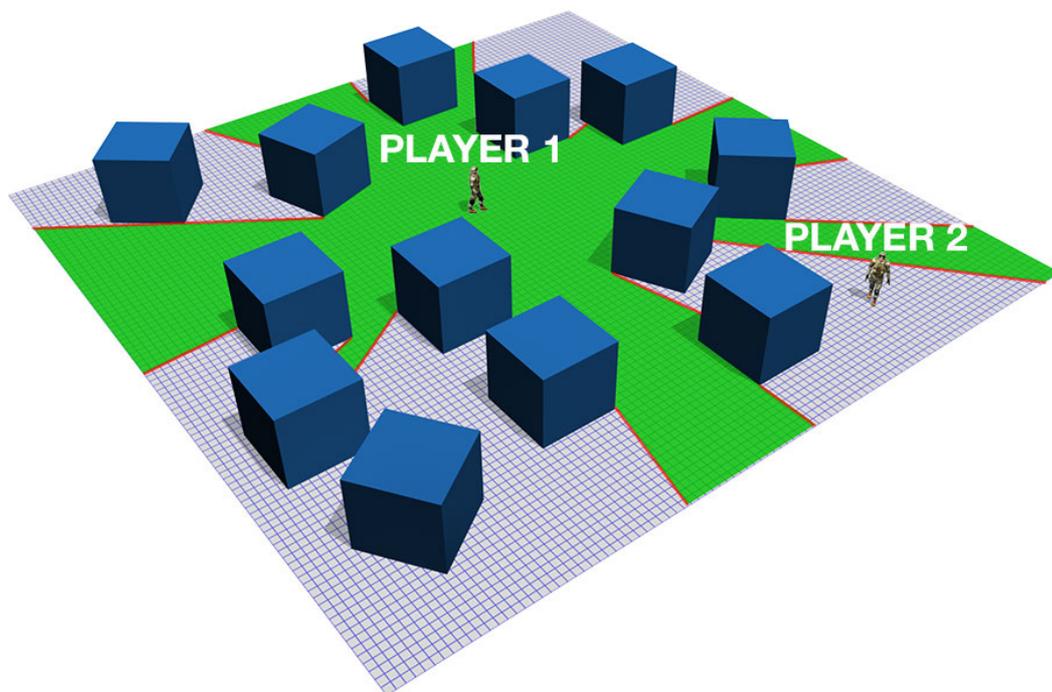


Figure 23: A player isovist

The analysis of isovist properties has been proven to predict the movement patterns of people through indoor environments (Turner and Penn, 2002) and outdoor environments by using virtual environments (Meilinger et al., 2009). In virtual environments isovist properties have been proven to be recognised by users in determining routes, and the most exposed or secluded locations in an environment (Conroy, 2001), (Wiener et al., 2007).

Although isovists are an abstract geometrical abstraction, recent research has shown that isovists are correlated with spatial behaviour and affective responses to indoor spaces (Meilinger et al., 2009)

In figure 2, player 1 will recognise that there are occluded edges to their field of view, the isovist, and depending on the form of gameplay anticipate that this may mean danger or a possible direction for investigation.

Isovists have been proven to correlate with human way finding and behaviours in real environments, simulated real environments and purely virtual worlds. Therefore it can be said they have characteristics that can inform the design and analysis of gameplay and game environments based on real world environments.

When real world environments are transferred into game environments isovists offer a methodology to compare, interpret and quantify the space in both the real world and the game space. They enable the measurement of existing game spaces to explore and compare the current properties of game environments. These measurements can then enable the investigation of cultural differences in order to inform the design of future environments.

Depthmap calculates the isovist properties for any point within an environment and the value for isovists across a grid applied to the whole environment. Initial properties considered as having design significance are the isovist area, perimeter, occlusivity, compactness and maximum radial. Using *Depthmap* the average, median, maximum minimum and standard deviation of these properties for a grid of isovist points across the whole environment can be calculated. These isovist properties offer metrics in order to discuss primary level game architecture (Adams, 2002) and narrow, intimate and prospect space (Totten, 2011) as discussed in Section 4.1.3 Games and Architectural Theory.

5.2.1 Isovist Area

The area of an isovist relates to the size of the visible area from a single observation point. If an environment consists of a number of large open spaces then the mean area across the environment will be high compared to those consisting of small confined spaces. Discussed in terms of primary level architecture in games, large isovist areas may be dangerous or may offer levels of player control. The measurement of these areas may offer an understanding of balance across a game environment.

If an individual isovist is considered then the nature of the area measurement is relatively indicative of the effect on gameplay, as its size is obvious. The shape of the isovist area is not and so this metric must be correlated with other metrics in order to determine how shape might affect a player's interpretation of the isovist area. Measuring isovist area across an environment will give some indication of the environment if the statistical analysis ensures consideration of the spread of the data and correlates this with data for the shape of isovists.

5.2.2 Isovist Perimeter

This is the length of the isovist perimeter. If a player has to watch the perimeter of their viewfield in order to determine gameplay actions then the greater the perimeter the harder it is to watch. This is proportional to the area of the isovist as the perimeter becomes easier to watch if the player positions themselves further back from it so they can hold a larger section of perimeter within their field of view.

Therefore measuring across an environment offers a metric to consider how hard it is for players to control areas within the environment if correlated with other isovist shape metrics.

5.2.3 Isovist Occlusivity

This is a measure of how much of an isovist perimeter is occluded as opposed to a fixed boundary, such as a wall. This means there is a space that can be entered from for that occluded section of the perimeter that cannot be viewed from the player's position. If something can enter a player's viewfield from an occluded area it means it is necessary to watch that portion of the viewfield. This makes the player position harder to control as the perimeter becomes more complicated to observe as occlusion increases.

Measured across an environment this offers an understanding of how complex an environment is for the player to be able to control and interpret their viewfield. Correlated with perimeter and area this metric begins to indicate how complex viewfields might be for players within that environment.

5.2.4 Isovist Maximum Radial

This measure is the maximum distance to the perimeter of the isovist polygon determined from the viewpoint. Maximum distances for isovists across the environment offer an understanding of the largest and smallest view distances within the environment. Gameplay decisions can often be made based on a position that offers long lines of sight. Landmarks for navigation need to ensure there are positions with long lines of sight in order to see them. In studies using virtual environments Wiener states that, “With respect to movement decisions, participants reliably chose the option that featured the longest line of sight.” (Wiener et al., 2011)

5.2.5 Isovist Compactness also known as Circularity

This is a measurement of how convex or concave, or alternatively how detailed or jagged the isovist perimeter shape is. It is calculated as:

$$\frac{4 \times \pi \times \text{area}}{\text{perimeter}^2}$$

This gives a mathematical measure of the concavity of the polygon and has been determined to perceive the complexity of polygon perimeters. Circles have the greatest area to perimeter ratio and will give a value approaching 1, squares are around 0.78, spikier or jagged isovists are lower values.

For a player with a complex, jagged, perimeter as their viewfield it means that a range of distances may be involved when viewing that perimeter making it more difficult to watch and to take longer to make way-finding decisions.

Compactness has been correlated with navigational performance and Wiener states:

The basic initial hypothesis that isovists capture behaviourally relevant environmental properties was supported by the result that the isovist measure jaggedness was strongly negatively correlated with navigation performance...

...Pointing in the same direction, the results of the rating tasks showed positive correlations between jaggedness and rated complexity, and negative correlations between jaggedness and clarity...

...In a spatial context, jaggedness may additionally characterize configurational complexity, leading to an increased task difficulty, which may implicate a negative influence on navigation performance. (Wiener et al., 2007)

This would imply that if a group of players were less able to deal with screen based complexity then they would be disadvantaged in navigational tasks. This is too simplistic a correlation with cultural differences and the cognitive interpretation of the 2D image of a game environment, but it does offer a starting point. Compactness gives a measure of the complexity of an environment and for cultures that interpret complexity differently, as with Eastern and Western cognitive approaches, this could indicate areas of cultural design differences within the design and interpretation of 3D game environments.

5.2.6 Isovists in a Game Environment

In a game environment these isovist properties can be interpreted alongside each other to offer statistical interpretations valuable to analysing and designing gameplay spaces.

A large area with a high occlusion and a jagged perimeter means that an opposing player may enter the area from a large proportion of a visually complicated perimeter. This is not a safe area to wait in, although if this area is then given an object that may offer a player some form of protection it becomes a tactically important area.

Isovist data is useful for singular locations in a game environment giving clear statistical indicators to the designer of the spatial and therefore gameplay characteristics of a point within the game environment. This can prove useful when designing key areas in an environment such as player starting points, game goals and bonus areas where a designer may balance the benefit of a bonus against the risk of entering the area.

Figure 25 shows in-game screen shots of a player's viewfield with occluded edges indicated in red. The compactness of the viewfield and the level of occlusion can vary greatly in game spaces dependent on the geometry. This may require the player to focus across the screen or in the centre of the screen as shown in Figure 25. Occlusions in these images are both vertical and horizontal edges so this has to be considered within

the deconstruction of environments. The 2D isovist indicates a slice through the three dimensional environment but this slice can be resolved at eye level to consider lines of sight or at knee level to consider lines of movement.

The vertically occluded edges in Figure 25 indicate areas of the screen an opposing player might enter the field of view from. These vertical edges correspond with the points on the perimeter of an isovist polygon and therefore the polygons compactness. The edges also correspond to where changes in the screen may occur as an opposing player enters the field of view. As stated in section 3.3.3 East Asians are better than Americans at detecting colour changes over a wider screen region but are slower at detecting changes in the centre of the screen (Boduroglu et al., 2009). Isovist compactness and occlusion offer measures to compare where changes in the screen can occur as they indicate how complex the viewfield might be for the player to observe.

In Section 4.1.2 the findings by Miyamoto et al (2006) examined the holistic and analytic perceptual affordances of real world environments and concluded that Japanese scenes contained more elements than American scenes and that “culturally characteristic environments may afford distinctive patterns of perception”. The isovist in a Japanese scene would be expected to be more compact than that in an American scene due to the increased number of elements it contains.

Isovist measures can be said to indicate the complexity of the viewfield across the screen and of the elements in the viewfield as they break up the perimeter of the isovist and affect the measures of compactness and occlusion. Isovists therefore offer the chance to analyse game environments for distinctive patterns of perception that may determine culturally characteristic environments.

Figure 24 demonstrates how the values of the isovist viewfield for a player change as they move across the gamespace shown previously in Figure 23. The perimeter value of the isovist associated to the player’s location does not change significantly while the area and compactness changes by over 30%. The player would therefore be trying to watch the same perimeter size as the viewfield increases in complexity and area as the player moves through the gamespace.

A single isovist only offers the interpretation of the environment at a single location. As players move around game environments encountering constantly changing values the

spatial values across the environment are required. This issue is resolved through the application of visibility graph analysis (VGA) enabling the calculation of isovist values across a grid within the game environment.

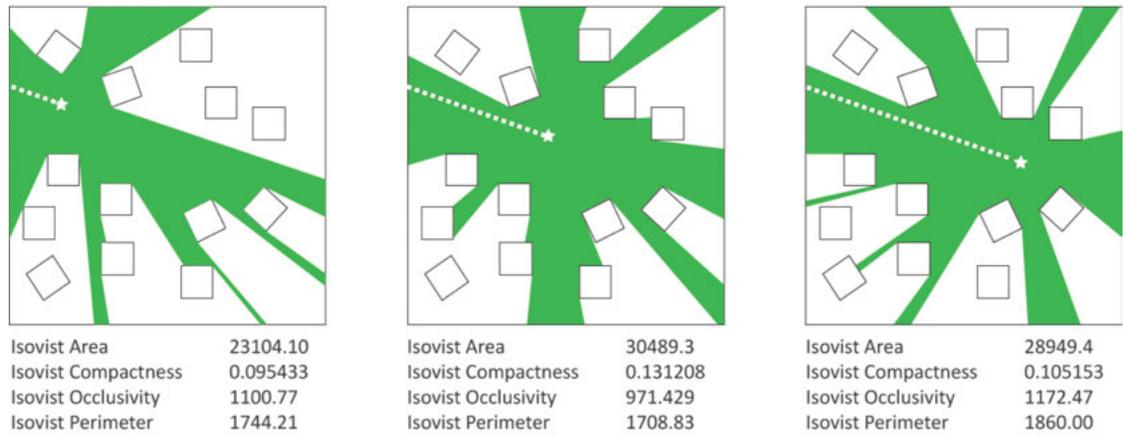


Figure 24: Isovist characteristics changing as the player moves through the environment



Figure 25: Screen shots indicating occluded edges in red

5.3 Visibility Graph Analysis (VGA) as Applied to Games

A development in Space Syntax theory was the introduction of Visibility Graph Analysis (VGA) where a space is effectively filled with a grid of points and the visual relationships of each point to other points within the space can be analysed. Statistical analysis of areas and comparisons of environmental characteristics then becomes possible. The use of multiple points in a regular pattern across an environment enables the consideration of the global properties of the whole environment as opposed to the individual isovist properties at a single location. Therefore environments may be statistically compared in order to inform design and possible cultural idiosyncrasies.

These points are not isovist points, although *Depthmap* can produce an isovist calculation for each point that is used in this study, the points are a grid with which to examine visual relationships between the points.

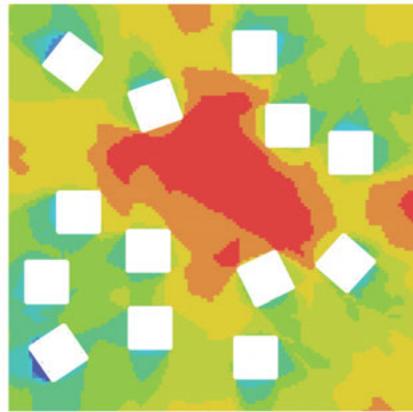
Way-finding algorithms using the visual field information contained in the VGA for an environment have been proven to accurately estimate human movement patterns through the space (Conroy, 2001). This offers further possibilities for game design to run analysis on environments in order to look for the transfer of a player's way-finding knowledge from real environments.

... the outcomes of this study suggest that isovist and visibility graph analysis, analysing space from an inside beholder-centred perspective, provide generic descriptions of architectural spaces that have predictive power for subjects' spatial experience and behaviour (Wiener and Franz, 2005)

This way-finding correlation provides methods for testing game environments that may prove beneficial to environment designers in the games industry who previously have relied on periods of player testing for game environments.

... so visibility graph analysis may represent a step towards exploring the relationship between architects, as designers of spaces, and users, as architects of their own experience of space. (Turner et al., 2001)

The development of visibility graph analysis (VGA) builds on the understanding of isovists and applies it to points across an environment creating values for the connections between those points. This visibility graph establishes how many other points can be seen from each point on a grid. The values are represented in the grid by a colour revealing a pattern of visual relationships across the space that means there is a visual indicator of areas of interest to a game designer.



Visual Integration	
Average	0.522385
Minimum	0.477628
Maximum	0.543131
Std Dev	0.010545

Figure 26: Visual Integration

The VGA enables the comparison of global characteristics of environments by both quantitative values and through the visual interpretation of the VGA values. A statistical property visual integration can be calculated on the shortest number of turns the number of visual steps or by distance to any other point in the environment. A visual graph of this is shown in Figure 26.

Initially the connectivity of all the points in the environment is calculated as described and this is then used to produce a range of visual based metrics for the space. The calculation of global measures analyses the relationship of one point to all the other points in the environment. This can be used to calculate a range of statistics based on the depth of a point within the graph. Metrics such as visual integration can then specify parameters such as the number of visual steps, the turns a player may need to make, or a metric distance for the navigation from one point to other points in the environment.

Calculating the visual integration values of an environment using the number of turns as an analytical property equates with the nature of a FPS game environment, where distance is often not considered by a player, as their in-game speed is not realistic. In a fast paced game a player may make the minimum number of turns while moving quickly around an environment working with their immediate visual field. The visual integration property may indicate within a game environment the areas that a player, moving quickly around a map and using minimum turns, is most likely to move through and keep returning to. This would also then indicate an area where players are most likely to encounter each other which in turn informs the design of gameplay in that area.

Local measures are metrics based on the neighbourhood of points a single point can see. This neighbourhood is in effect a set of points that can be treated like an isovist polygon in terms of perimeter and area measurements. The advantage of this is that calculations analysing how many points on the grid can see each other within that neighbourhood/polygon are possible where as an isovist polygon can only calculate this using perimeter points.

In this study the spatial metrics are established using the *Depthmap* software but it is useful to discuss the methodology and the math involved in the VGA process, as it is not as straightforward to implement, as isovist calculation would be within a game engine. While it may be possible in future to implement it directly in a game engine or write plugins for *Depthmap* it also makes clear the underpinning space syntax theory in the next elements of this study.

The discussion of the application of visual graph metrics to game design is considered with each metric. It is too visually complicated to conclude on the benefits at this point and so they are applied to control maps in section 5.4 to offer a more visually comprehensive understanding of their possibilities for the design of game environments.

5.3.1 Constructing a Visibility Graph

Topological graph based analysis is used within the analysis of environments as visibility graphs are based on the exploration of the connections and relationships of a single point in a system to all others.

Figure 27 demonstrates how a system that only discusses nodes, such as Lynch's, would see both shapes as equal as they contain the same number of nodes and links between nodes. When lines of sight are considered the system on the right now has three more lines of sight than the system on the left as a long line of sight has been broken up. This then changes the mean depth of the system indicating a difference in the two systems.

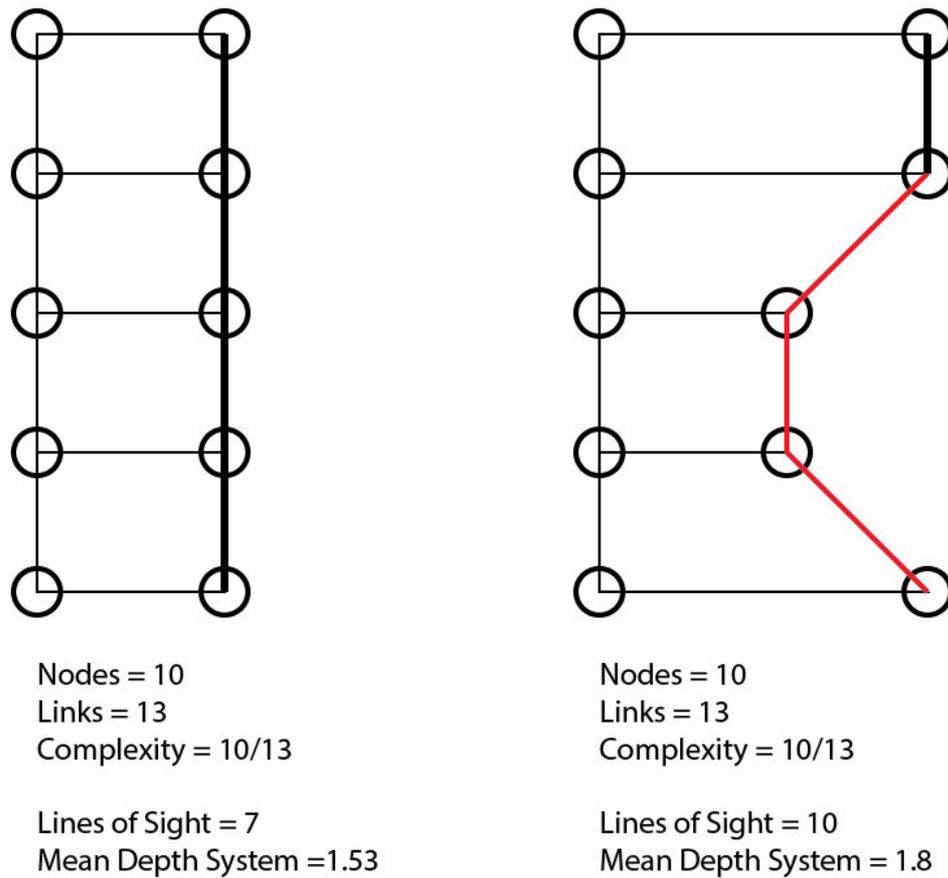


Figure 27: Graph based analysis

To define the methodology graph based analysis systems require the nodes in the graph and the lines of sight that connect nodes in order to begin to construct the visibility graph that all other metrics are based on.

The space syntax community has released many papers discussing the theory and the calculations for visibility graph analysis. While an environment designer will not need to understand the maths it is useful to set it out in this study with each metric used as it is now being applied to a new academic field, that of games design, with a slightly different remit.

Of the many papers and books on Space Syntax essentials to begin to understand the philosophical and mathematical perspectives were *The Social Logic of Space* (Hillier and Hanson, 1989), *Space is the Machine* (Hillier, 2007). The work of Alisdair Turner is incredibly helpful with a range of papers discussing isovist theory and visibility graph analysis and its implementation in *Depthmap*. As a designer and not a mathematician

the logical steps of these authors makes it thought provoking from a design perspective and educational in terms of mathematics. The paper *The Mathematics of Spatial Configuration: Revisiting, Revising and Critiquing Justified Plan Graph Theory* (Ostwald, 2011) is a good starting point to dive straight into the mathematics and an up to date context of the work in this field.

In mathematical terms the graph that is applied across the environment, graph G , consists of two sets: the set of the vertices in the graph, labelled $V(G)$, and the set of edges connecting pairs of vertices, labelled $E(G)$. This information is summarised by writing the graph as the pair of these sets: $G(V, E)$.

The visibility graph is a grid of vertices imposed upon the environment representing the locations where visual measures will be generated from so the set of vertices is:

$$V = \{v_1, v_2, v_3, \dots, v_n\}.$$

Edges are pairs of mutually visible vertices so an edge joining v_1 and v_2 can be written as $\{v_1, v_2\}$, or as e_{12} . Therefore the set of edges is:

$$E = \{e_{12}, e_{23}, \dots, e_{ij}\}, \text{ where } e_{ij} \Leftrightarrow e_{ji}.$$

On a 2D plane, the graph edges are undirected (that is, if v_1 can see v_2 , then v_2 can see v_1). Edges in graphs may be directed if dealing with multiple levels in an environment through the use of sub graphs to differentiate between changes in elevation or exits.

This is the first consideration when preparing game environments for analysis, as it is possible for a player to be able to jump down from a ledge but not up to the ledge yet the ledge can be seen from below. Initially this study deals with undirected edges and the consideration of directed edges are considered when preparing an environment for analysis. Once a greater understanding of implementation methods has been reached it will be possible to advance this issue.

Once the graph has been implemented a visibility graph can be stored as a list of vertices and characteristics for each vertex beginning with the list of vertices visible to every other vertex.

Depthmap does not store $E(G)$, the set of all edges or visibility connections in the graph, but works from the set of neighbourhood vertices for each vertex in the graph $V(G_i)$.

This keeps processing to a minimum rather than storing the connections for every vertex in the system and is worth noting if this is to be implemented in a game engine.

5.3.2 The Neighbourhood

The neighbourhood of a vertex is the set of vertices immediately connected to that vertex, those sharing an edge. Using graph notation the neighbourhood N_i of a location v_i is those directly visible written as the set:

$$N_i = \{v_j : e_{ij} \in E\} .$$

It is important to note that the neighbourhood of a vertex does not include itself.

Neighbourhoods are the starting point for further graph analysis and are calculated after flood filling the environment plan with a grid of a suitable scale to pick up appropriate details. The lower the number of vertices in the grid means that the density of vertices in the grid will not be sufficient to capture all the detail in an environment. *Depthmap* gives an indication of an appropriate density when setting the grid but in certain cases this study has been analysing environments of the same scale so the same grid scale has been used across environments.

Turner (Turner, 2001) writes an algorithm for the establishment of the visibility graph, where each vertex v_i will have a set of connected vertices, its neighbourhood written as $V(I_i)$.

```

for  $v_i$  in  $V(G)$ 
begin
  for  $v_j$  in  $V(G)$ 
  begin
    if  $v_i$  'can see'  $v_j$  then add  $v_j$  to  $V(I_i)$ 
  end
end
end

```

This would be a sensible place to consider the mutual visibility of vertices within any graph implementation. The demarcation of sets of vertices as invisible to each other or directional could be implemented after the establishment of the grid and before the visibility graph is initiated.

The number of vertices in a neighbourhood is calculable and is written k_i where:

$$k_i = |V(I_i)| = |\{v_j : \{v_i, v_j\} \in E(G)\}|$$

Each vertex then has the following properties;

- The vertex identity
- The list of its neighbourhood vertex identities.
- The vertex location coordinates within the environment

Taking the value of k_i , the number of vertices in the neighbourhood, for each vertex and applying a colour spectrum to the values across the plan is the first indication of spatial attributes and connectivity in the environment. This measure of connectivity is then the basis for measuring the graph for further spatial relationships.

This neighbourhood for v_i is related to the isovist area for the isovist at location v_i as long as the grid has enough density to capture the detail of the isovist perimeter.

Measurements in the analysis of this graph consist of two measures; global measures considering all the vertices in the graph and local measures, that use only the vertices in their neighbourhood.

5.3.3 Global Measurements: Mean Depth

The mean depth L_i is the average of the number of graph steps used to reach any other vertex in the graph by the shortest number of steps. This is a visual measurement and not a metric measurement and it represents the number of turns required as opposed to the distance involved.

The shortest path from v_i to v_j is the set of unique intervening vertices through line of sight ($v_i, \dots, v_n, \dots, v_j$) consecutively joined to each other by an edge in the graph representing the number of turns (plus one) to get to v_j .

In this relationship the edge has no geographical distance measure as all edges are of equal value as this is counting lines of sight and therefore the number of times the direction of the path from one vertex to another changes direction. The length of the path is the number of edges and the distance d_{ij} is the shortest path. The notation for the mean shortest path is:

$$L_i = \frac{1}{|V|} \sum_j^{v_j \in V} d_{ij}$$

or

$$\text{Mean Depth (MD)} = T/(N-1)$$

Where T=Total Depth and N=number of vertices in the system.

The issue with mean depth is that if comparing environments of different sizes then the difference in the number of vertices in the graph will affect the mean depth so comparison is only possible if environments have a similar number of vertices.

5.3.4 Global Measurements: Visual Integration

Visual integration is the reciprocal of the mean depth for a vertex compared to all other vertices in the system. The mean depth is how deep or shallow the vertex is within the graph compared to how deep or shallow it could be. This measure is also called Relative Asymmetry and it eliminates the effect of the number of vertices in the system.

$$\text{Relative Asymmetry (RA)} = 2(\text{MD}-1)/(N-2)$$

MD = Mean Depth and N = total number of vertices in the system.

The Relative Asymmetry is a normalised value for within a single system but to compare multiple systems, as intended in this study, the number of vertices in the graph for each system may differ so RA requires further normalisation. This further measure is discussed as the Real Relative Asymmetry.

There are three forms of normalisation for visual integration within *Depthmap*, Hillier-Hanson, P-value and Teklenburg and a useful discussion of these in relation to their use in comparing multiple systems is *A Proposed Methodology to Normalise Total Depth Values* (de Arruda Campos and Fong, 2003).

The visual integration metric is calculated as:

$$\text{Real Relative Asymmetry (RRA)} = \text{RA}/D_k$$

or

$$\text{RRA} = \text{RA}/P_k$$

Where k= the relative asymmetry of a diamond shape D, or pyramid shape P, pattern of k spaces, giving the D-value or P-value. These D and P value are measures discussed in the Social Logic of Space (Hillier and Hanson, 1989) to counteract the fact that built

systems do not have constant depth. The recommendation is to use D-value other than when calculating the depth from a large number of roots in a system when P should be used.

In *Depthmap* the D and P values are calculated as

$$D \text{ value} = 2.0 * (N * (\text{math.log}((N + 2.0) / 3.0, 2) - 1.0) + 1.0) / ((N - 1.0) * (N - 2.0))$$

$$P \text{ value} = 2.0 * (N - \text{math.log}(N, 2) - 1.0) / ((N - 1.0) * (N - 2.0))$$

The visual integration measures are then calculated within *Depthmap* as

$$\text{Visual Integration [HH]} = 1.0 / \text{RRA};$$

$$\text{Visual Integration [P]} = 1.0 / (\text{RA} / P)$$

$$\text{Visual Integration [tekl]} = \text{math.log}(0.5 * (N - 2.0)) / \text{math.log}(T - N + 1.0)$$

Where N= number of vertices and T=total depth

According to Campos (de Arruda Campos and Fong, 2003) the D-value while used consistently in certain systems of spatial analysis is not as robust in visibility graph analysis and a P-value is more efficient for correlation across environments. During the analysis of environments Visual Integration [Tekl] values proved statistically significant so a study, discussed in section 5.6, based on the methodology used by de Arruda Campos and Fong was carried out to analyse its reliability for this study.

5.3.5 Global Measurements: Relativised Visual Entropy

Entropy is a measure of order considering the distribution of vertices in the graph in terms of their visual depth from an individual vertex rather than their depth in the system. If a lot of vertices are visually close to an individual vertex then the visual depth from that location is asymmetric and so entropy is low. If the visual depth is more evenly distributed from the vertex then entropy is higher. Relativised entropy takes account of the expected distribution from the node considering that in a normal distribution the number of vertices encountered when moving through the graph would increase up to the mean depth and then decline afterwards.

This measure is useful to the game designer because it can indicate how ordered a system is. It will demarcate areas such as doorways where the number of connected

vertices will suddenly increase if opening out onto a larger space. This can correlate directly to primary level game architecture and forms of prospect and refuge.

The equations for this measure within *Depthmap* are discussed in *Depthmap: A Program to Perform Visibility Graph Analysis* (Turner, 2001) where a detailed mathematical analysis can be found.

5.3.6 Local Measurements: Clustering Coefficient

This is effectively how convex, or alternatively, spiky a neighbourhood is for a vertex. It measures how many vertices within the neighbourhood can see each other against how many are in the neighbourhood. A value of 1 means all vertices can see each other and as the shape of the neighbourhood becomes more concave it approaches 0.

It has been discussed in terms of the analysis of real environments as indicating junctions as these are where neighbourhoods can be very spiky as the visible vertices run off down the different routes. This measure was discussed in Conroy (Conroy, 2001) as points were subjects stopped to make decisions.

Because movement in some sense involves making decisions about which parts of one's current visual information to leave behind, the clustering coefficient is potentially related to the decision making process in way-finding and navigation and certainly marks out key decision points within complex configurations. (Turner et al., 2001)

The consideration that this is an indication of a location in the environment that is linked to decision-making is important to the analysis of environments for cultural indicators. How spiky these areas are, and the balance of them within the overall environment, can give an indication of the complexity of the environment. The analysis of this metric may be used to determine characteristics of the game environment that indicate the detail and complexity of navigating through that game space.

5.3.7 Local Measurements: Visual Control

Visual control is a local measurement but it picks out areas that are visually dominant within the overall grid by comparing the size of the current neighbourhood with the size of the adjoining neighbourhoods. This is calculated by using the reciprocal of the connectivity for each vertex in the neighbourhood. If a vertex is well connected then its reciprocal of connectivity will be small and vice versa. Visual control adds the

reciprocated connectivity values together for the neighbourhood to give the visual control measurement for the vertex.

$$c_i = \frac{k_i}{|\cup V(\Gamma_j) : v_j \in V(\Gamma_i)|}$$

If a location is to be considered as a dominant controlling location then it must have a large visual field where the locations it can see do not have large visual fields. This gives the game designer a clear indicator of where landmarks or other strategic elements for gameplay might be placed.

5.3.8 Local Measurements: Visual Controllability

Visual controllability indicates areas within the grid that may be visually dominated. To calculate it for a location it is the ratio of the total number of vertices up to radius 2 to the connectivity.

5.4 Applying Spatial Metrics to Control Environments

In order to establish how spatial properties can inform the analysis and design of game environments a control environment was processed using *Depthmap* to evaluate the interpretation of data. A common form of gameplay within the FPS genre is the Capture the Flag (CTF) tournament where teams try to steal the flag from the opposing teams base and return it to their base. Flags are at opposing ends of a roughly symmetrical environment in order to ensure balance for the journeys both teams will have to make.

The symmetrical form of this environment is used to compare how the data informs the design of an environment when perfectly symmetrical and when certain environmental objects are moved.

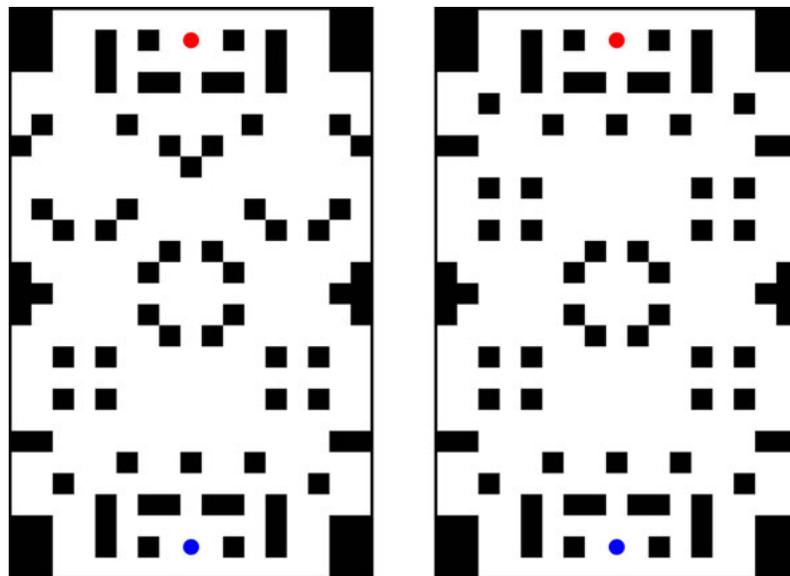


Figure 28: Control maps 1 and 2, symmetrical and asymmetrical designs

In game design a clearly symmetrical map is often not wanted, as it is too simplistic in terms of understanding player movements and anticipating tactics. Moving objects to create the appearance of a realistic environment can mean a visually pleasing design has imbalances in gameplay offering advantages to one team of players.

If these gameplay imbalances can be determined at the design stage before user testing then a more efficient design process can be employed.

5.4.1 Control Maps with Isovist Area

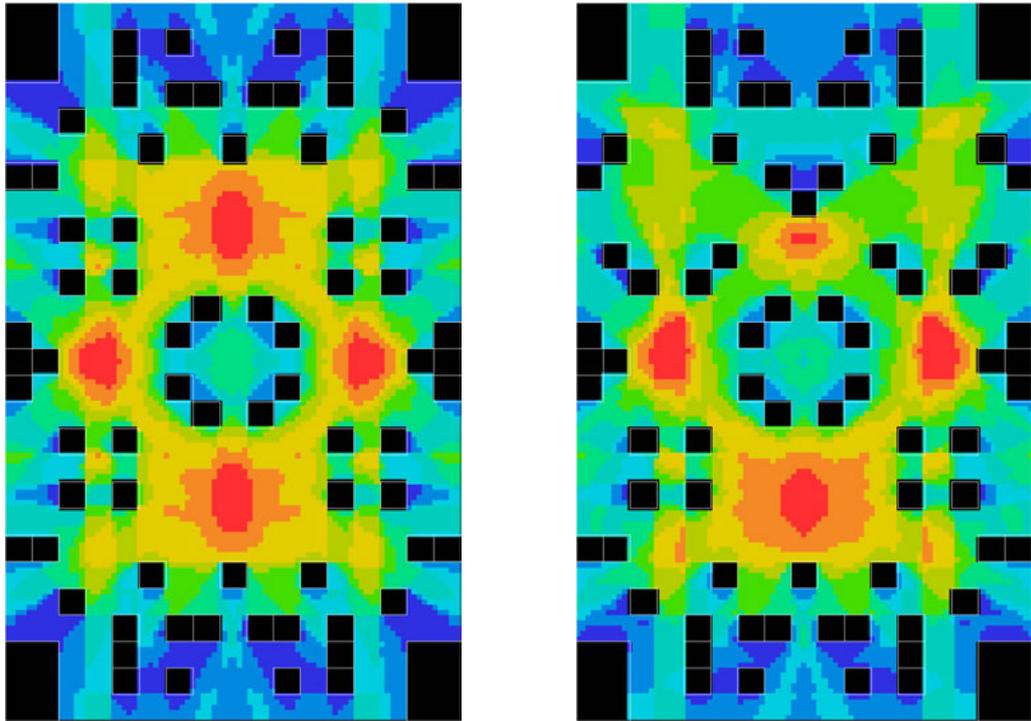


Figure 29: Control maps indicating Isovist Area

Changing the environment layout alters the size of isovist areas for the top half of the environment producing a much less open area clearly indicated by the reduction in high values as demonstrated visually by the size of the red area.

This affects the symmetry of the gameplay, as now the team advancing on the base at the top of the image has to move through an open area much smaller than that of their opponents.

In this visualisation the red colour could be said to indicate dangerous areas as crossing these areas is inherently dangerous due to their exposure.

This visual form instantly indicates areas in an environment that directly affect gameplay and are of relevance to a game designer. While it might be said that these areas should be immediately noticeable to a professional game designer the colour indication will allow a designer to visually balance a game environment when it is designed to not be immediately symmetrical and are larger or more complex.

5.4.2 Control Maps with Isovist Perimeter

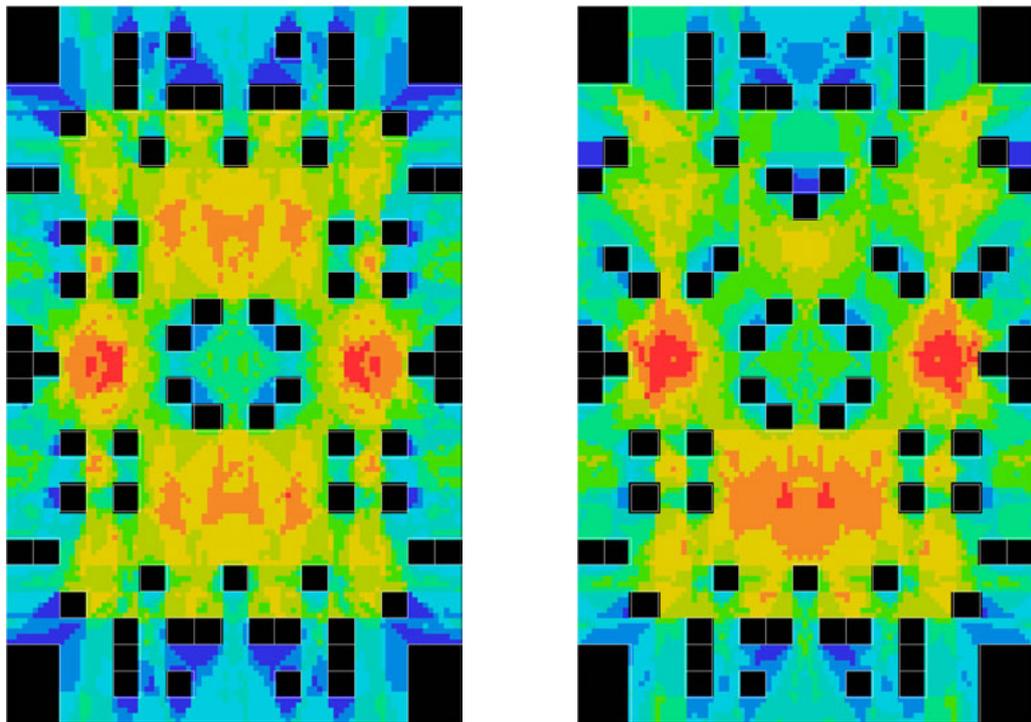


Figure 30: Control maps indicating Isovist Perimeter

The points in the environment with largest isovist perimeters that players may need to watch in order to protect themselves or control an area are clearly indicated in red. These demonstrate areas that may be dangerous for a player, as with the isovist area information, but perimeter adds more subtle detail than the area information. Perimeter indicates areas where a player wishing to defend an area from an opposing team can see more of the surrounding area in order to defend that position.

While the areas of high value are, as to be expected, the same as isovist area small areas of red are now visible indicating more detail in the information for a game designer.

5.4.3 Control Maps with Isovist Occlusivity

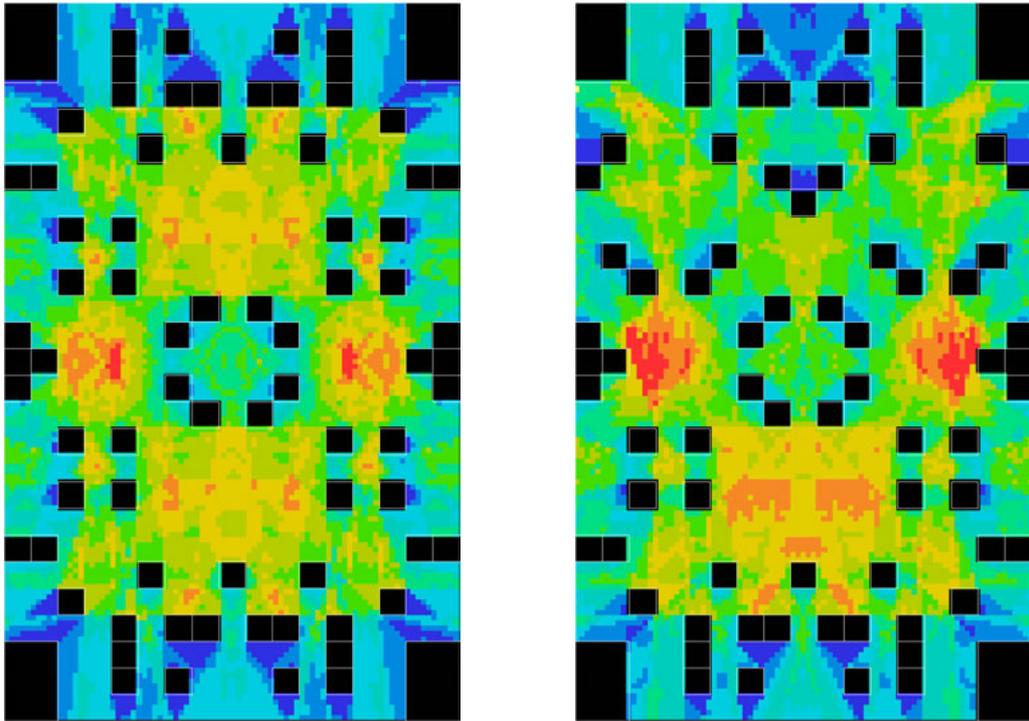


Figure 31: Control maps indicating Occlusivity

Isovist occlusivity indicates dangerous sections of the isovist perimeter as these are sections that the player must watch more carefully due to the connected area being hidden from view.

The indication of perimeters with the greatest occlusion corresponds with area and perimeter as expected but as with perimeter begins to add more subtle information for the game designer than area alone.

The occlusion values show that while area indicates large dangerous areas there are differences within those areas where the perimeter has more occlusion and so the risk to a player from hidden opponents is increased.

This is a very subtle difference in the control maps but occlusion does indicate areas within the large open areas where there are safer paths through those open areas.

5.4.4 Control Maps with Isovist Compactness

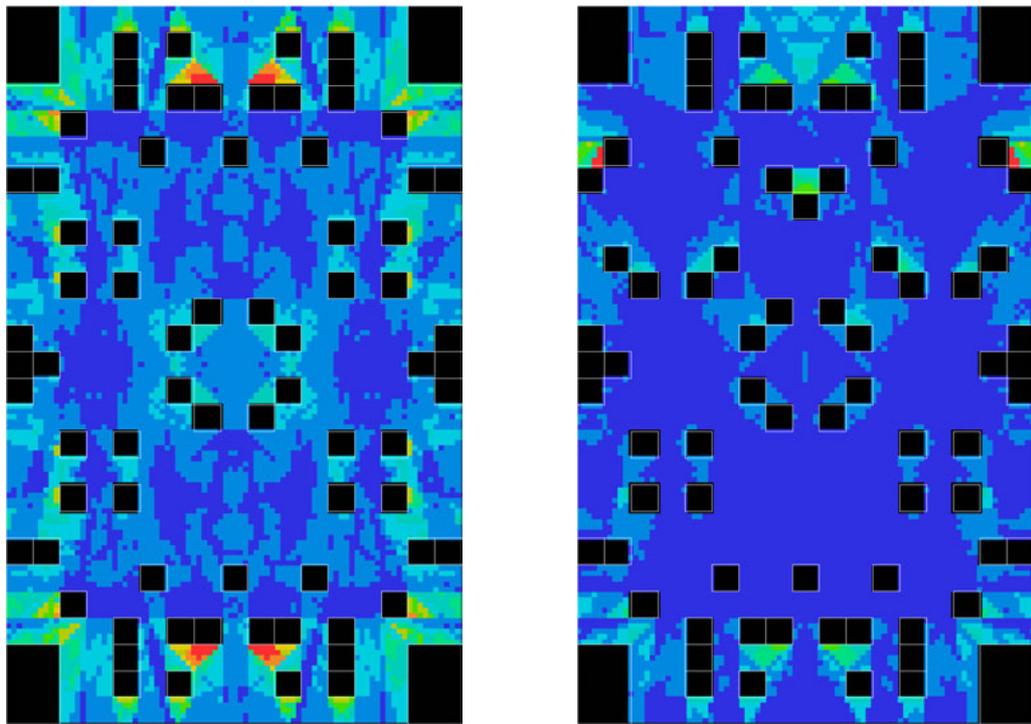


Figure 32: Control maps indicating Compactness

The compactness of an isovist is how jagged or spiky the isovist shape is and the difference between the two control maps is visually significant. Control map 1 demonstrates a symmetrical range of values across the environment meaning a variety of levels of attention required for the player as they move through the environment.

Control map 2 demonstrates a more even balance of compactness across the map though there is still asymmetry in the information. This offers an interesting aspect for a designer attempting to balance a map but not create a symmetrical environment. If compactness over an asymmetrical environment is evenly spread could this address imbalances in other isovist properties affecting gameplay.

5.4.5 Control Maps with Isovist Maximum Radial

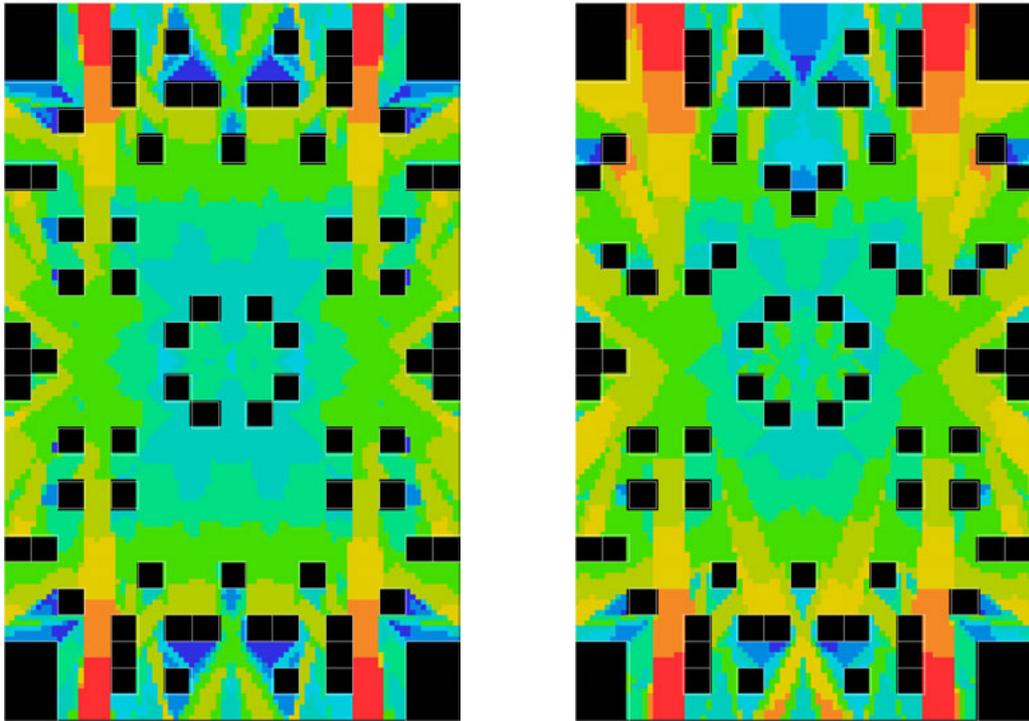


Figure 33: Control maps indicating Isovist Maximum Radial

The Maximum Radial is the distance to the furthest point of the isovist polygon from its centre. The highest values indicate areas where a player might be able to see areas of an environment that are at a great distance offering advantage if using a long range tactical weapon in the game environment.

The areas in red within the control environments are obvious areas for a game designer to consider, as there is a straight field of view across the environment. For this property the interest to the game designer is in the middle to high values indicated in the yellow to orange spectrum. On control map 2 the bottom half of the environment now has greater number of small areas of yellow at the sides of the environment than for the top half. This means even though the top half has what might be interpreted as a more defensive area they are more vulnerable to long range attacks by the other team as the other team can use a range of areas to instigate those attacks.

The areas for the top team useful for long range attacks are closer to their base and correspond with open areas.

5.4.6 Control Maps with Visual Integration

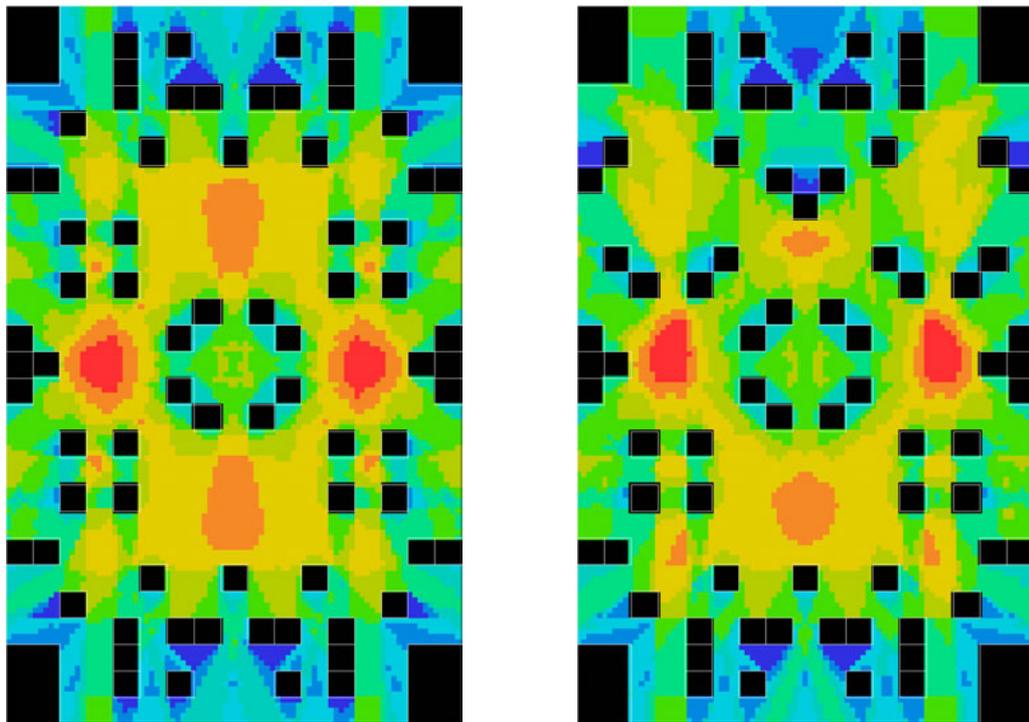


Figure 34: Control maps indicating Visual Integration

The visual integration property is calculated using the visibility graph analysis (VGA) data and has been seen to represent the movement of people within an environment. The statistical property of visual integration is calculated on the shortest number of visual steps to any other point in the environment, mean depth, compared to all other points in the environment. This indicates that areas of high visual integration are more easily seen from other parts of the environment.

For the game designer it can be considered that if a player is moving around the environment at speed, as is normal for certain gameplay tactics, the areas of high visual integration will be areas that player will move through more frequently until they become more familiar with the environment and other possible routes.

This enables the game designer to anticipate initial player movements in an environment and consider how they wish to develop the player's gameplay. This may be obvious with the control maps but this might remove an element of the requirement for game testing game of more complex environments.

5.4.7 Control Maps with Relativised Visual Entropy

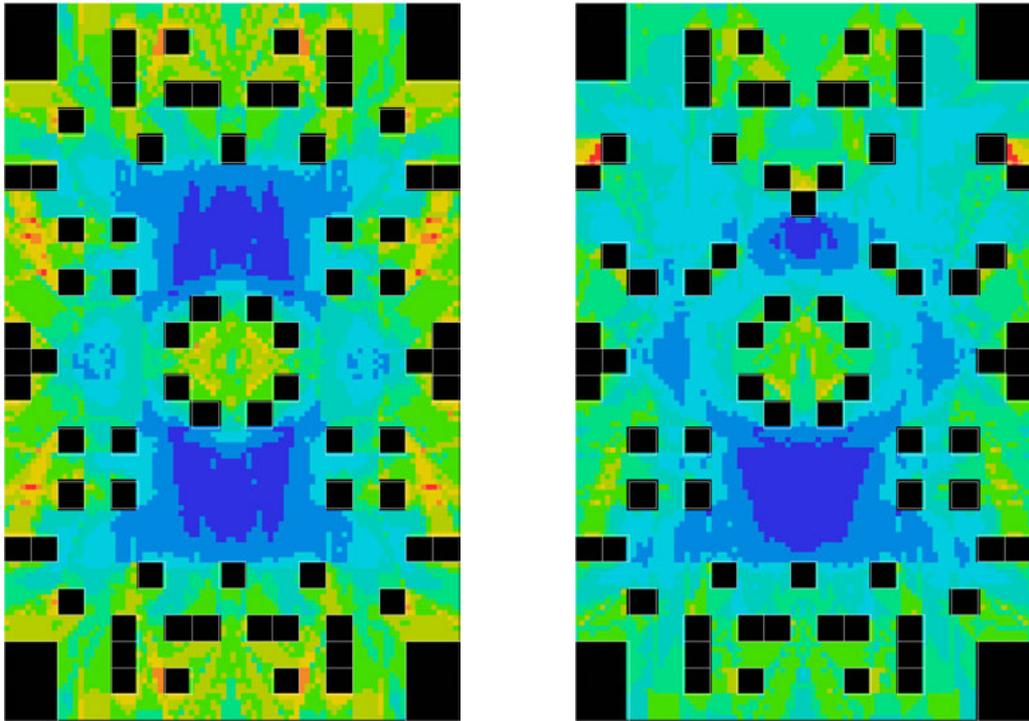


Figure 35: Control maps indicating Relativised Visualised Entropy

Relativised visual entropy is a property calculated using the VGA that analyses the change in depth moving from one area to another and is relativised so each point is considered against all other points in the environment. It indicates how ordered an environment is as moving rapidly from a small area to a large area indicates an unordered environment with sharp changes between areas. High values mean that movement from that area will mean rapidly encountering areas of a different dimension.

The usefulness of this property is shown in control map 2 where small areas of protection indicated in red balance open areas at the top of the map. This instantly indicates where elements of game balance may be required in order to offer some form of compromise to areas that may be difficult to traverse otherwise.

5.4.8 Control Maps with Visual Control and Visual Controllability

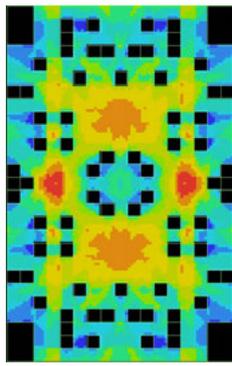


Figure 36: Control maps Visual Control

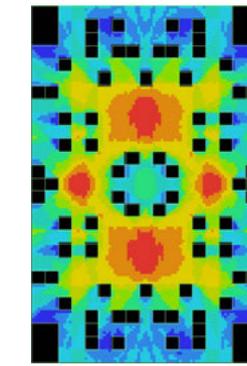
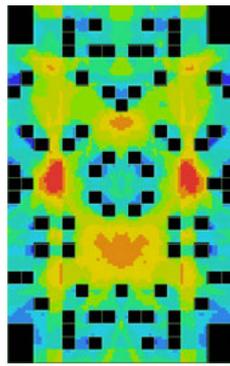


Figure 37: Control maps Visual Controllability

Visual control and visual controllability offer interesting and subtle indicators for game design. A location in an environment can be both controlling and have high controllability. This is demonstrated in the two red central areas in the maps to the left and right of the centre. A player in this position has a strong control of the surrounding areas with smaller fields of view but this area is also dominated by lots of other areas and so is in turn has high controllability.

It is in balancing game environments where these spatial indicators can prove their value to the design process where they will indicate how subtle changes may affect the balance of control across a game environment. Otherwise this would be left to be determined later in the production process through play testing and the more subjective reporting from that process.

5.4.9 Conclusion

The range of isovist and VGA properties when applied to control maps demonstrate clear possibilities to inform the design of game environments and enable the game designer to anticipate possible gameplay issues in the environment.

The visual graphing of properties will allow a designer to see where areas of interest lie and to see directly how any changes address identified issues.

The consideration of different properties offers a method of balancing gameplay across complex asymmetrical environments to ensure gameplay is fair to competing players. An environment where one team may be disadvantaged, as they have more occluded areas around a key point may be advantaged by another spatial property.

Through a Space Syntax methodology the use of spatial metrics in the analysis of game environments will help to develop an understanding of the differences in current game environments and gameplay preferences.

5.5 Processing an Environment

The method of processing game environments in order for them to be analysed by the *Depthmap* software involved the development of a method of taking 3D data out of a game. It was then stripped down to a two dimensional floor plan indicating visual obstructions that block the player's field of view.

This process involves several software stages and may take between 2 and 8 hours per map depending on complexity. The map must first be extracted from the game data using the modding tools supplied with the game. This map can then be imported into a three dimensional modelling package and individual elements of the map are removed.

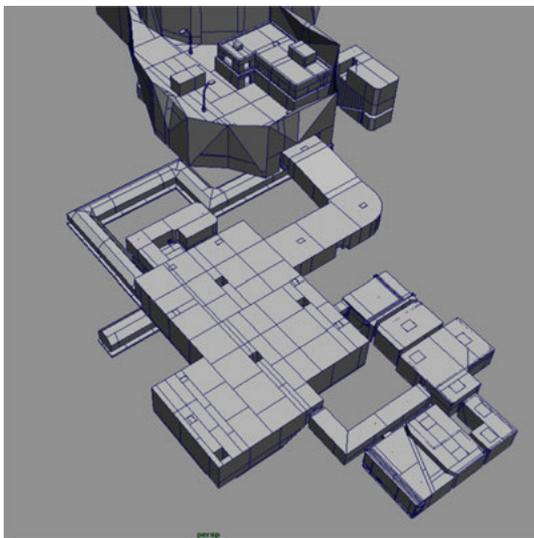


Figure 38: Extracted game environment

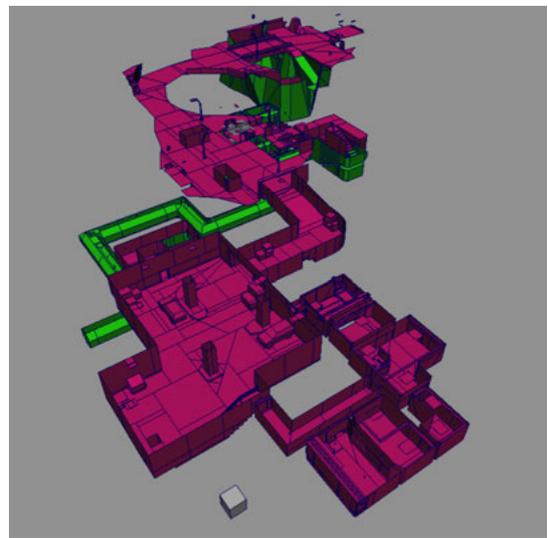


Figure 39: Processed game environment

Figure 38 shows the map as it appears in the modelling software on the left and then ceiling elements have been selected and removed in Figure 39.

The process involves the use of consistent rules for dealing with geometrical details that have been developed in the process of converting the maps. Some maps have had to be discounted due to limitations in the process, as it is unable to deal with multilevel open environments.

Once the model is stripped down to the bare geometry it is exported as a top down plan view to a vector software package where any minor alterations can be done before it is imported into the *Depthmap* software.

Certain design decisions must be made in the processing of models for analysis. These were considered with a view of the design of the gameplay, the visual field of a player and the movement of the player. In the following analysis of First Person Shooter environments these were considered against the need to move quickly around the environment while being vigilant of other players.

It was decided that any object that the player needed to jump over would remain in the model to be processed as an impediment to movement. When moving quickly it is often the way to move around these objects as to jump over them exposes the player in the environment and the need for an extra keyboard action.

As discussed in the math, the analysis is established by two way connections between points so a ledge or platform only allowing movement in one direction i.e. the ability to jump down from it but not up to it was designated as a barrier. This is an obvious limitation at present to the analysis.

The processing of the environment also requires different levels in an environment to be separated and the grid points are linked back together within *Depthmap*. There are discussions to be had around these processing considerations but for this study it was important to begin with some consistency while exploring the possibilities of this methodology.

5.6 Observations and Cross Map Comparison Issues

Earlier observations in the study used only 3D models where the model could be compared against other models, this ensured there was parity of scale for each environment. By referencing uniform objects found in each environment their scale could be ensured to be consistent across environments.

When the study began to use plans of environments where there was not direct access to models, or they were models from different game environments, consistency of measurements had to be verified. *Depthmap* has measurements that are relativized for use in the comparison of environments but there are queries as to how visibility graph analysis works across environments of different scales as the majority of research deals only with single environments. This has mainly been concerning external environments and a game environment may replicate an external environment but it can be considered an internal one as it is an enclosed virtual space with clear boundaries.

With no clear calibration of scale across the plans of different environments there is a requirement to ensure measurements used in comparative studies are relativized and offering a valid comparison.

Campos discussed the problem of comparing graphs of different sizes using *Depthmap* to establish the optimal visual integration metric (de Arruda Campos and Fong, 2003). In their study they examined the measures using “D-value” and “P-value” adjustments to normalise graphs concluding that visual integration using P-value adjustments are more useful in overcoming issues of size.

In the analysis of certain maps the visual integration measure using Teklenburg’s method of normalization (tekl), was demonstrating significant differences across environments while visual integration using the “P-value” did not. This form of normalization is using a formula from Teklenburg *Space Syntax: standardized integration measures and some simulations* (Teklenburg et al., 1993). It was then necessary to investigate further the calculation used by *Depthmap* to ensure results can be validated.

The requirement was to ensure that the visual integration measure “tekl”, that is indicating differences between maps, is valid for maps of different sizes. This ensures that whatever form of input is used to create the files required for processing scale issues do not affect the findings.

In order to do this the methodology by de Arruda et al for comparing “D-value” and “P-value” can be referred to using the control maps used earlier (de Arruda Campos and Fong, 2003).

The methodology is to first compare the same map using different grid sizes for the establishment of the visual graph. This establishes how the measurements correlate for maps of the same topological structure but different sizes as they will have a different number of nodes corresponding to the scale of the environment, larger environments more nodes. If the measurements remain consistent across different scales then it can be assumed comparing maps of similar size and structure is possible. A second process is to then compare how differences between the two different maps are affected by changes in the scale of the grid.

For the two control maps the analysis was run with a grid size of 0.5, 1 and 2 giving the number of nodes on the maps as over 500 nodes at 2, over 2300 nodes at 1 and over 9000 nodes at 0.5. The number of nodes increases processing time but captures more of the detail in an environment at higher densities of nodes.

The control maps indicating visual integration [tekl] using grids of 0.5, 1 and 2 are shown in Table 6, where the bottom maps have the grid overlay visible. This indicates how the visual graph alters due to scaling of either the grid or of the environment.

Considering the box plot analysis in Table 7, the integration using P-value shows minimal differences to the change in the number of nodes. Using HH as a normalization method demonstrates a clear scaling in values as consistent with other studies. The integration measure using Tekl does not appear to be as stable as with P-value but does not demonstrate the levels of difference indicated by the HH value. It can be considered useful as an indicator, but should not be relied on as a singular parameter for design decision-making.

Table 6: The two control maps on separate rows, showing visual integration [tekl] using grids of 0.5, 1 and 2 from left to right. The bottom map displays the grid overlay.

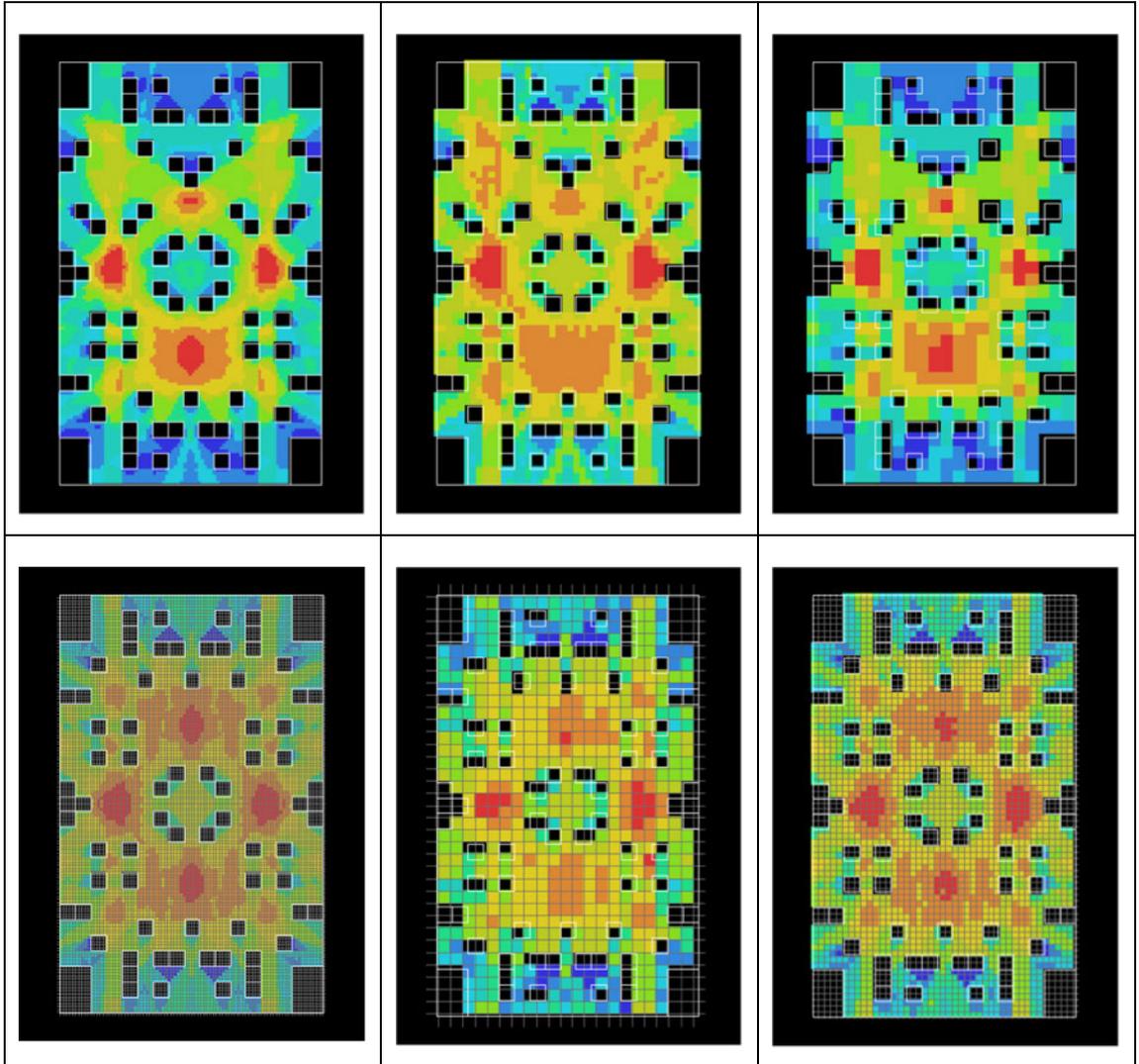
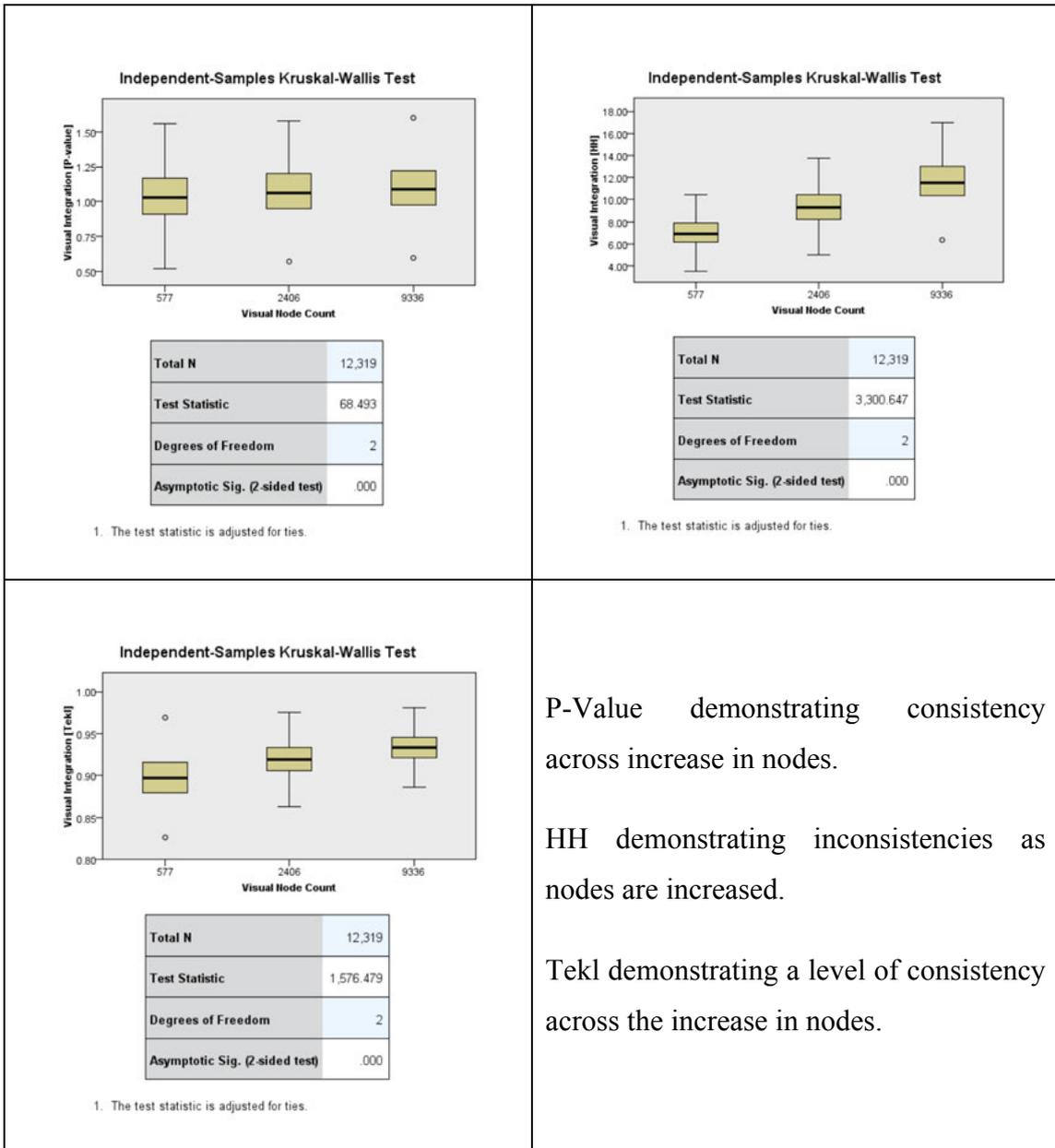


Table 7: Box plots for control map scaling



P-Value demonstrating consistency across increase in nodes.

HH demonstrating inconsistencies as nodes are increased.

Tekl demonstrating a level of consistency across the increase in nodes.

5.7 Conclusions

The confirmation that the method, and the software to apply the method were valid in the analysis of game environments was the main consideration of this element of the study. After examining the metrics and resulting visuals generated by the software it can be said that the Isovist measures and the measures generated by visibility graph analysis offer useful characteristics to inform the design of a game environment. As a comparative measure the visual rendering of the VGA mapped to the environment enables the determination of small changes to the game environment.

The comparison of multiple maps is possible with this method but the Teklenburg form of normalisation used by *Depthmap* will not be considered on its own for design decisions.

Finally the processing of game environments will require the application of a consistent method for breaking down the environment due to the 2D limitation of the software.

With these conclusions it is possible to move forward with the analysis of game environments.

Chapter 6: Interpreting Game Environments

Investigating the implementation of experiential and cultural knowledge in the design and use of game environments has led to the design research methodology where narrative texture and the secondary principles of game architecture are separated from primary game architecture. This means that primary game architecture can be analysed using spatial parameters recognised as relevant to game design principles. These parameters give quantitative results enabling the statistical analysis of design decisions within the game design process that could only previously have been discussed subjectively. This chapter deals with the application of this method to game environments.

In section 6.1 the identification of *Counter-Strike* as an appropriate game offering the range and quantity of game environments for analysis provides evidence for the aims within this stage of the study. Then the application of the method to a sample of amateur and professional game maps in section 6.2.1 meets the criteria of identifying differences between samples. And examining game environments designed without the financial implications of professional game maps.

The analysis of a set of maps across different international applications of *Counter-Strike* in section 6.2.2 indicates spatial parameters for the map *Dust2* that can inform the design of multicultural game spaces. This map is analysed individually in section 6.2.3 to determine more about its spatial design.

The transfer of real environments into game environments is considered in section 6.4 considering the previously discussed environment of *The Getaway* and another large city environment from *Grand Theft Auto III*.

In section 6.5 the spatial design of a set of environments from Asian FPS games is compared to a set of Western FPS environments to determine cultural differences in their spatial characteristics. This concludes with a set of differences in spatial characteristics listed in section 6.5.5.

Finally in order to try and understand how the results may be implemented back into a design methodology section 6.6 considers patterns in the spatial data from the environments tested.

6.1 Determining Game Environments for Analysis

Aims: *To determine a suitable game offering a range of environments for analysis.*

It was necessary to first determine the criteria required to enable the application of a spatial metrics methodology. Games where environments could be extracted, in order to be processed by the *Depthmap* software were essential. The software requires the input of a two dimensional plan of an environment in order to perform an analysis. The initial criterion was that games were required to support the ability to add modifications known as mods. This means the developer has packaged environment development tools with the game. This is for players to build their own game levels meaning the ability to extract game environments for this study.

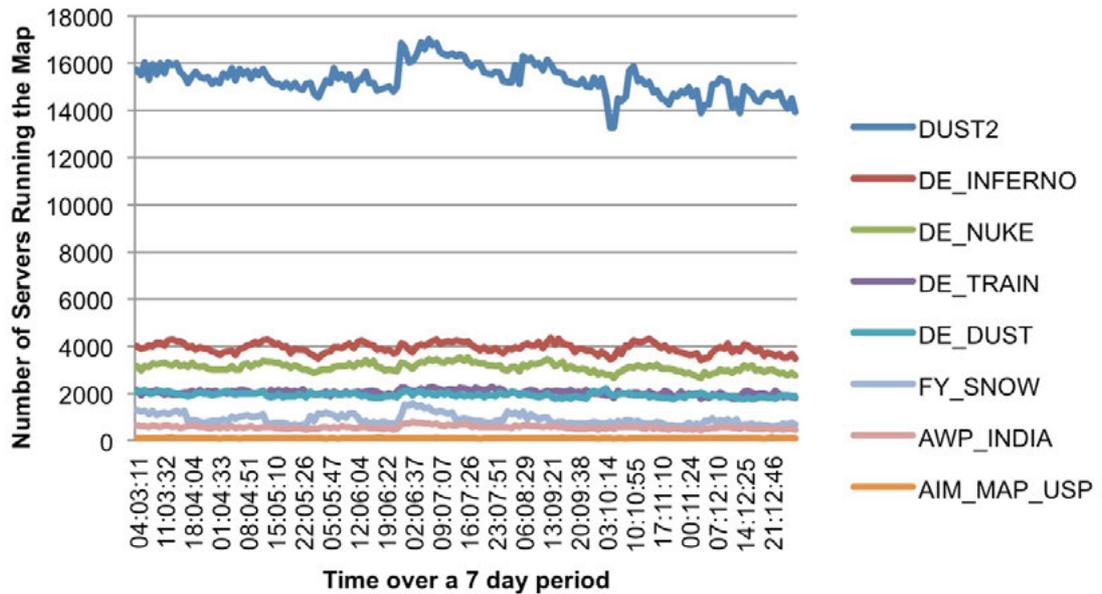
Several games were identified as having potential to be part of the study. The next criteria were how many environments are available to be analysed and what is the global demographics of players. The use of a game in the World Cyber Games indicated a measure of global value then examining game server statistics from different game sites gave an indication of international usage.

The game *Counter-Strike* was chosen as it satisfies a wide range of criteria. The game has developed with a large online community of amateur game designers known as modders, creating new game environments referred to as maps or mods. This meant that there was the opportunity to contrast amateur and professionally built environments satisfying the criteria of analysing game environments free from commercial constraints. This could indicate whether industry parameters have influenced the design process over time and possible cultural and tacit nuances have been lost. It is one of the earliest games to appear in world championship gaming tournaments and is played globally. The length of time *Counter-Strike* has been in the marketplace means that the game has spread globally with significant numbers of Asian servers observed on game statistic sites indicating the possibility for cross cultural studies. A version of *Counter-Strike* called *Counter-Strike Online* has been developed specifically for an Asian market enabling this study to examine environments created specifically for this sector of the market.

In order to decide which game maps should be analysed a script was created to collect *Counter-Strike* server details every hour over a period of seven days from an

international game monitoring site, www.game-monitor.com. This enabled the assessment of the most popular maps for *Counter-Strike* including peak playing times globally.

Table 8: The most popular game maps for Counter-Strike over a seven-day period from www.game-monitor.com



The results of this data enabled a choice of 50 maps that were then researched to establish their authorship as professionally designed or from the mod community.

15 professional maps were chosen, all in the top maps list, and 15 maps by non-professionals. This consisted of 9 from the top maps list and 6 popular downloaded maps from *Counter-Strike* mod sites.

Counter-Strike maps may be designed for particular forms of gameplay; this is generally indicated in the prefix to the name, though some maps are used for several types of gameplay. The particular game mode for each map was recorded in order to ascertain any implications due to the design for particular gameplay.

De_dust2 was clearly the most popular map from the seven-day sample and is spatially analysed separately as a comparative measure to examine possible characteristics that make it so popular internationally. The prefixes to the map names, *de* in de_dust2, are indicative of the type of game that may be played in that environment. The *de* prefix indicates the *defuse* game type, a competition between two teams to plant explosives at

particular points in an environment while the opposing team tries to stop them. The game type is relevant but the prefix will be dropped when discussing maps as this is not the norm when discussing them within game design.

A version of *Counter-Strike* developed specifically for the Asian market, by Nexon Corporation based in South Korea, called *Counter-Strike Online* (Nexon Corporation, 2008) was released in 2008. This game contained several exclusive maps designed for its target market by Nexon, alongside some existing maps from the original game. Five maps in this specific Asian release were analysed, three completely new maps as these may offer possible insight into cultural differences along with two of the original maps `de_dust2` and `de_train`.

The analysis of the specific *Counter-Strike* environments used in the World Cyber Games can inform the study as these are recognised as having gameplay parity in order to be interchangeable at professional gaming competitions.

Conclusion:

Counter-Strike offers the opportunity to study a diverse body of game environments including, amateur maps and professional maps of Eastern and Western origin. This game offers the scope to answer many of this study's questions.

6.2 Counter-Strike: Initial Map Analysis

Processing the game maps through the *Depthmap* software resulted in a large body of data covering a range of spatial analysis parameters for each map. Maps consisted of up to 15500 points on the VGA each with a set of isovist and visual parameters. Data was processed through *Depthmap* to generate the spatial data, *Microsoft Excel* to assemble data into meaningful configurations and then analysed in *SPSS*.

The data collected from each map was assembled to examine both the average value and the median of each spatial variable. This first spatial analysis consisted of isovist properties and global VGA properties. Local measures on the VGA were not processed for this initial test due to the intensive processing times required. This was a result of large open spaces within some amateur maps and the requirement to keep a constant grid value. The grid would normally be reduced for environments of this nature.

6.2.1 Professional and Amateur Maps

Aims: *Is it possible to identify differences between two groups of maps from this data?*

Choosing amateur and professional maps offers evidence for whether amateur map designers, free from commercial constraints, might be building game environments with different spatial characteristics to professional designers. The analysis is of the most popular downloaded maps both professional and amateur therefore this may highlight any possible developments led by independent map designers not apparent in professional maps.

The hypothesis was that there is no difference in spatial properties between the means or the medians of the sample of professionally designed maps compared to those of the sample of amateur designed maps.

H_0 : The two samples come from identical populations

H_a : The two samples come from different populations

The data was first explored to determine its characteristics and what form of test would be appropriate. The data exhibited outliers for both means and median data sets throughout isovist and spatial parameters. It was therefore determined a non-parametric Mann-Whitney *U* test should be conducted to evaluate the hypothesis. The result of the

test was statistically significant within the parameters of visual integration and relativised visual entropy.

Visual integration is a normalised version of the mean depth, which means it can be used for comparative studies. There are three parameters for visual integration produced by *Depthmap*, HH, P-value and Tekl, differentiated by their normalisation methods. The normalisation method of HH has been discussed in Chapter 4.6 in relation to comparison across environments and is not used. A lower value for visual integration indicates a less integrated point within the environment while a higher value indicates a more integrated point in relation to all other points in the environment.

Relativised visual entropy factors in the visual distribution of points on the graph calculating the visual depth of other points from a point as opposed to simply the depth itself. Entropy indicates whether many points are visually close to a point or more evenly distributed and relativised entropy factors in the expected distribution from the mean depth. A lower value indicates that there are many other points visually close to a point.

Distributions for both normalisation methods of visual integration for professional and amateur maps were not similar, as assessed by visual inspection. The results for the test on visual integration for the average and median values of the spatial data was statistically significantly different with both visual integration methods giving the same results as shown in Table 9. Professional maps had a mean rank lower than amateur maps for both the means and the medians of the spatial data.

Distribution for relativised visual entropy was not similar, as assessed by visual inspection. The results for the test on relativised visual entropy for the average and median values of the spatial data was statistically significantly different with professional maps having an average rank higher than amateur maps shown in Table 10.

When the maps are examined by game type the amateur maps in the top played maps include *awp* and *fy* forms of gameplay map developed independently of professional developers by amateur mapmakers. These have not been packaged with the commercial versions of the game until the development of *Counter-Strike Online* for the Asian market where *awp* maps are included.

Table 9: Visual Integration across Professional and Amateur Environments

Visual Integration				
	<i>z</i>	<i>P</i> <i>Significant as p<0.05</i>	<i>Professional Maps</i> <i>Mean Rank</i>	<i>Amateur</i> <i>Mean Rank</i>
Visual Integration [P]				
Comparison of Averages:	-2.841	0.004	10.93	20.07
Comparison of Medians:	-2.551	0.011	11.40	19.60
Visual Integration [TEKL]				
Comparison of Averages:	-2.841	0.004	10.93	20.07
Comparison of Medians:	-2.551	0.011	11.40	19.60

Table 10: Relativised Visual Entropy across Professional and Amateur Environments

Relativised Visual Entropy				
	<i>z</i>	<i>P</i> <i>Significant as p<0.05</i>	<i>Professional Maps</i> <i>Mean Rank</i>	<i>Amateur</i> <i>Mean Rank</i>
Comparison of Averages:	-2.841	0.004	19.73	11.27
Comparison of Medians:	-2.8	0.004	20.00	11.00

The *awp* map is where the players are limited to using a long-range weapon. In order to accommodate this form of gameplay most *awp* maps contain larger open areas and greater distances in order to test the player’s skill with the weapon. This is evident within the data when considering the high visual integration values for these maps and low entropy values meaning large open areas. They also have the highest values for isovist maximum radial, the maximum distance from the centre of an isovist to its perimeter indicating long viewfields.

The *fy* map is known as a fight yard where weapons are scattered around a small environment in order to allow players to practice with different weapons. Within the sample analysed these maps are the second most integrated after the *awp* maps, which is to be expected as *fy* maps contain open spaces containing a range of objects for cover. The size of these maps for gameplay is indicated in the below average maximum and minimum radial measurements indicating smaller areas with closer gameplay. The low

entropy and high integration values again reflect the predominance of open areas within the environment.

Conclusion:

In conclusion the analysis of spatial parameters has indicated statistically significant differences in the characteristics of the group of professional maps and the group of amateur maps. Importantly it is not the isovist area, or any of the isovist properties, that indicate statistical differences between the groups. The visual metrics derived from the VGA indicate differences. These are calculated across the maps as opposed to isovist metrics that may be discerned from a visual analysis of the environment.

This is evidence of a more holistic understanding of intelligibility evident in the professional maps. This is rather than a visual imageability led approach, to the design of these environments. The question whether this professional intelligibility is implicit or tacit and whether it is affected by culture now becomes a more clearly defined line of enquiry.

6.2.2 Spatial Metrics Across Subsets of Maps

***Aims:** To explore spatial differences in groups of Counter-Strike maps in relation to their different applications professionally and culturally.*

The body of maps collected enabled the analysis of certain professional groupings in order to interpret possible design rules and values built into the maps by their designers. Comparative studies between groups of maps based on industry or professional criteria will now be spatially measured and compared.

Five of the professional maps analysed are used in the World Cyber Games *Counter-Strike* tournaments where they are considered to have a level of parity. At a professional competition level they must be considered similar enough to be interchangeable for tournament play. This element of parity and a recognised professional standard is worthy of consideration in order to measure what spatial characteristics may be a factor.

Counter-Strike Online was produced for an Asian market and contains several of the professional maps already analysed along with a number of maps designed for the Asian release. These extra maps developed directly for an Asian market by an Asian company

is an opportunity to determine if the spatial characteristics of this group of maps differ from those of the original Western developer of *Counter-Strike*.

A Kruskal-Wallis test was run in *SPSS* to determine if there were differences in spatial parameters between the 15 Western professional maps, 15 Western amateur Maps, 5 *Counter-Strike Online* maps and 5 maps used in the World Cyber Games. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. This test is using the data from the three groups rather than running separate Mann-Whitney tests on the groups.

Visual integration [P-value] was statistically significantly different between the four groups of maps, $\chi^2(3) = 9.839$, $p = .020$. *Post-hoc* analysis revealed statistically significant differences in visual integration [P-value] between the Western Professional maps ($Mdn = 0.338$) and the Amateur maps ($Mdn = 0.497$) ($p = .014$). There was no statistically significant difference between Western Professional and Asian maps ($Mdn = 0.485$), Western Professional and World Cyber Games maps ($Mdn = 0.363$) or other combinations.

Visual integration [Tekl] was statistically significantly different between the four groups of maps, $\chi^2(3) = 9.976$, $p = .019$. *Post-hoc* analysis revealed statistically significant differences in visual integration [Tekl] between the Western Professional maps ($Mdn = 0.447$) and the Amateur maps ($Mdn = 0.465$) ($p = .024$). There was no statistically significant difference between Western Professional and Asian maps ($Mdn = 0.462$), Western Professional and World Cyber Games maps ($Mdn = 0.448$) or other combinations.

Relativised visual entropy was statistically significantly different between the three groups of maps, $\chi^2(3) = 10.055$, $p = .018$. *Post-hoc* analysis revealed statistically significant differences in relativised visual entropy between the Western Professional maps ($Mdn = 2.496$) and Amateur maps ($Mdn = 2.310$) ($p = .015$). There was no statistically significant difference between Western Professional and Asian maps ($Mdn = 2.344$), Western Professional and World Cyber Games maps ($Mdn = 2.438$) or other combinations.

In conclusion to the Kruskal-Wallis test and *post-hoc* analysis the statistically significant differences indicated are only with visual integration and relativised visual

entropy between the groups of Western professional and amateur maps. This was already established in the previous Mann-Whitney test between these two groups.

The statistical indicators are questionable in terms of the number of maps in certain groups. This could not be helped at this stage, as extracting geometry from *Counter-Strike Online* for analysis is problematic. The Western professional maps and the Asian maps did indicate p of 0.06 for visual integration and a p of 0.07 for relativised visual entropy that may indicate with more maps in the Asian group a statistically significant result may be possible.

The lack of difference between Western professional maps and the maps from the World Cyber Games is not unexpected as these are a subset of the professional group. The lack of differentiation between Asian, World Cyber Games and amateur maps is more interesting as this indicates some commonality in the distribution of spatial values. The examination of these distributions may indicate common characteristics picked up on by amateurs developers and recognised by Asian developers.

The map Dust2 was found to be significantly more popular than any other map in the global game server analysis. It is in the Western professional group of maps, the World Cyber Games group of maps and, as it is distributed with *Counter Strike Online*, it is in the Asian group as well. This would indicate that this map has characteristics that are globally popular satisfying both Western and Eastern cultural values with the gameplay in this environment. Analysing Dust2 as an individual category of map enables the consideration of spatial values that may define multicultural design values for game environments.

Box plots of spatial parameters for the map groups of Western Professional, Amateur, Asian, World Cyber Games and Dust2 were plotted. A visual analysis of the most interesting distributions of characteristics was carried out and occlusion, max radial, compactness, visual integration [Tekl] and relativised visual entropy are shown in Figure 43, Figure 44, Figure 45, Figure 46 and Figure 47, respectively.

In Figure 40: Box Plot of Occlusion the amateur map group shows a much larger interquartile range than the other groups and this is also evident in the box plots for maximum radial and visual integration. This could be considered indicative of the lack of professional constraints. Amateur map designers are more likely to experiment with

extreme spatial measures and not be influenced by prior knowledge, as professional designers working with known spatial forms for industry maps will be.

The interquartile range of Asian maps for occlusion, maximum radial and visual integration is also larger than Western professional maps but its range excluding outliers is not as large. This may indicate more control in this spread of spatial metrics within the Asian maps.

The Western professional maps demonstrate a very even range across the interquartile range and the limits of the range in all except relativised visual entropy. Other groups in this parameter indicate much smaller ranges. This means much more variety in the distribution of the points in these Western maps compared to a much more balanced range of average distribution of points within the Asian maps. The Western maps demonstrate a small interquartile range for compactness while the Asian maps vary more in their average values.

The five maps forming the World Cyber Games group demonstrate a close interquartile range with only outliers in some parameters. This is to be expected for a group of maps requiring a strong level of parity between them. The interquartile range for this group is also within the interquartile range for Western professional maps and Asian maps for the isovist properties of occlusion, max radial and compactness but not the VGA properties of visual integration and relativised visual entropy. This is an indicator of the similarities in the immediate visual isovist properties of the environments but not in their visual graph, VGA, properties.

The Western professional maps can be seen to have a much smaller and lower value range for visual integration and a higher value range for relativised visual entropy than the other groups.

The lower integration values are indicative of less integrated maps. This must be considered in terms of the complexity of the map as simple open amateur maps would be considered more integrated, as they have less detail than well designed professional maps. This larger range of values for relativised visual entropy indicates more asymmetrical spreads of points.

In comparing visual integration for just Western and Asian map groups it can be seen that Dust2 is on the upper and lower interquartile limit for Western and Asian groups

respectively. It is a very similar situation for relativised visual entropy as well. Dust2 appears to sit within, or at the limits of, the interquartile range of Asian and Western professional maps in all parameters, isovist and VGA. This confirms Dust2 should be more carefully analysed for the spatial values that make it fit this range and also make it so globally popular.

Conclusions:

In conclusion of the groups of maps, the smaller number of maps in the Asian group means that results may not be statistically significantly different within *Counter-Strike* maps. This result should be considered against the strong indicators of the close to significant p values and with the visual differences in the box plots of isovist and VGA parameters.

Of great interest is the map Dust2 as it is on the threshold of the interquartile range for Western and Asian maps and this might indicate why it is so globally popular. This environment required further analysis to see how its spatial characteristics can inform the design of multicultural environments.

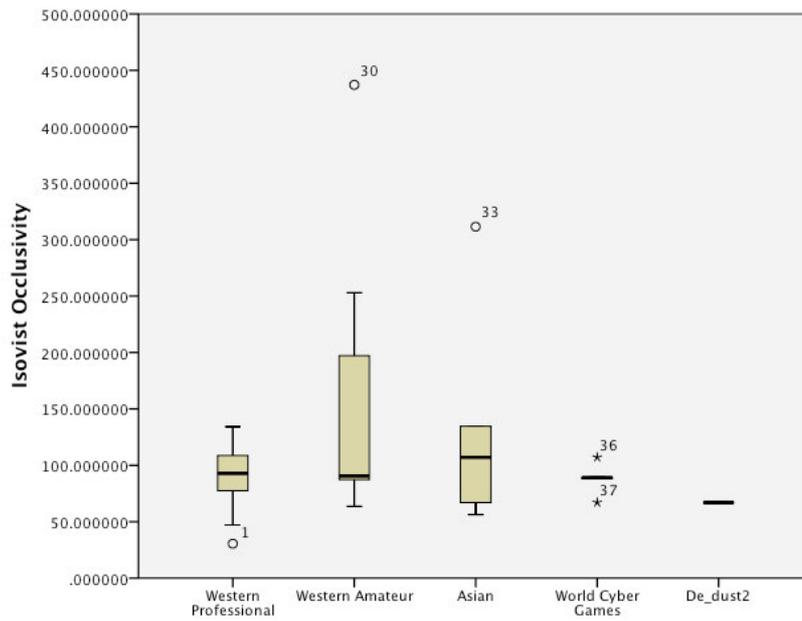


Figure 40: Box Plot of Occlusion

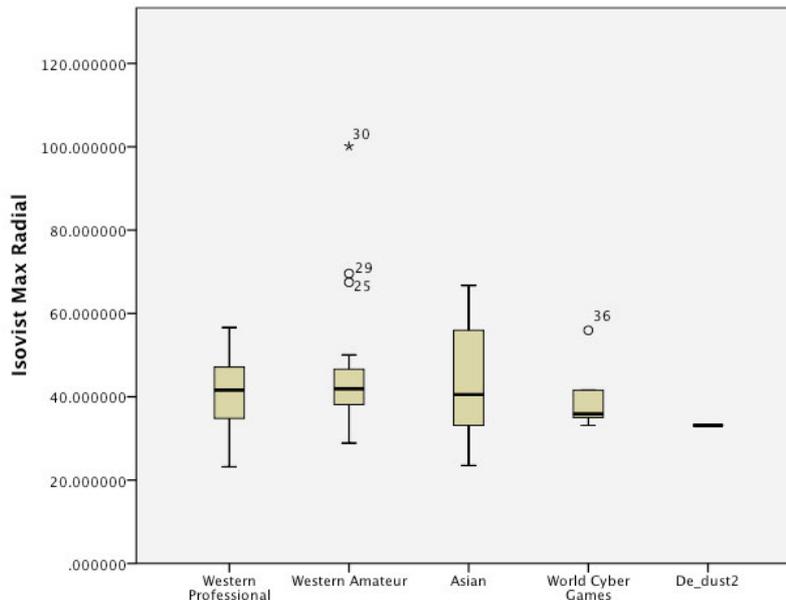


Figure 41: Boxplot of Iovist Max Radial

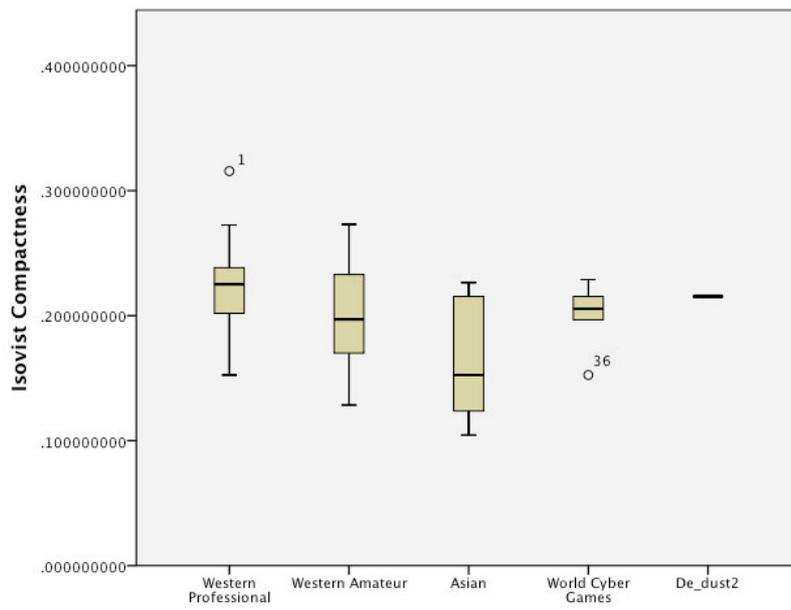


Figure 42: Boxplot of Compactness

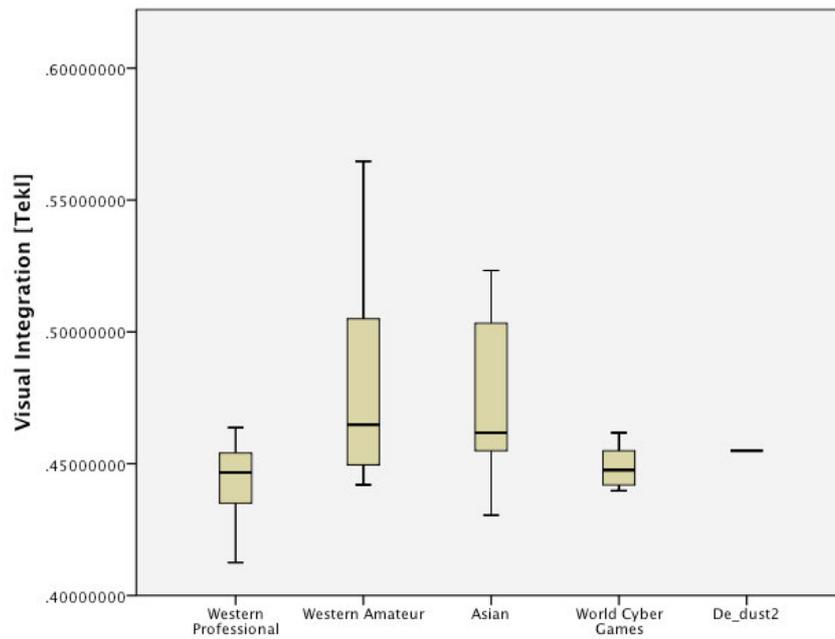


Figure 43: Box Plot of Visual Integration

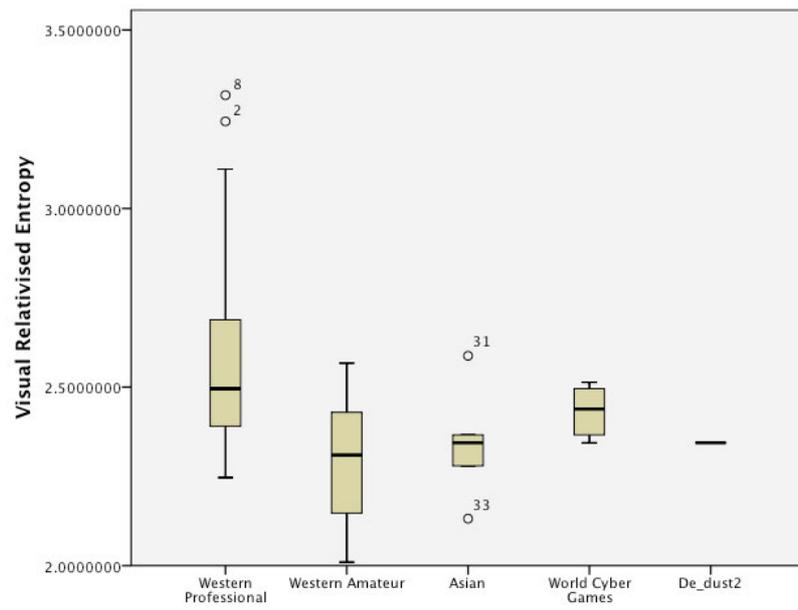


Figure 44: Boxplot of Visual Relativised Entropy

6.3 Spatial Analysis of Dust2

Aims: *To investigate the significance of the environment Dust2 which is both internationally popular and exhibits spatial characteristics at the intersection of Western and Asian map results.*

The difference between the numbers of servers running the Dust2 map compared to any other map, Table 8, indicates a preference for the gameplay in the environment of Dust2. This is not just the defuse (*de* prefix) game format as servers for other *de* maps were recorded in much lower quantities. The defuse maps are where one team of players must plant bombs while the other team protects the targets and defuses any bombs planted.

The statistical analysis of the spatial measurements of Dust2 to interpret its intelligibility in relation to design characteristics and its imageability is important in order to determine how these characteristics can be replicated. To begin to explore the structural properties of the environment a scatter plot analysis of Dust2's spatial characteristics was undertaken. *Depthmap* produces scatter plots of the spatial data enabling a visual examination of the relationship between VGA values and isovist parameters. The relationship between two different parameters generated by the VGA is possible with an R-squared (R^2) correlation function giving a measure of the relationship between the parameters. While R^2 is a measure of fit often used for prediction in this study it gives a measure of how much one parameter may be dependent on another. The hypothesis is that a VGA parameter demonstrating a level of intelligibility across the environment, but not clearly distinguishable from a visual analysis of the environment, may have a strong linear relationship with an isovist parameter that can be visually recognised by the designer within the imageability of the environment.

The first step was to examine the VGA parameters of visual integration and relativised visual entropy within Dust2. These have been identified as parameters that might offer areas of insight into cultural design within the previous spatial investigation. The relationship of these VGA parameters was analysed against the isovist parameters of perimeter, occlusion, maximum radial and compactness.

An R^2 value of 0 to 0.3 indicates a weak positive or negative linear relationship via a tentative linear rule. R^2 values of 0.3 to 0.7 indicate a moderate positive or negative linear relationship via a linear rule that is becoming firm but is not definitive. R^2 values of 0.7 to 1.0 indicate a strong positive or negative linear relationship via a firm linear rule that can be considered in terms of prediction.

A consideration of the R^2 values generated is that this study is not looking for values that enable prediction as every environment is different and so the relationship between the parameters will be different. This is a comparative exercise to determine the balance of parameters forming the intelligibility of Dust2 deemed of interest to the study in order to discuss them in more subjective design terms.

These R^2 relationships to be discussed are only between two parameters at a time. It is statistically possible to perform a multiple regression analysis on a dependent variable and ascertain the balance of multiple predictor variables. In this case the predictor variables do not meet the multicollinearity requirements for a multiple regression. This is because the isovist parameters used are strongly correlated so any change to one will deeply affect the others making statistical prediction impossible. In a multiple regression on this data a dependent variable with high correlation to another would be removed or the two variables combined into a new variable. This is a consideration for further statistical analysis where occlusion and perimeter could be converted to a single value of percentage of the perimeter that is occluded.

The isovist parameters examined were perimeter, occlusion, maximum radial and compactness. These are parameters that can be visually interpreted in the environment and recognised within the environment design and building process. The VGA parameters of visual integration and relativised visual entropy are mathematical measures across the environment making them more difficult for a designer to visually interpret within the design process. The R^2 values for both can be seen in Table 11: R^2 for Visual Integration [TEKL] and Visual Entropy.

The next requirement was to determine which VGA parameter to use in the comparative studies. The mean of the values for the R^2 correlations for visual integration was higher than that of visual related entropy. This is just a scalar measure and it is not the intention to sum R^2 values for prediction purposes this is simply a measure for comparative purposes.

Table 11: R² for Visual Integration [TEKL] and Visual Entropy

Dust2	Occlusivity	Perimeter	Max Radial	Compactness	Mean
Visual Integration	0.617	0.568	0.367	0.684	0.559
Visual Relativised Entropy	0.525	0.676	0.548	0.399	0.537

It was decided to use visual integration as the dependent variable as correlations are stronger for occlusivity and compactness than with relativised visual entropy. Between the two forms of normalisation for visual integration the Teklenburg version was used as it was indicating a slightly higher correlation with compactness. Using this spatial parameter gives a stronger basis for determining whether compactness and complexity might be culturally apparent in the imageability of Dust2.

The analysis of scatter plots showed a visual trend for Dust2 where values are grouped tighter to a regression line than other maps examined. An example of this is demonstrated in the comparison of scatter plots for Dust2 and de_inferno Figure 45: Scatter plots for de_dust 2 and de_inferno.

The regression line indicates the relationship between the two parameters as a linear line determined by an equation mathematically calculated such that the sum of distances from each data point to the line is minimized. The R² value or coefficient of determination measures the proportion of the total variation in visual integration about its mean explained by the regression of visual integration on the spatial parameter on the x-axis. The value must not be confused with the average of the parameter across the environment but with how structured they are within the visual integration of the system. This means they are correlated with the intelligibility of the environment and as this is visual integration then how navigable the environment is.

A comparison of the average of R² values demonstrated that Dust2 is more consistent in the correlation of visual integration to the four spatial variables than most maps tested. Several maps are shown in Table 12: R² values for visual integration and isovist space syntax parameter.

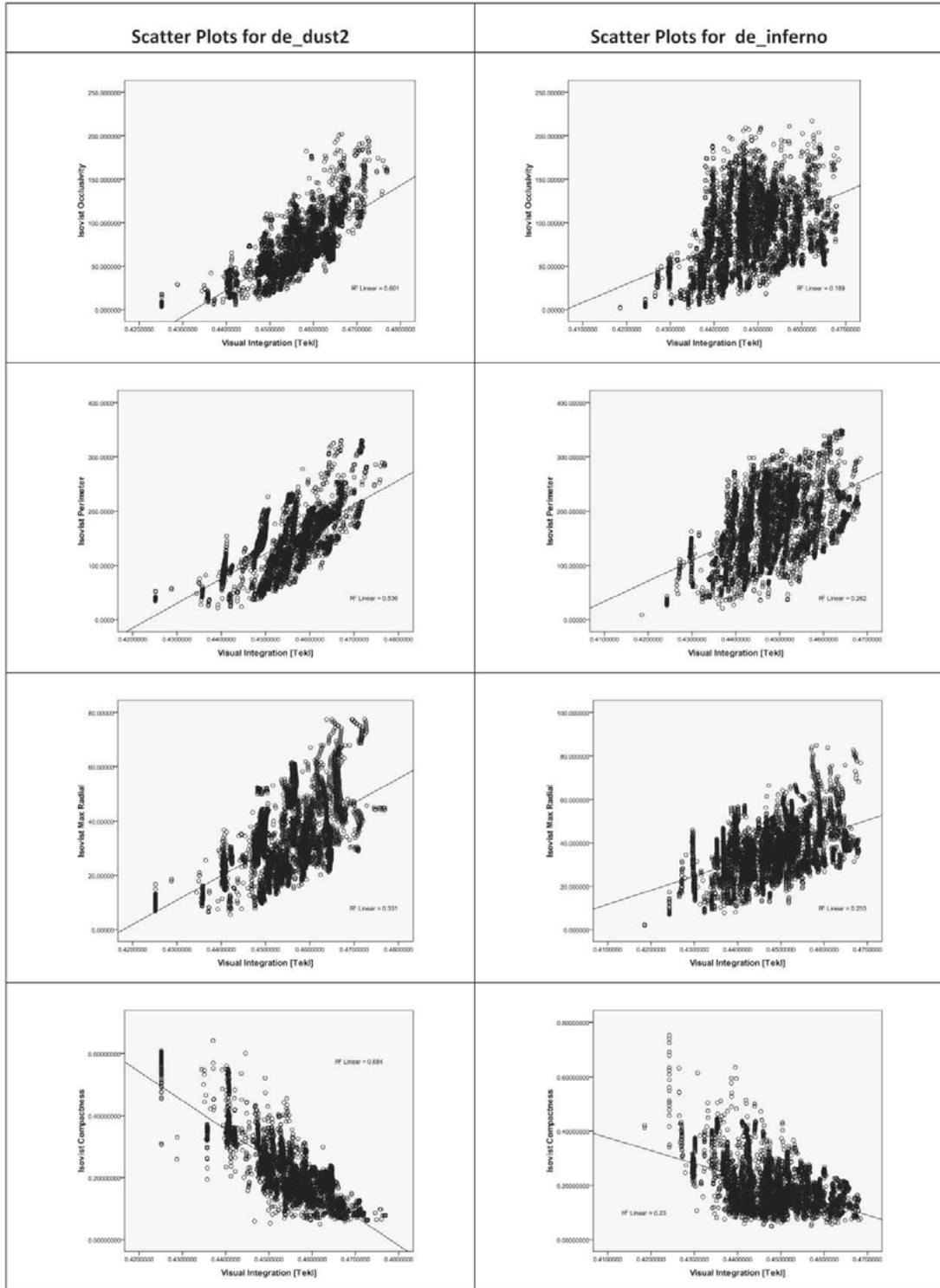


Figure 45: Scatter plots for de_dust 2 and de_inferno.

Table 12: R² values for visual integration and isovist space syntax parameters

Map	Occlusivity	Perimeter	Max Radial	Compactness	Average
Dust2	0.617	0.568	0.367	0.684	0.5590
Nuke	0.619	0.606	0.353	0.252	0.4575
Clan1_mill	0.440	0.513	0.371	0.247	0.3928
Inferno	0.189	0.262	0.253	0.230	0.2335
Dust	0.259	0.214	0.147	0.227	0.2118
Train	0.007	0.140	0.273	0.088	0.1270

Conclusions:

The correlations of isovist perimeter, occlusivity, complexity and maximum distance with visual integration for Dust2 offer the first measure of a statistical indicator for design purposes. This is a methodology that may inform a more detailed design analysis of why Dust2 is globally popular.

It offers possible insight into how the underlying spatial structure of an environment, the intelligibility, might be quantified to produce environments with known gameplay characteristics. These are measures that could be used by designers of new environments within the design process as statistical measures to aim for before play testing is required.

This is a first step towards space syntax measures for gameplay and with the overriding global popularity of Dust2 it is a statistically valid one.

6.4 Real World Analysis

Aims: To establish spatial considerations for the transfer of real world environments into game environments

A spatial analysis methodology offers a way to examine environments that have been developed from real world information. This enables the investigation of the use of experiential knowledge in developing game environments considering possible knowledge transfer from the real environment to the virtual.

Professional game designers will be expected to consider all elements of a real environment for gameplay through a considered design process having developed their knowledge set within a professional environment. An amateur game designer may focus on reality in the first instance if trying to make a realistic map then gameplay afterwards. This is where modding is often used to demonstrate skills in modelling rather than a consideration for gameplay as discussed in Chapter 3.2.1.

Several amateur maps have been identified as having a priority on realism before gameplay. These were analysed to explore the difference between professionally developed maps based on real world environments and those directly replicated into game environments.

6.4.1 Replicating a Locale

Replicating a known location exactly into a game world transfers the form and function of the location even though this form and function is not necessary for the virtual environment. As discussed in Chapter 4.1 designers often replicate everything from the chosen environment as Martin Chudley expressed:

The artists, particularly in the old days, wanted to make the setting pristine – every corner, every bollard, every lamppost had to be in exactly the right place. From a design perspective, we were going ‘no, no, no! – we’ve got to make this more playable!’ Always we would be trying to remove that bollard, shave a little from that corner – to make it better from a gameplay perspective. There’s always been a compromise. We wanted to make sure that the city is completely recognizable. (Simons, 2007)

It is still possible to find this form of design challenge within the modding community where an environment will be mapped exactly into a playable form. Applying spatial

syntax to such an environment enables a discussion to be had about the pros and cons of this form of design.

Boskoop is a mod map for *Counter-Strike* built by a modder known as cat food aka v33n and downloaded from <http://www.css.gamebanana.com/maps/25823>. It is a direct transfer of a village in the Netherlands into the *Counter-Strike* engine. The author of the map has uploaded photographs alongside the same camera points in the game environment. The modelling and texturing are very professional and the map has had many admiring comments and discussions on how realistic it is.

The interesting element for this study is that it is modelled to include a variety of general street furniture such as benches and signposts, alongside objects including cars and bicycles. These street elements appear to be placed appropriate to the positioning of their real world counterparts as opposed to positioning for gameplay. How the transfer of a near complete environment affects space syntax parameters is what is interesting about this environment.

The resulting correlations between visual integration [Tekl] and space syntax parameters are shown in Table 13. The environment has a high average visual integration level correlated to the space syntax parameters of 0.547. When the virtual environment is analysed without the street furniture this correlation increases to 0.67 as with the obstacles removed direct lines of sight are improved.

Table 13: R² values for Visual Integration and a listed space syntax parameter

Map	Occlusivity	Perimeter	Max Radial	Compactness	Average
Boskoop	0.574	0.597	0.562	0.453	0.547
Boskoop no street furniture	0.700	0.881	0.697	0.401	0.670
Dust2	0.617	0.568	0.367	0.684	0.559

The overall correlations of parameters with visual integration are similar to those of Dust2 but stronger on perimeter and maximum radial. Occlusivity and compactness for Dust2 have stronger correlations with visual integration than in Boskoop, significantly more so on compactness.

In order to make more sense of these broad figures it is necessary to examine the average metrics for each environment in more detail from Table 14: Comparison of Boskoop and Dust2 spatial correlations.

Dust2 is a much smaller area than de_boskoop as can be seen by the maximum values. Visual integration has been demonstrated as not affected by scale but the design and use of the space does affect the visual integration. Compactness as a relativised measure is similar but does not need to be as considered in terms of integration when the nature of the space is larger and more open.

An area designed for pedestrians and vehicles will inherently be more accessible to move around in than an area designed for players on foot due to the need for wider access areas. This will result in larger and less complex viewfields for safety and navigation reasons so maximum viewing distances, maximum radial, will be influential on the visual integration in the real environment. In Dust2, a smaller and more complex environment, compactness is more correlated with visual integration as the design considers how the complexity of the viewfield works within movement around the environment.

Table 14: Comparison of Boskoop and Dust2 spatial correlations

Map	Occlusivity	Perimeter	Max Radial	Compactness	Visual Integration
Boskoop Correlation	0.574	0.597	0.562	0.453	
Average	407.19	531.22	73.91	0.07	0.86
Maximum	1577.36	1757.7	164.77	0.76	0.91
Minimum	0.52	4.433	1.25	0.01	0.80
Standard Deviation	285.32	319.9	31.52	0.07	0.02
Dust2 Correlation	0.617	0.568	0.367	0.684	
Average	66.35	141.37	32.89	0.22	0.45
Maximum	201.75	330.33	77.51	0.64	0.48
Minimum	0	21.60	5.49	0.05	0.43
Standard Deviation	33.71	53.75	13.45	0.10	0.01

With the street furniture in the environment there would still need to be large vehicular access and so the street furniture is placed to the side of main thoroughfares and does not lower the visual integration below a high correlation.

Conclusions:

Overall these results are indicative of the design functions of the environments. The consideration for safety and clear lines of sight through the maximisation of viewing distances is appropriate for large real world environments. Small compact game environments require the consideration of the complexity of the viewfield to be a priority in their design in order to facilitate player movement.

Spatial metrics need to be considered contextually when transferring an environment as a direct replication into a game environment.

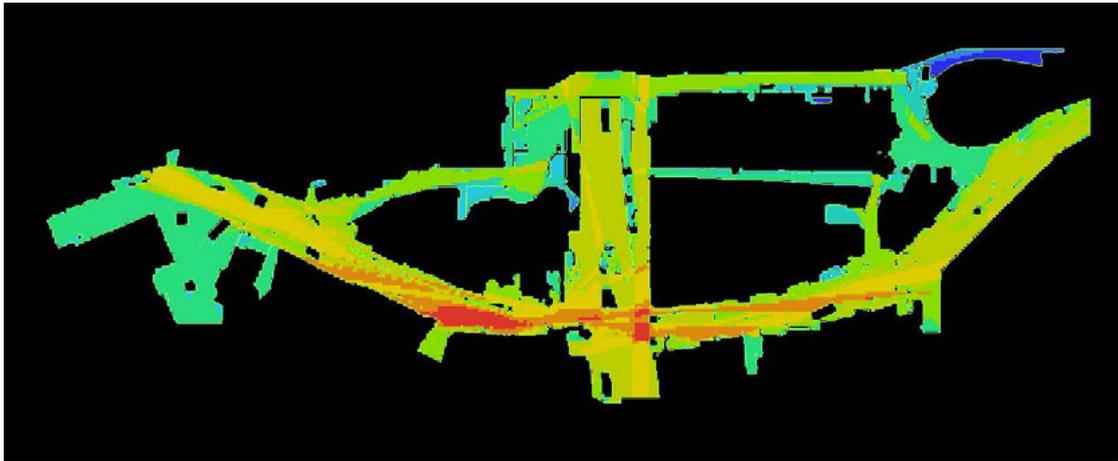


Figure 46: Boskoop with street furniture showing visual integration Tekl

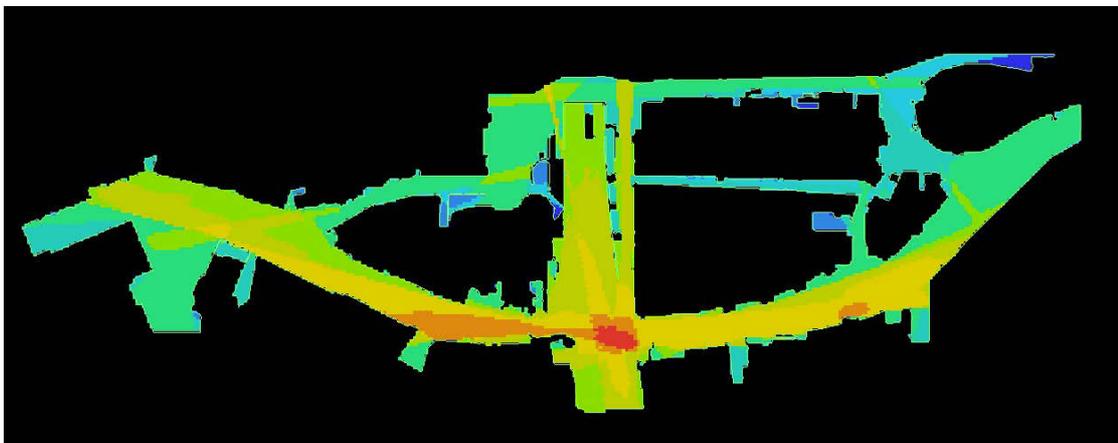


Figure 47: Boskoop without street furniture showing visual integration Tekl

6.4.2 Culture in The Overall Environment

Aims: *To consider the spatial metrics of large urban game environments with recognised cultural patterns in their layout.*

In Chapter 4.1.2 it was noted how Hall and others have discussed the effect of culture on the overall structure of a town or city and how the spatial structure of a town will reflect the spatial modalities of its builders. *The Getaway* was discussed in Chapter 4.2.4 as a direct geospatial transfer of an area of central London into a game world and the consideration that players may be used to more formulaic street structures. This is an obvious issue if a player is use to the grid system that American cities are often based upon as London is far from grid like in its structure.

If VGA analysis is applied to *The Getaway's* map of London taken directly from the map supplied with the game, Figure 49, then the resulting visual analysis using Tekl normalisation is shown in Figure 48. Visually this indicates a central integrated area, which is to be expected at the heart of a city, with the outer areas becoming less integrated.

The correlation of space syntax parameters with visual integration when compared to other games in Table 15 does indicate a demonstrably lower value across all parameters averaging at 0.2705. Even if there is no cultural element to deal with this is a demonstrably weaker spatially integrated environment.

Table 15: R² values for Visual Integration [Tekl] and a listed space syntax parameter

Map	Oclusivity	Perimeter	Max Radial	Compactness	Average
The Getaway	0.310	0.313	0.247	0.212	0.2705
GTA III	0.289	0.371	0.388	0.237	0.321
GTA III start area	0.356	0.461	0.455	0.508	0.445
Boskoop	0.574	0.597	0.562	0.453	0.547
Boskoop no street furniture	0.700	0.881	0.697	0.401	0.670
Dust2	0.617	0.568	0.367	0.684	0.559



Figure 50: *Grand Theft Auto III* environment with visual integration [Tekl]



Figure 51: *Grand Theft Auto III* starting area with visual integration [Tekl]

Table 15 also shows the metrics for the game *Grand Theft Auto 3* (Rockstar, 2002) a game using a similar form of gameplay of driving and pedestrian movement. This game series are all set in environments based on distinctive American cities and using traditional American grid layouts for the main elements of the environment. Table 15 shows the metrics for the complete environment as shown in Figure 50 and the metrics for just the area the player is contained in while they complete the first element of the game shown in Figure 51.

The starting environment for *Grand Theft Auto III* has an average correlation of 0.445 that is then reduced to 0.321 when analysing the whole system. It is to be expected that a starting environment will be easier to navigate than the complete environment, as this is where the player is introduced to the environment and the gameplay. As this game is set in an American context the use of the more regular grid system aids this integration and even when the more organic areas outside of the city are introduced the overall average correlation is over 0.3.

With both the *Getaway* and the *Grand Theft Auto* environments they are analysed without any street furniture. It is just the roads the player has to navigate and as seen with *de_boskoop* the addition of street furniture reduced the overall correlation by over 0.1.

The fact that *The Getaway* included a printed map indicating London landmarks may be indicative of designers recognising, tacitly or implicitly, the imageability of London balanced with the lack of intelligibility to its structure.

Conclusions:

The discussion of spatial metrics can aid the design discussion of navigability in large game environments. The analysis of appropriate urban layouts dependent on cultural knowledge will be useful at the start of large environment design projects. The ability to consider smaller beginner environments and the stepping up of navigability challenges as areas open up to a player is a useful design tool.

6.5 Asian FPS

Aim: *To determine if there are cultural differences between Asian and Western FPS game environments indicated by spatial metrics.*

In order to explore the hypothesis of the transfer of cultural experiential knowledge being evident in game environments meant the spatial analysis of Asian game environments. These game environments were required to be of similar form of gameplay to those already analysed from *Counter-Strike* and this meant exploring the first person shooter (FPS) genre for more suitable games.

The age of the game was also considered as it can be expected that the designers of the latest FPS games will have had more global exposure to the genre and therefore cultural nuances may already be disappearing. The market history for FPS games in Asia is a separate study in itself and for this element of the study South Korea has the most active FPS game development community.

The FPS genre has had a history of poor market impact in Japan as discussed in Chapter 2.1.1 though some discussion of whether certain Japanese games can be classified as being FPS such as the game series of *Metroid Prime* (Retro Studios, 2002) or *Front Mission* (G-Craft, 1995) was encountered. For this element of the study the games analysed are required to be of parity with the *Counter-Strike* series of games and the South Korean market has developed several that are similar in form.

The online FPS *Special Force* (Dragonfly, 2004) was originally released in South Korea and has since been released in other markets known as *Soldier Force* and is commonly referred to as SF. Other online FPS games released in South Korea around the same time were *Sudden Attack* (GameHi, 2005) and *War Rock* (Dream Execution, 2005). All three games are currently accessible online having been updated to compete with more modern FPS games though the latest online FPS games such as *Cross Fire* (SmileGate, 2007) and *Combat Arms* (Doobic Studios, 2008) are now much more popular.

In order to analyse different game environments it was previously necessary to process the 3D models as described in chapter 5.5 using modelling software to reduce the environment down to its component floor plan. The online FPS game does download environments to the user's computer but unlike *Counter-Strike* they do not provide

toolsets to enable personal modifications of those environments. This availability in *Counter-Strike* and other stand-alone FPS games also created the amateur modding community. Without these tools any environment analysed would only be from professional game designers and not amateur designers who are not constrained by commercial interests. This meant that there was unlikely to be seen the development of new game types, as with *Counter-Strike*.

Several South Korean, or the relevant Western version, online FPS games were tested to see whether it was possible to extract the map data required to process for analysis but this was not possible. It was discovered that certain members of game communities had managed to find ways to extract texture files within player models and replace them with their own personalized imagery, but environment models had not been hacked in this way.

This meant that the construction of plans for the environments to be analysed would have to be painstakingly built up from available imagery in game guides from the developer and player sites. This was then cross-referenced with video and screen shots from in the games. To ensure comparable scale for spatial measurements the standard object in all environments and used across most FPS games, the crate, gave a comparable measure in plan view.

In this way low-resolution outline plans could be built up using design software into the required DXF formats for *Depthmap*. The process of acquiring screen shots and in game video proved easier in some games where a private game environment for training could be established. In other games it was necessary to join other players in the environment and use the time to take screen shots and capture footage instead of joining in. This was occasionally noticed by other players and led to my poor player statistics on some game servers as well as occasional unfriendly comments.

6.5.1 Map Analysis

Aims: *To establish if there are spatial differences between a group of Western and a group of Asian FPS game environments.*

In order to choose maps from any game they had to correspond with the mode of gameplay in *Counter-Strike*. The game *Sudden Attack* has a game mode called demolition, and the game *Special Force* has a game mode called Team Battle Mode and

Combat Arms has a range of gameplay modes all of which involve opposing teams defending or attacking within the environment.

Initial analysis is of five maps from *Special Force*, five maps from *Combat Arms* and two from *Sudden Attack*. The number of maps is not as many as would be expected to determine a clear result but the obtaining and processing the maps is problematic. It is hoped that by establishing the hypotheses and a valid methodology this will open routes into industry to obtain access to the 3D data to further develop these early conclusions.

At present it is not known if these maps have been adapted over the life of the game but they have been chosen because of early development dates or their specificity to the South Korean version of the game.

The first test was to see whether the individual game environments from the three different South Korean games offered statistically different environments or were comparable as a single group of game environments.

A Kruskal-Wallis test was run to determine if there were differences between space syntax measures between game environments grouped by game. The isovist parameters of area, compactness, maximum radial, occlusivity and perimeter were tested along with the VGA parameters of visual integration [Tekl], visual integration [P-value] and relativised visual entropy.

There was no statistically significant difference between the three game groups except for the parameter maximum isovist radial where pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. The maximum radial parameter was not statistically significantly different when corrected for multiple comparisons between the games of *Sudden Attack* and *Combat Arms* ($p = 1$), *Sudden Attack* and *Sudden Force* ($p = 0.067$) or *Combat Arms* and *Sudden Force* ($p = 0.197$),

Therefore this establishes an initial position that these environments are comparable as a group of environments from South Korean games in terms of space syntax measures.

Table 16: Results for the Kruskal-Wallis comparison of the three South Korean Games

Parameter	<i>Sudden Force Mdn</i>	<i>Sudden Attack Mdn</i>	<i>Combat Arms Mdn</i>	$\chi^2(2)$	<i>p</i>
Area	1123	512	984	5.915	0.052
Compactness	0.197	0.270	0.206	1.646	0.439
Max Radial	63	43	57	6.346	0.042
Occlusivity	133	67	123	4.231	0.121
Perimeter	275	169	260	4.846	0.089
Visual Integration [P-value]	0.415	0.367	0.448	0.746	0.689
Visual Integration [Tekl]	0.846	0.823	0.852	1.731	0.421
Relativised Visual Entropy	2.33	2.48	2.35	0.254	0.881

The twelve maps can now be determined to be consistent as a group of South Korean maps. This means the five maps from *Counter-Strike Online* designed for the Asian market can be compared to the new group of South Korean maps.

A Mann-Whitney U test was run to determine if there were differences in spatial parameters between *Counter-Strike Online* maps and the group of South Korean maps. Distributions of all the spatial parameters were not similar, as assessed by visual inspection. There was no statistically significantly difference in spatial parameters between *Counter-Strike Online* maps and the group of South Korean maps except within visual integration [Tekl]. The results are listed in Table 17. Visual Integration [Tekl] for maps from *Counter-Strike Online* (mean rank = 3.00) were statistically significantly lower than for South Korean maps (mean rank = 11.5), $U = 0$, $z = -3.162$, $p = .002$.

Table 17: Results for the Mann-Whitney comparison of *CS Online* and South Korean Games

Parameter	<i>U</i>	<i>z</i>	<i>p</i>
Area	14.00	-1.687	0.092
Compactness	17.00	-1.370	0.171
Max Radial	17.00	-1.370	0.171
Oclusivity	27.00	-0.316	0.752
Perimeter	20.00	-1.054	0.292
Visual Integration [P-value]	39.00	0.949	0.343
Visual Integration [Tekl]	0.00	-3.162	0.002
Relativised Visual Entropy	6.00	-0.422	0.673

The five maps shipped with *Counter-Strike-Online* have been compared to the group of South Korean game environments in this test and the spatial parameters are comparable in all areas except visual integration with Teklenburg normalization. The maps for *Counter-Strike Online*, either chosen or developed specifically for the Asian market by the South Korean developer, match the characteristics of other maps for this market.

The next test was to compare these environments against the group of original Western *Counter-Strike* environments previously used in comparing professional and amateur environments. A Mann-Whitney U test was run to determine if there were differences in spatial parameters between *Counter-Strike* maps and the group of South Korean maps including the maps from *Counter-Strike Online*.

Spatial parameters were not statistically significantly different between *Counter-Strike* maps and the group of South Korean maps for isovist area and isovist compactness and are reported in Table 18.

Spatial parameters were statistically significantly different between *Counter-Strike* maps and the group of South Korean maps for isovist maximum radial, isovist oclusivity, isovist perimeter, visual integration [Tekl], visual integration [P-value] and relativised visual entropy. These are reported in Table 19. Distributions of all the spatial parameters were similar, as assessed by visual inspection except for visual integration [Tekl].

Table 18: Non significant results for the comparison of *Counter-Strike* and South Korean maps

Parameter	<i>U</i>	<i>z</i>	<i>p</i>	<i>Counter-Strike Mean Rank</i>	<i>South Korean Mean Rank</i>
Area	169.00	1.567	0.117	13.73	18.94
Compactness	90.00	-1.416	0.157	19.00	14.29

Table 19: Significant results for the comparison of *Counter-Strike* and South Korean maps

Parameter	<i>U</i>	<i>z</i>	<i>p</i>	<i>Counter-Strike Median</i>	<i>South Korean Median</i>
Max Radial	195.00	2.549	0.011	41.58	56.79
Occlusivity	182.00	2.058	0.040	92.86	123.63
Perimeter	182.00	2.058	0.040	191.39	247.42
Visual Integration [P-value]	182.00	2.058	0.040	0.34	0.45
Visual Integration [Tekl]	238.00	4.174	0.000	Mean Rank 9.13	Mean Rank 23.00
Relativised Visual Entropy	63.00	-2.436	0.015	2.50	2.35

This indicates there are a range of spatial parameters that are significantly statistically different between the group of maps designed for *Counter-Strike* and the group of maps designed for South Korean games including *Counter-Strike Online*.

The significance of occlusivity, perimeter and maximum radial values but not compactness between *Counter-Strike* maps and the group of South Korean maps Table 18 and Table 19 is interesting from a cultural design element. Drawing on Nisbett and others work on the cultural cognitive differences in reading the visual field. Asian subjects demonstrated an ability to read more complex images than Westerners. It was thought that the viewfield for the player in a game developed by an Asian developer and for Asian markets would indicate significance in compactness, as discussed in Chapter 4, but this is not apparent.

These results indicate the Asian designed maps have a longer maximum radial, higher occlusivity and longer perimeters than the group of Western designed maps. The higher occlusion parameter is indicative of a more complex isovist boundary. The parameters of a larger maximum radial and larger perimeter can be argued either way as these may

mean longer more focussed fields of view suiting the Western model or larger fields of view suiting the Asian model.

Visual integration is higher for the Asian maps indicating more considered environments with lower entropy indicating less rapid changes in the nature of the environment as a player moves through it. This would indicate the Asian maps are more controlled environments for the player to move through as they are more integrated without rapid changes in depth.

Conclusions:

These initial results indicate there are differences between the two cultural groups of 3D environments but the expected areas for visual design differences have not been significant. Compactness of the viewfield has not been significant in comparisons between Western and Asian maps but the VGA measures may be indicating a more holistic design thinking to the map possibly in line with Nisbett's theory on Asian thinking if not on the 2D viewfield.

6.5.2 Visual Integration Method

***Aim:** To determine if the Teklenburg normalisation methods for visual integration is reliable to continue considering its results.*

Visual integration [Tekl] did not have compatible distributions when visually assessed for the Mann-Whitney test but visual integration [P-series] did. The Teklenburg method has been slightly stronger in indicating differences in areas where cultural differences were expected to be indicated. It had been noted in Chapter 4.2.5 that visual integration [Tekl] would not be used as a sole major element in design interpretations. To determine in more depth what is occurring within both methods of normalisation the correlation between isovist properties for individual South Korean maps is indicated in Table 21 and Table 22. The immediately noticeable element is that visual integration [Tekl] is consistently higher in the South Korean game environments (CA, SA, SF) than in the Counter-Strike-Online environments (CSO).

Table 20: Isovist Correlation with Visual Integration [Tekl]

Map	Game	Visual Int [Tekl]	Occlusivity R ₂	Perimeter R ₂	R ₂ Max Radial	Compactness R ₂	Mean R ₂
Train	CSO	0.462	0.007	0.140	0.273	0.088	0.127
Greesia	CSO	0.523	0.670	0.796	0.544	0.576	0.647
Rex	CSO	0.431	0.503	0.602	0.529	0.342	0.494
Tunnel	CSO	0.503	0.809	0.857	0.016	0.461	0.536
Dust2	CSO	0.455	0.617	0.568	0.367	0.684	0.559
Nervegas	SF	0.838	0.266	0.280	0.111	0.407	0.266
Hospital	SF	0.839	0.386	0.403	0.254	0.189	0.308
Missile	SF	0.846	0.577	0.526	0.336	0.387	0.457
Shanghai	SF	0.865	0.587	0.581	0.304	0.388	0.465
Desert Camp	SF	0.866	0.659	0.684	0.451	0.431	0.556
Old Town	SA	0.803	0.355	0.347	0.304	0.396	0.351
3rd Supply	SA	0.842	0.498	0.663	0.450	0.353	0.491
Warhead	CA	0.814	0.638	0.663	0.578	0.321	0.550
Sandhog	CA	0.832	0.539	0.589	0.561	0.342	0.508
Grayhammer	CA	0.852	0.690	0.727	0.621	0.310	0.587
Pumpjack	CA	0.853	0.703	0.654	0.445	0.713	0.629
Coldseed	CA	0.882	0.607	0.707	0.513	0.234	0.515

Table 21: Isovist Correlation with Visual Integration [P-value]

Map	Game	Visual Int [P-value]	Occlusivity R ₂	Perimeter R ₂	R ₂ Max Radial	Compactness R ₂	Mean R ₂
Train	CSO	0.274	0.545	0.64	0.553	0.368	0.527
Greesia	CSO	0.309	0.655	0.643	0.364	0.264	0.482
Rex	CSO	0.485	0.009	0.146	0.271	0.091	0.129
Tunnel	CSO	1.064	0.808	0.859	0.009	0.411	0.522
Dust2	CSO	1.480	0.69	0.817	0.534	0.567	0.652
Nervegas	SF	0.348	0.251	0.267	0.100	0.381	0.250
Hospital	SF	0.358	0.417	0.440	0.269	0.200	0.332
Missile	SF	0.415	0.586	0.525	0.326	0.374	0.453
Shanghai	SF	0.520	0.601	0.587	0.302	0.371	0.465
Desert Camp	SF	0.535	0.672	0.685	0.425	0.431	0.553
Old Town	SA	0.285	0.38	0.363	0.321	0.413	0.369
3rd Supply	SA	0.448	0.538	0.714	0.475	0.362	0.522
Warhead	CA	0.296	0.682	0.703	0.613	0.316	0.579
Sandhog	CA	0.368	0.618	0.657	0.599	0.380	0.564
Grayhammer	CA	0.448	0.726	0.777	0.643	0.313	0.615
Pumpjack	CA	0.456	0.719	0.677	0.446	0.661	0.626
Coldseed	CA	0.643	0.623	0.719	0.509	0.208	0.515

In order to consider what might be the key isovist parameters within the players viewfield that are correlated with the overall visual integration a linear regression was produced for both forms of integration. The purpose was to explore whether correlations were apparent and to inform the decision on which visual integration parameter to continue forward with.

The R value for the correlation of parameters with Visual Integration [Tekl] was 0.350 and the R^2 was 0.122 with $p > 0.05$. This means the independent variables explain 12.2% of visual integration [Tekl] and do not add statistically significantly to its prediction.

The R value for the correlation of parameters with Visual Integration [P-series] was 0.76 and the R^2 was 0.578 with $p < 0.05$. This indicates the independent variables explain 57.8% of visual integration [P-series] and add statistically significantly to its prediction.

Conclusion:

The assumption will now be made that visual integration Tekl is not reliable for correlation with visible design parameters even though early results showed correlation. This does not invalidate earlier discussions of the comparison of single environments but as the number of environments compared increases the more robust method of Visual integration using the P-series normalisation will be used.

6.5.3 Deeper Visibility Graph Analysis

***Aim:** To determine were the complexity in Asian environments is compared to Western environments if it is not in the expected isovist metric of compactness.*

Statistical comparisons of groups of game environments indicate significant differences between them within certain space syntax metrics. To connect these to design elements, and effectively findings on cultural differences with the interpretation of the visual image, the focus has been on isovist or viewfield metrics directly relevant to the design process.

The metrics of occlusivity, perimeter size, maximum radial and compactness are measures that can be ascertained from a single viewpoint in the game space by a designer. They translate to design questions of how far can the player see (maximum

radial), how difficult to interpret and control is the perimeter of my field of view (perimeter size, occlusion, compactness). These are under the direct control of designers who may position themselves in an appropriate place to adjust these through the manipulation of elements within the environment. The designer can move a wall, place an object in a line of sight or block an occluded element of the perimeter to alter these metrics.

The use of visual integration as the dependent correlated metric makes sense for this investigation in terms of the transfer of knowledge into game environments. It has a relationship to a person's movement and their way finding decisions within an environment.

Cultural findings on the differences in the interpretation of the visual image by Western and Eastern cultures indicate differences would be expected to be in the interpretation of complexity within an image. Eastern subjects are more adept at interpreting information across the field of view while Western subjects are more focussed on the central area of an image. Translating this into the two dimensional representation on a screen of a three dimensional environment would indicate possible differences in the four isovist metrics investigated.

Long viewfields and less compactness and occlusion would indicate simpler screen images in clear goal driven game environments. High compactness would indicate more complex viewfields and with high occlusion would mean complicated screen images for the player to interpret.

This initial interpretation of the transfer of cultural differences into spatial metrics is not borne out by the results indicated. Compactness is not significantly different across cultural groups of environments yet other spatial metrics are. The conundrum for the designer is that the next set of metrics to be considered are categorised as *visual* metrics but do not have the obvious visual starting point of a designer considering the view from the centre of an isovist. The term visual is applied to them as they are derived through the use of visibility graph analysis (VGA) as described in chapter 5.3.

Visual integration is a normalised measure of the space using visibility graph analysis. It is a measurement considering how deep or shallow a vertex is within the grid of vertices applied to the environment. It is a reciprocal of the mean depth within the grid compared to all the other vertices in the grid. This measure is not something a designer

can have an immediate design view on, as it is a measurement within the context of all the other points in the environment. Changes the designer makes will have an effect on all other vertices in the graph and the visual integration values across the environment. This led to the initial starting point of correlating isovist metrics with this visual graph measure.

Visual clustering coefficient, visual control and visual controllability are other VGA VGA metrics explained in detail in Chapter 5.3. They are considered as local measures meaning they are calculated by using their local neighbourhood within the VGA. A Mann-Whitney U test was run to determine if there were differences in visual clustering coefficient, visual control and visual controllability between the group of Western *Counter-Strike* maps and the group of South Korean maps. Distributions of the spatial parameters were similar, as assessed by visual inspection.

The median visual clustering coefficient was statistically significantly higher in Western maps (0.756) than in South Korean (0.715), $U = 55, z = -2.738, p = .006$.

The median visual controllability was statistically significantly higher in Western maps (0.379) than in South Korean (0.308), $U = 64, z = -2.398, p = .016$.

The median visual control was not statistically significantly different in Western maps to the South Korean, $U = 135, z = 0.238, p = .777$.

Conclusion:

The VGA measures of visual integration, visual clustering coefficient, visual controllability and relativised visual entropy can be said to be significantly statistically different in the comparison of game environments from the Western version of *Counter-Strike* to those environments from the South Korean games.

These are VGA measures that are calculated across the environment so changes in one area made by the designer will have an impact across the environment. This will not be visible other than through these spatial metrics that represent the intelligibility of the environment. This is a tacit design ability to produce a visually integrated environment without a visual measure.

6.5.4 Balance of Correlations

Aim: *To find out which isovist measures are influencing the VGA measures within the Eastern and Western groups of game environments.*

The evidence that visual integration, visual clustering coefficient, visual controllability and relativised visual entropy are significantly different means that there is a set of spatial metrics that are not immediately obvious in terms of design decisions of how to adjust them. Any change to them alters the characteristics of the system and not just the local area the designer may be changing. This is indicative of the tacit knowledge of the designer intuitively designing these spatial differences.

In order to examine what was important in terms of creating the levels of visual integration a comparison of the isovist metrics influencing visual integration for each environment was implemented. The R^2 value was used for the isovist metrics of perimeter, occlusion, compactness and maximum radial. A Mann-Whitney U test was run for measurement of correlation to visual integration for the isovist parameters between the Western and Asian groups listed in Table 22.

Table 22: Break down of Western and Asian Game Environments

Western	Asian
Office	Greesia
Estate	Tunnel
Train	Rex
Dust2	Sandhog
747	Coldseed
Cobble	Warhead
Inferno	Grayhammer
Dust	Pumpjack
Siege	Desert Camp
Nuke	Hospital
Tuscan	Missile
Italy	Nervegas
Militia	Shanghai
Back Alley	3 rd Supply
Prodigy	Old Town

In order to consider a deeper level of statistical correlation with design differences the game maps were divided into two categories. This time game maps developed purposefully for the *Asian Counter-Strike Online* game were placed in the Asian category assuming an Asian design origin but those original maps that were shipped with *Counter-Strike Online* developed earlier for the Western *Counter-Strike* game were left in the Western category.

The Mann-Whitney U tests for the statistical characteristics of the correlation with visual integration indicated statistically significant differences between the category of Asian and Western environments only in the areas of R^2 compactness.

The distributions of these for Western and Asian environments were similar, as assessed by visual inspection. Median R^2 compactness was statistically significantly higher in Asian environments (0.374) than in Western environments (0.302), $U = 51$, $z = -2.551$, $p = .011$.

This indicates that in the design of the Asian environments, which demonstrate higher levels of visual integration than Western environments, the consideration of visual compactness is stronger.

As these are slightly different groups to the earlier Asian and Western map groups tested a Mann-Whitney U test of the visual clustering coefficient and the isovist compactness for the groups was conducted. This was to ensure that a direct comparison between the visual clustering coefficients would still be significant and the isovist compactness would not.

The distributions of these parameters for Western and Asian environments were similar, as assessed by visual inspection. Median visual clustering coefficient was statistically significantly higher in Western environments (0.756) than in Eastern environments (0.711), $U = 45$, $z = -2.8$, $p = .005$.

Median isovist compactness was not statistically significantly higher in Western environments (0.225) than in Eastern environments (0.202), $U = 83$, $z = -1.224$, $p = .221$.

Conclusion:

This indicates that when considering the design of visual integration compactness plays a stronger part in the design of Asian environments than it does in Western environments.

A significant difference is not evident at the isovist level as an independent parameter but the visual clustering coefficient is. The stronger influence of compactness on visual integration and the lower visual clustering coefficient in the Asian environments is indicative of the expected cultural differences in the cognitive process of the designer.

The design of the Asian environments involves higher levels of visual integration strongly influenced by the compactness of individual isovists. The Asian environments are also more complex in terms of the neighbourhoods of isovists making up the spaces in the environment.

6.5.5 Asian FPS conclusions

The results indicate that there are design differences between the original *Counter-Strike* maps and similar maps from Asian FPS games. The *Counter-Strike* environments adapted for the Asian market and distributed with *Counter-Strike Online* are comparable to the maps from the other Asian FPS games. This indicates a considered design approach, either tacitly or explicitly, for a different cultural market.

There is a need for a greater diversity of game environments and access to more detailed models to be able to analyse nuances in cultural design differences but it can be stated that this methodology does offer a positive direction for determining cultural differences with the initial results, listed in Table 23, giving indicative spatial design differences applied to the geometry and therefore the intelligibility of the environment.

Asian maps indicated higher perimeter, occlusion and maximum radial measurements, but with no difference in area. This establishes that even though the area of isovists is similar the shape cannot be as the perimeter is not. Two isovists with similar areas but not perimeters or maximum radials means one must be a different shape to the other. The issue was that compactness does not indicate a significant difference to indicate spikiness only the perimeter length being higher indicates a more complex shape. As occlusion is also higher then so is the complexity of the viewfield meaning Asian maps have isovist viewfields of a similar area but spikier and more complex. This creates a

more complex 2D image of the 3D space when seen on screen by the player. This is as expected from the cultural hypothesis that Eastern cultures cope better with complex 2D images than Western cultures.

The lower visual controllability in Asian maps indicates less space that can be dominated by the spaces around it and the lower relativised visual entropy indicates less rapid changes in distribution as you move through the graph. This indicates environments with smaller evenly distributed spaces rather than areas of larger easily controlled spaces. The lower visual clustering coefficient supports the spikiness of the viewfields across the environment. Asian maps can therefore be said to contain smaller, more complex viewfields yet be better integrated as spaces due to their higher visual integration. This again is as expected from the cultural hypothesis that Eastern cultures cope better with complex 2D images than Western cultures.

Table 23: Comparison of significant spatial differences

Spatial Parameter	Western	Asian
Isovist Area	No Difference	No Difference
Isovist Perimeter	Lower	Higher
Isovist Occlusion	Lower	Higher
Isovist Maximum Radial	Lower	Higher
Isovist Compactness	Weaker influence on visual integration	Stronger influence on visual integration
Visual Integration	Lower	Higher
Relativised Visual Entropy	Higher	Lower
Visual Clustering Coefficient	Higher	Lower
Visual Control	No Difference	No Difference
Visual Controllability	Higher	Lower

The stronger influence of compactness on the visual integration of Asian maps is to be expected if these maps are considered to be more complex. That it is only significant in the correlation to visual integration and is not significant when measuring the geometry

implies tacit knowledge more than an explicit design strategy on the part of the designer.

The results so far have to be carefully considered as the level of data available is minimal and not in the quantity to establish definitive answers. In a design context dealing with culture and the human interaction with designed artefacts definitive answers are rare. To be able to discuss if design elements and cultural differences could be identified through the methodology and considered in terms of design rules and the knowledge of the designer then a definite starting position has been established.

6.6 Intelligible Patterns for Imageability

***Aim:** To examine the current data for design patterns that are possible to be considered during the process of designing and building a game environment.*

When a designer considers an environment this is often as a 2D system through the method of drawing out the environment on paper. Within this process the designer has explicit and tacit knowledge of the considerations of a 3D environment through professional and cultural experience. At the beginning of the design process the designer is not just considering a 2D viewfield as seen by the player but is thinking about the environment's intelligibility. This considers the subsystems within that environment and their implications of intelligibility and imageability. Subsystems can be thought of as small game spaces that would consist of combinations of first level architecture considering the flow of the player through the gamespace.

The consideration of visual integration at this point is tacit, through the correlating isovist elements as drawn in initial design plans and the way finding property of visual integration evolves through this. This can be considered to be the natural thinking of a designer considering how a player will travel through the environment. The correlating aspect of visual integration is the spatial complexity of the subsystems within the overall environment.

In order to explicitly inform the designer and game design, statistical patterns in spatial properties correlated to visual properties would be beneficial. A cultural difference in intelligibility measurements correlated to imageability in a form understandable to designers is the next aim.

6.6.1 Statistical Distribution Patterns

***Aim:** To examine current results for statistical distribution patterns that may be visible to the designer through colour representations in the VGA of the environment.*

Results so far are based on the mean of each spatial parameter across the game environments and the statistically significant differences in medians of the groups of maps using those means. In order to consider a deeper level of statistical correlation with cultural differences by the designer the analysis of two categories for the parameters of visual integration, visual clustering coefficient and isovist compactness

were again conducted. This time the comparison used the mean, standard deviation, median, relative standard deviation, kurtosis, skewness and inter-quartile range of each parameter. These give a more robust understanding of the statistical qualities and shape of the data spread for each spatial parameter. The game maps were divided using the two categories in Table 22. Game maps developed for the Asian *Counter-Strike Online* game are placed in the Asian category but original maps that shipped with *Counter-Strike Online* developed for the Western *Counter-Strike* game were left solely in a Western category. This assumes a level of cultural design influence from the designer as opposed to for the player.

The consideration of the pattern or shape of the data can be fed back to the visual inspection of the visual graph for each parameter. If there are indicators of significant differences in the shape of the graph of the data, as might be indicated by kurtosis or skewness, these offer the possibility of visual patterns in the spread of values across the colour rendering of the environment's VGA. Consequently certain statistical patterns might indicate geometric patterns enabling the correlation of statistical interpretations to the visual graph and the discussion of design decisions.

The Mann-Whitney U test was run to determine if there were differences in the group of statistical parameters containing the mean, standard deviation, median, relative standard deviation, kurtosis, skewness and inter-quartile range for the spatial properties of visual integration (vi), visual clustering coefficient (vcc). These two VGA parameters are considered important to the design but hard to interpret without a visual graph indicating them. The use of acronyms aids discussion when statistically discussing statistical measures.

The Mann-Whitney U tests for visual integration indicated statistically significant differences in Western and Asian environments in the measurements of vi-mean and vi-standard deviation for environments, but not in the other categories.

The distributions for vi-mean and vi-standard deviation were similar, as assessed by visual inspection. Median for the vi-mean was statistically significantly higher in Asian environments (0.445) than in Western environments (0.338), $U = 161$, $z = 2.012$, $p = .044$. Median for the vi-standard deviation was statistically significantly higher in Asian environments (0.093) than in Western environments (0.071), $U = 161$, $z = 2.012$, $p = .044$.

Visual integration can therefore be said to be statistically significantly higher in the environments in the Asian category than environments in the Western category. This was already known from section 6.5.4. The new finding is the higher standard deviation in the Asian group of maps than the Western group and the similarity in the statistical measures of median, relative standard deviation, kurtosis, skewness and interquartile range.

These indicate the only difference between visual integration for Western and Asian maps are the higher level of visual integration and the higher standard deviation of the medians for this group. Asian maps have a wider spread of visual integration but the shape of the distribution is similar to that of Western maps.

The Mann-Whitney U tests for the statistical characteristics of the visual clustering coefficients indicated statistically significant differences in the vcc-mean, vcc-median, vcc-relative standard deviation and vcc-skewness. The distributions of these for Western and Asian environments were similar, as assessed by visual inspection.

Median vcc-mean was statistically significantly higher in Western environments (0.756) than in Asian environments (0.711), $U = 46$, $z = -2.758$, $p = .006$.

Median vcc-median was statistically significantly higher in Western environments (0.759) than in Asian environments (0.706), $U = 47$, $z = -2.717$, $p = .007$.

Median vcc-relative standard deviation was statistically significantly higher in Asian environments (0.18) than in Western environments (0.166), $U = 176$, $z = 2.634$, $p = .008$.

The more vertices a vertex can see within its own neighbourhood the higher the value of the visual clustering coefficient for that vertex. If most of the locations within a neighbourhood can see each other this value approaches one and the more complex an environment the lower the value. The statistically higher mean and median for visual clustering coefficients indicate that the Western environments contain simpler locations as indicated in section 6.5.4. The higher standard deviation for Asian environment points to a larger range of values for visual clustering coefficients in these environments.

Median vcc-skewness was statistically significantly different in Eastern environments (0.158) than in Western environments (-0.07), $U = 172$, $z = 2.468$, $p = .013$.

The positive skew to Asian environments means values in the lower range of visual clustering coefficient are more frequent and build up quickly then the frequency drops as the visual clustering coefficient gets higher. The negative skew to Western environments means frequency rises slowly to a higher value and then quickly drops off. This is commensurate with a larger frequency of high values for visual clustering coefficients in the Western group of environments.

Conclusion:

For visual integration it will be evident in the VGA rendering of a greater standard deviation across the spectrum of colours used to indicate values on Asian maps. Visual clustering coefficient will be evident on the graph as a weighting to the colour spread with a stronger use of the colours indicating lower values for Western environments and higher values for Asian environments.

6.6.2 Hierarchical Clustering

***Aim:** To look for design patterns across the spatial metrics of all the game environments through statistical analysis using hierarchical clustering.*

In order to explore design patterns across all of the game environments a statistical comparative methodology was attempted in order to establish a starting point for a deeper level of design discussion. The data from all Western and Asian maps was processed with a hierarchical clustering methodology to establish if there were hierarchies evident with environments through the different spatial metrics. *SPSS* was used to construct a dendrogram for the relevant visual metrics from the environments. This method is comparing the data from a specific metric across environments as opposed to the previous consideration of the sets of metrics for each environment.

Hierarchical clustering looks to build a hierarchy through specific strategies for clustering the data. This data was examined using Ward's method where the decision to merge data into clusters is an agglomerative approach 'bottom up' approach. The clusters with minimum distance between them are merged progressively giving a hierarchy of data clusters with the distance between the nodes where clusters are merged indicative of similarity.

This approach illustrates through the dendrogram possible groupings of environments for the visual metric. The distance between the clustering is of interest as there are large clusters of data at the first level with visual integration in Figure 52 and relativised visual entropy in Figure 53. There is then a large distance between following nodes where the clusters are deemed comparable. This instant clustering indicates similarities between the environments within these visual metrics. This is not apparent in the dendrograms for clustering coefficient, Figure 54, and controllability in Figure 55.

Conclusions:

These groupings do not indicate a cultural hierarchy as Western and Eastern games are spread throughout the initial clusters. Therefore the groupings are indicative of multicultural hierarchies.

The spread of environments from specific games is not immediately indicative of strong individual game characteristics, as environments are not grouped by specific game. This indicates that hierarchies for these parameters are not specifically stronger for any game, Western or Asian.

In the investigation of design characteristics dependent on these spatial metrics they do offer further lines of inquiry. These groupings offer a starting point for a discussion of the visual graphs of specific metrics and possible design patterns. The indication of environments that can be grouped together offers a focus to the design interpretation of visual graphs.

A heightened importance to the design characteristics of visual integration and relativised visual entropy is apparent, as the distance to establish comparable clusters for these within the hierarchy was initially minimal. It then required a greater distance before the clusters could be merged demonstrating strong independent groups of characteristics. This could be important when considering how to begin to analyse the design of game environments in establishing design patterns within these two parameters.

This hierarchical methodology does not enable conclusions to cultural questions but does highlight possible starting points for understanding statistical patterns in the design of the game environments.

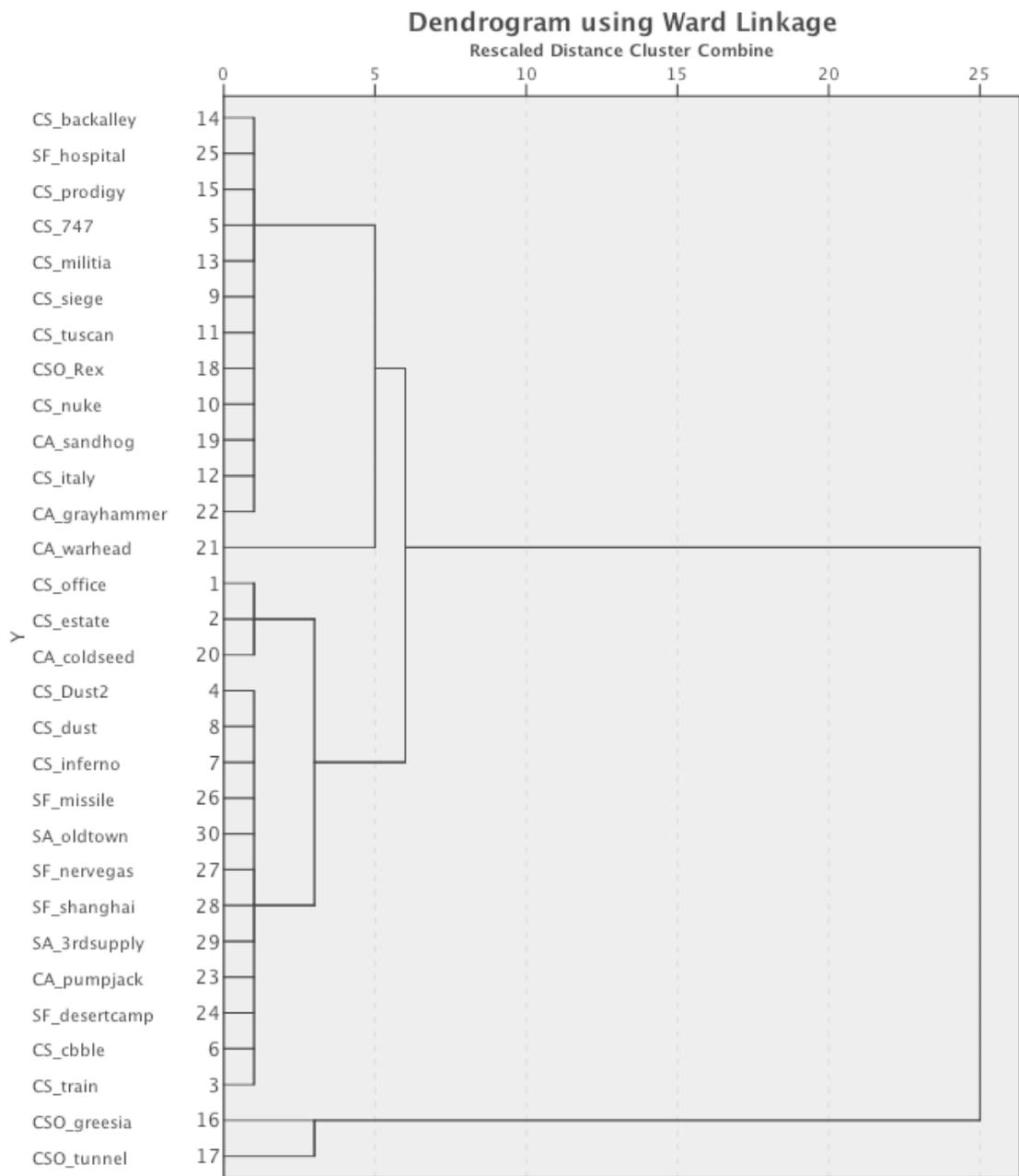


Figure 52: Dendrogram of Visual Integration

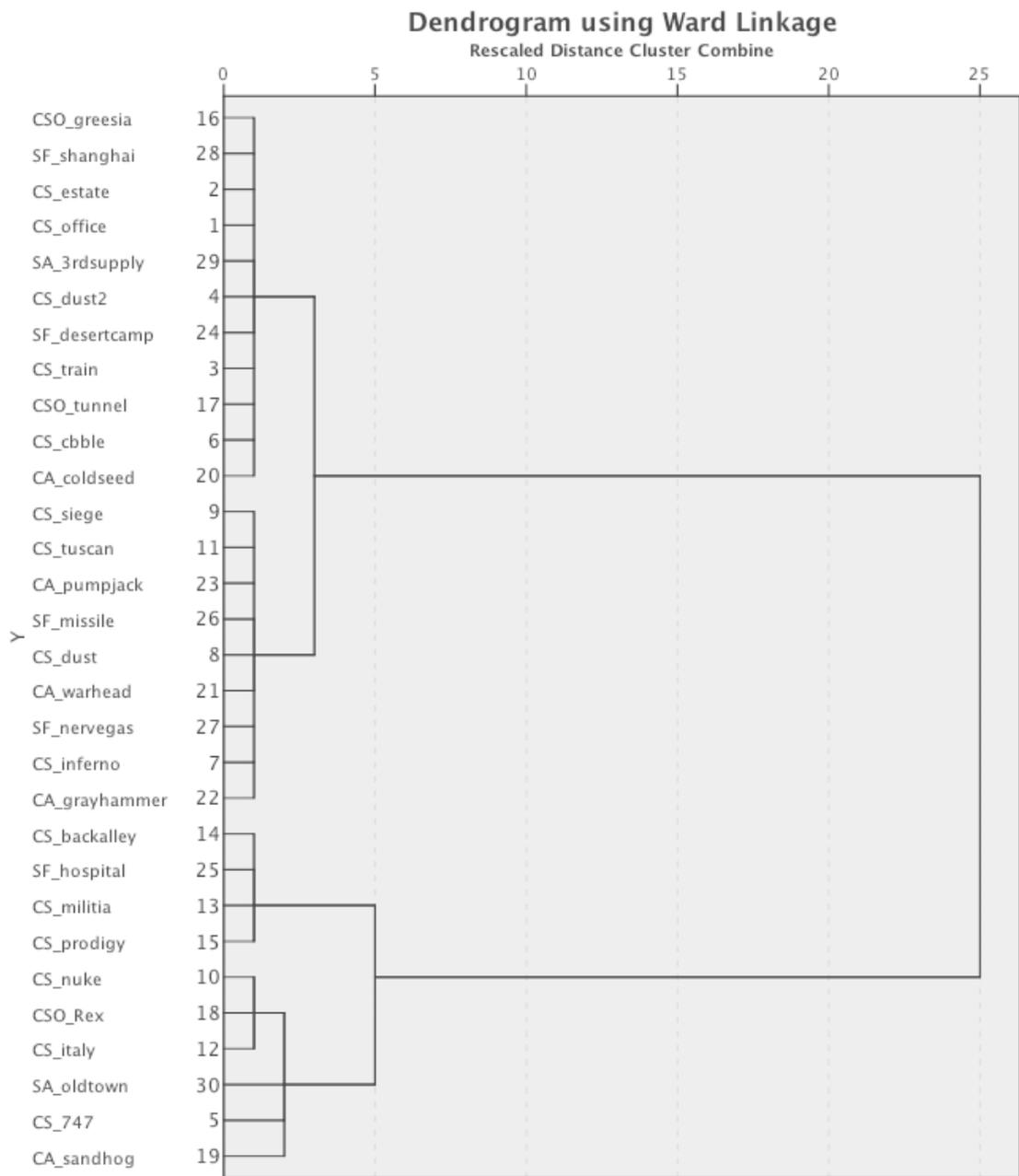


Figure 53: Dendrogram of Relativised Visual Entropy

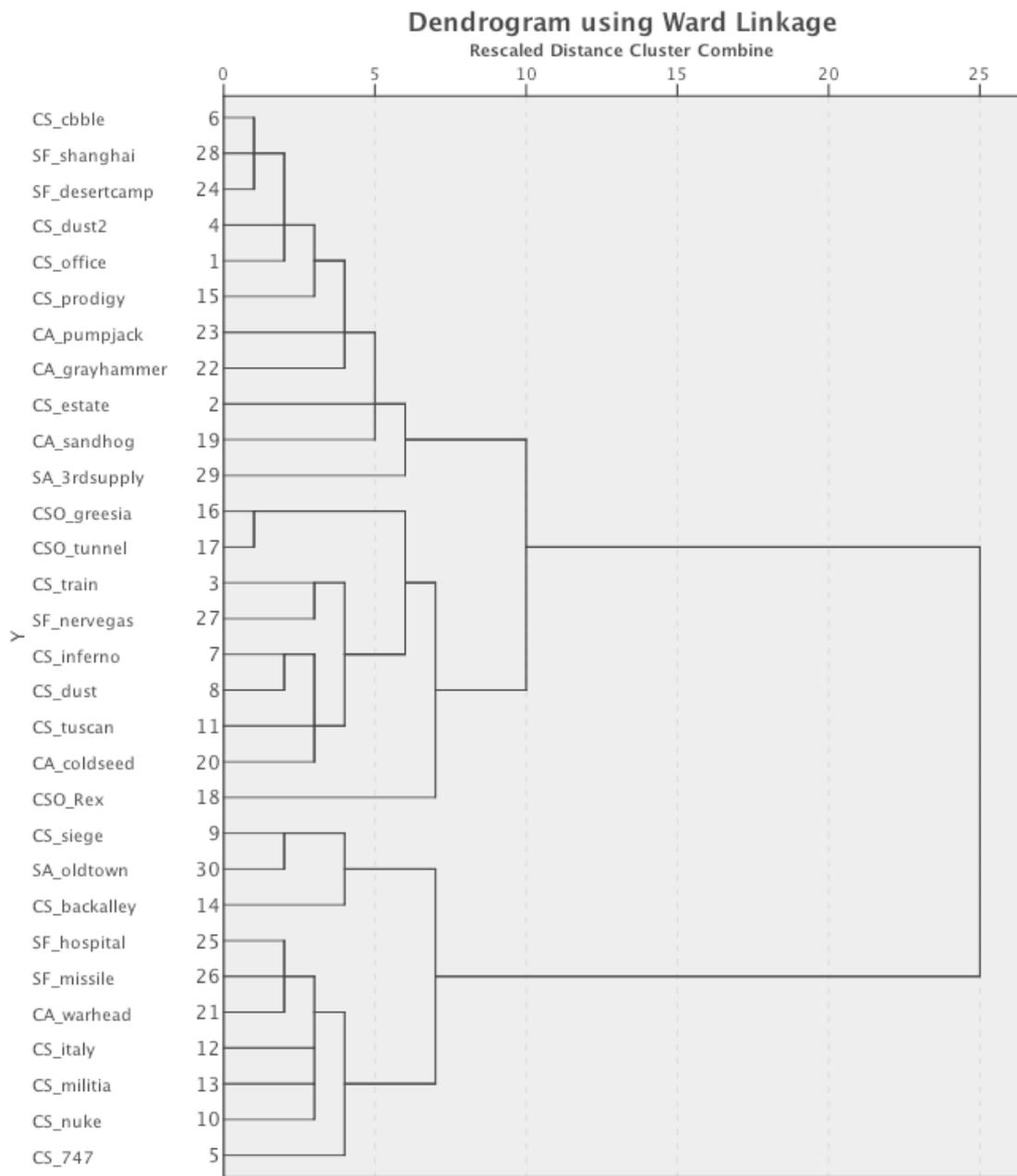


Figure 54: Dendrogram of Clustering Coefficient

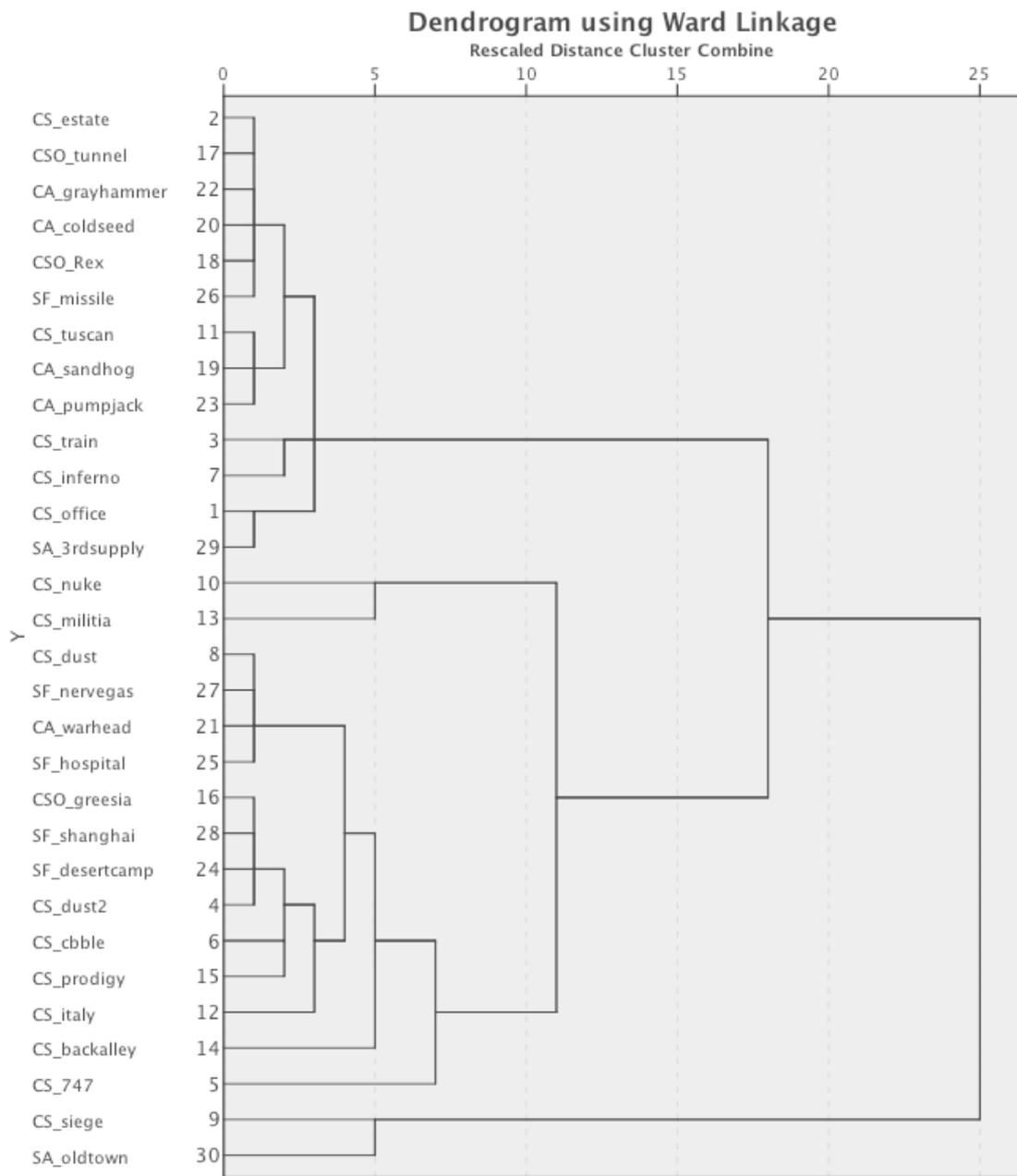


Figure 55: Dendrogram of Controllability

6.7 Chapter Conclusion

This element of the study had two aims to be considered through the data collected using spatial measures as a methodology for the analysis of game environments.

The first aim was in part to determine the effectiveness of the methodology to inform game design as previously only control environments had been discussed. That this methodology could be used to analyse and evaluate the transfer of experiential knowledge from real environments into game environments proves its effectiveness. Spatial measures have demonstrated analytical possibilities useful to game designers as a method of analysing individual environments or comparing and contrasting pairs or groups of environments. A real environment and its virtual manifestation can be comparatively analysed through their spatial parameters for tacit and implicit knowledge of the functions of the real space and the contrasting needs of the game space. This means game environment designers can make use of this methodology as an analytical tool to inform design decisions before the need for play testing.

The second aim of this element of the study was to determine whether cultural cognitive differences could be evidenced through the analysis of game environments using a spatial methodology. This has been met at the level of the isovist view field where the Asian environments demonstrated statistically significant differences in isovist parameters. These indicate more complex viewfields for players within those environments correlating with the imageability of the 2D screen image as seen by the player and designer.

The use of VGA metrics indicate further cultural differences that extend the hypothesis past the specific visual isovist parameters directly influencing the design of individual viewfields and onto the designer's implementation of the whole environment. Asian environments tested were statistically significantly more complex and more visually integrated than Western environments. This indicates a holistic approach to the design of the environment that can be considered to be a culturally implicit approach rather than an explicit design decision. This is because a designer making decisions based on player viewfields cannot easily manipulate VGA parameters calculated across the whole environment. The evidence of this design approach corresponds to the cultural cognitive differences discussed by Nisbett being implicit in the design of the environments.

Chapter 7: Design Considerations Using Spatial Metrics

In order to consider how these spatial findings may influence the design of game environments the balance of imageability and intelligibility within the design process must be considered. Environments for games have to look good and play well. This is where intelligibility and imageability have always been discussed albeit using different terminologies. The questions for this study to consider is how and where within a design process does the intelligibility brought to environments through spatial metrics prove useful. How the measurement and statistical understanding of intelligibility can be balanced with the imageability of the game environment will be an individual decision by the designer. It is not expected that this study's findings will lead to a change in existing design methodologies but will provide the ability to make informed design decisions based on a structured discussion of player behaviours and spatial characteristics.

In order to statistically analyse environments for this study they have been stripped down to the game geometry beneath the narrative led layers of texture. Game geometry has been considered at several scales, as an overall structure in the replication of large city environments, as smaller sub-environments and as a single space. Space syntax measures have been discussed as applicable in consideration at all these levels from the single player view field using isovists to the sub environment and larger environments of city layouts and their analysis using visual graph measures.

This analytical method used within the design process allows the intelligibility of the environment structure to be considered separate to the addition of narrative elements. Whether the intelligibility of an environment should be considered before the imageability depends on the game and the narrative context.

Where a narrative may be based on a real world environment the designer may construct the geometry based upon the real environment without recognising any underlying intelligibility or cultural way finding issues. In this process imageability, the recognisable elements of the city are prioritised before playability may be considered. In this case spatial analysis can be used to retrospectively add intelligibility to the environment.

This method would also work for a single room environment where a designer may sketch out the imageability of the room to ensure narrative consistency. Isovist properties may then be applied to discuss what areas a player may focus on and how they may interpret the narrative from different viewpoints within the room.

The small 'map' environment built of several interconnected spaces, as with those analysed in chapter 6, is where spatial metrics may prove most useful. These are where gameplay may be required to move at different speeds and the understanding of where to go and what to do is a priority for game flow. The intelligibility and imageability of these environments is a fine balance so measurable properties for structure can offer a more informed decision making process.

To turn the findings into applied design knowledge a breakdown of where and when to consider design findings is necessary. The evidence suggests that three levels are useful for this discussion:

First the smallest design viewpoint is considered as the immediate local space of a player considering their viewfield and the relationship of that space to the screen image as seen by the player.

Second the intelligibility of large game environments is discussed. This is the scale where vehicular exploration is often required due to its size and is revealed slowly to the player through out a game as they experience it through the gameplay.

The third design viewpoint and the most complex will be termed the pedestrian space. This form of environment is often a single small environment with quick travel distances completely open to player exploration without the need for vehicular transport.

As game design may evolve from any of these three design viewpoints they offer a structure for the discussion of intelligibility as a design consideration resulting from the use of spatial metrics.

7.1 The Immediate Local Space.

The immediate local space is the player's visual field and part of the original hypothesis of using a spatial methodology was to determine cultural differences in this viewfield. Research in chapter 5 explored where cultural cognitive differences in the two dimensional visual field would be demonstrable in the 2D screen projection of a 3D space.

VGA and isovist properties correlate to the complexity of the two dimensional image, a recognised cultural difference, have been proven evident in the immediate viewfield when analysing the design of environments. Isovist parameters could be used to analyse and evaluate individual locations in the environment throughout the design process as discussed in chapter 4, but VGA measures require more consideration.

A starting point for designing a local viewpoint may be the discussion within space syntax that a user will recognise the local area as a subspace of the global space. The user translates knowledge gained from the local to their understanding of the global structure. This is effective for both imageability and intelligibility. The user may establish a global structure from recognizing the narrative of the space, a hospital, a station etc. and their implicit knowledge of that form of space. If the narrative is of a train station then the immediate space may, in terms of first level architecture, be an intimate space such as a waiting room. That would lead onto a platform or a prospect space such as the entrance hall of a train station, which could then lead onto a platform or out onto a street.

The consideration of intelligibility offers the immediate understanding of directions and options for movement through doors, or an understanding of the relationship to the sub city level as with the view through a window. Isovist compactness, occlusion and maximum radial will be important in order to see controlling or dominant locations within the larger environment that might be in turn be gameplay goals.

The cultural consideration in designing a local space is mainly imageability though not just textural but also geometry and the framing or *mise-en-scène* of the local environment. The reading of the 2D image is led in part by the player framing the image as a view of the 3D environment. The framing aspect and the consideration of cultural cognitive differences in reading the goals within the screen image means an

important consideration is how the geometry and texture lead the player to frame key information.

In the immediate local space intelligibility in the form of spatial parameters meets imageability as the player interprets the 3D environment through the two dimensional screen. At this level consideration of both imageability and intelligibility are crucial.

A window can make an obvious frame for looking out at a controlling area containing a landmark but the player must consider it important to look towards, or out of, that particular window. As discussed concerning Duffy's study of offices chapter 4.1.2 (Rapoport, 1990) the number of windows in an office is an important narrative element as to the occupier of the office. Imageability and intelligibility begin to conflate in this situation so the designer must consider both.

Imageability also occurs within the cultural identity of the environment as discussed by Miyamoto et al (Miyamoto et al., 2006) in chapter 4.1.2 and how a Japanese environment contains more elements than an American environment. This fits with the theory on cultural cognition of imagery, as a Japanese person will not find this as confusing as a Westerner. These elements will most often be in textures applied to basic geometry so spatial parameters and intelligibility are relevant but might be overpowered by the imageability of the textures applied to the geometry.

In conclusion within a players immediate game space the balance between imageability and intelligibility is a more delicate and subjective discussion for the designer. Spatial parameters are useful in determining elements of the complexity of the geometry and its relation to other elements of the environment but recognition of immediate cultural preference will be most likely tied to imageability.

7.2 Large Game Environments

Large game environments may be a recognisable city, as with the city of London in *The Getaway*, or a fictional city as in *Grand Theft Auto III*, or a country or continent as in *World of Warcraft*. Each structure, whatever the narrative scale, is a combination of interconnected locations in an intelligible format for a player to navigate.

The tension between realism in the replication of a real world city environment and the playability of that environment is discussed in chapter 4. The desire to make a true to life environment has to be considered against the playability of the environment. Spatial metrics offer the designer a less subjective method of approaching the task of replicating a real environment. With further investigations into spatial parameters for specific forms of gameplay the playability of a specific real environment could be analysed before the production process begins.

Cultural tension in the large game environment is evident in the spatial analysis of real world environments transferred directly into games in chapter 6. The city environment for *The Getaway* can be immediately questioned by the observations of Hall (Hall, 1988) and the incomprehensibility of foreign city layouts to tourists. This study has not analysed city layouts for cultural influence but space syntax has begun to investigate the idea of taxonomies for urban grids (Figueiredo and Amorim, 2007) that could prove beneficial in the design process.

The imageability of large game environments and balancing the use of imageable elements, such as landmarks, to aid navigability should be addressed through an understanding of the intelligibility of the environment. Landmarks should not be added because an environment is not intelligible. As discussed in chapter 5 the imageable elements Lynch recognised as important were dependent on elements of space syntax. The hypothesis that an imageable environment is also intelligible, but an intelligible environment does not have to be imageable is important for the design of large game environments.

7.3 The Pedestrian Game Space

The pedestrian game space is the prime game space for the consideration of elements of first level game architecture discussed in chapter 4.1.1. This is where narrow space, intimate space and prospect space are used with the expectation that the player will recognise the nature of the space through their experiential knowledge from real world environments.

If these forms for game spaces can be correlated with spatial metrics then basic environment principles for game design could be measured during the design process. Combinations of spatial metrics recognised as popular through the analysis of game environments could be recorded then implemented within new designs. This element of the study attempts to map first level principles with spatial metrics linked directly to the design process.

7.3.1 Visual Integration Across First Level Architecture

To begin the investigation four variations of geometry were chosen. These relate to narrow, intimate and prospect geometrical forms and the fourth adds a figure of eight route, often used as a simple movement artery around a game space. These can be seen respectively in Figure 56, Figure 57, Figure 58 and Figure 59.

The geometry is not intended to be instantly recognizable environments as these could become subject to narrative decisions. The geometric shapes are instead determined by their amplification of first level game architecture to facilitate environment patterns. Level designers discuss many forms for map layouts, these again become subject to narrative and gameplay decisions. The use of a simple form of a figure of eight as a navigational intervention in the geometry is to see how paths start to affect generic principles of game architecture. These are first steps into this area and it is expected that through these results principles for more detailed inquiry into level design techniques might be possible.

The spatial metrics of visual integration, clustering coefficient, control, controllability, relativised visual entropy, perimeter, occlusion, compactness and maximum radial were recorded. Visual integration was also used as the independent variable within the spatial metrics and the correlation of the other metrics to visual integration also recorded. This combination of the visual variables embedded in a deeper correlation with visual

integration can then be considered along side more directly design related isovist variables and the values of the parameters before correlation.

For comparative measures the values to consider for metrics are based around the values from the Dust 2 environment recognised as internationally successful so cultural elements should not factor into design decisions at this level. R squared correlations were considered to be good at the levels of 0.3 to 0.7 and subsequently highlighted in tables of results in green while below 0.3 is weak and in pink. Above 0.7 is marked in yellow as too strong a correlation in one area could be considered to be dominating within the visual integration and in turn the environment design.

In terms of the use of mean statistical data for spatial metrics several questions were asked for every parameter to better understand its influence. First was whether the median is within 2% of the mean in order to have faith in using the mean as a design factor. Whether the relative standard deviation was below 20% was asked in order to indicate lower variations within the results. Kurtosis and skewness were considered in terms of the shape of the distribution of the data and the inter quartile range in terms of the spread. Highlighting a 'yes' to these questions in green in the tables adds to the instant visual feedback from the tables of results.

The overall results for each map and the main spatial metric of visual integration with correlations for dependent metrics is shown in Table 24: Visual Integration and metric correlation across test maps. More detailed tables for all metrics are discussed with each set of environments but it is first worth noting points across the complete set of results.

The environments with grids have consistently higher means within visual integration than their counterparts with more randomized layouts. This is to be expected as randomizing the layout reduces the viewfield and a grid allows a player to see from one side of the environment to the other. What was not expected was for the mean and median for visual integration to be differentiated more when the environment contains a grid layout. Whether to use the mean or the median as a measure for decision-making can be discussed in terms of the level of how visually dominant a grid structure might be within the environment.

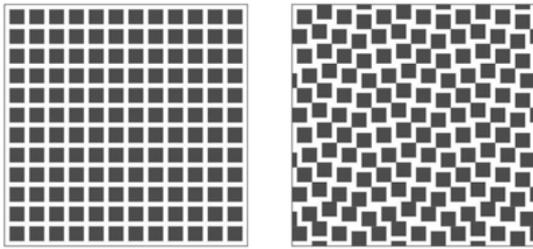


Figure 56: Narrow grid pattern and a randomised narrow grid pattern

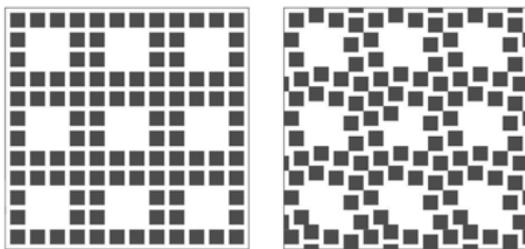


Figure 57: Intimate space added to the narrow grid and the randomised narrow grid



Figure 58: Prospect space added to the narrow grid and the randomised narrow grid

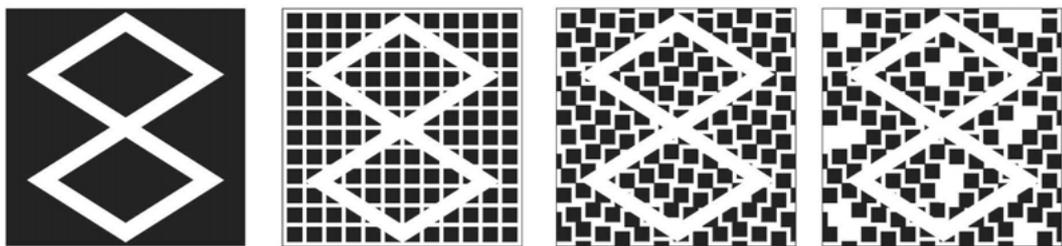


Figure 59: The figure of 8 with a narrow grid, random grid and random intimate space.

The addition of a grid affects the skewness in a positive direction across the environments. As statistically skewness is associated with the difference in mean and median this is to be expected. A positive skewness means values in the lower range are more frequent and build up quickly so the higher values for visual integration would be less frequent. A grid element may be a method of reducing or increasing skewness to directly affect the levels of visual integration across an environment and may prove a useful design mechanism.

The addition of a grid also decreases the visual integration correlation with the maximum radial. In terms of an environment with a grid the maximum radial is often the length of the environment and this negates any correlation with visual integration. When the environment is more randomized the maximum radial becomes an important factor.

Across the environments the intimate space with random element highlights green in 5 of the 8 correlation boxes and all of the statistical considerations boxes. This form of small, connected spaces, with no clear grid, i.e. lines of sight, connecting the spaces has the most theoretical resemblance to the type of game environments from *Counter-Strike*. If a large space is added, as with the prospect environments, then correlation may move to higher values but the visual integration becomes skewed.

Across all the environments occlusion is correlated with visual integration at over 0.3. Perimeter is also a key factor in all but the narrow random map where the perimeter would be smallest so any influence would be reduced. Occlusion and perimeter can be considered key design factors in balancing visual integration for any form of environment and as occlusion is related to perimeter further investigation of this relationship may provide elementary design rules.

These initial observations already begin to inform design thinking and spatial patterns are emerging to correlate with geometrical forms.

Table 24: Visual Integration and metric correlation across test maps

R2 Correlation to Visual Integration	Narrow Grid	Narrow Random	Intimate Grid	Intimate Random	Prospect Grid	Prospect Random	Fig 8	Fig 8 Grid	Fig 8 Random	Fig 8 Intimate
Visual Clustering Coefficient	0.9269	0.1024	0.5965	0.1422	0.0005	0.4920	0.4341	0.6747	0.0030	0.0769
Visual Control	0.9953	0.0418	0.6819	0.2662	0.6171	0.1636	0.6132	0.7398	0.2401	0.2225
Visual Controllability	0.2610	0.1809	0.0141	0.0025	0.9147	0.6505	0.9301	0.3818	0.0020	0.0801
Relativised Visual Entropy	0.8901	0.9232	0.0125	0.5527	0.7182	0.9082	0.5314	0.0023	0.9188	0.8990
Perimeter	0.9859	0.2841	0.8957	0.6336	0.9344	0.9417	0.9531	0.8732	0.8645	0.8331
Occlusion	0.5900	0.3087	0.4185	0.6904	0.7380	0.9172	0.3174	0.6945	0.8286	0.7944
Compactness	0.9094	0.2266	0.5034	0.3363	0.4631	0.0239	0.7809	0.2748	0.3208	0.4094
Max Radial	0.0583	0.2287	0.2888	0.5272	0.2848	0.7049	0.4645	0.0850	0.7701	0.7313
Visual Integration [p]										
Mean	0.8101	0.1745	0.8081	0.4261	1.2918	0.5613	1.0081	0.8798	0.4162	0.4494
SD	0.1278	0.0281	0.1177	0.0703	0.4671	0.2383	0.3071	0.1410	0.1268	0.1260
Median	0.7472	0.1737	0.7780	0.4231	1.0929	0.5752	1.0873	0.8359	0.4273	0.4557
Relative SD	0.1577	0.1613	0.1457	0.1650	0.3616	0.4245	0.3046	0.1603	0.3048	0.2803
Kurtosis	1.2550	-0.7346	-0.0052	0.1406	-1.6861	-1.6263	2.8199	-0.4529	-0.9518	-0.7810
Skewness	1.7775	0.0760	0.7157	-0.0059	0.2386	-0.2132	1.3343	0.6950	0.0558	0.1105
Interquartile Range	0.0213	0.0427	0.1107	0.0815	0.9457	0.4860	0.3857	0.2184	0.2255	0.1958
Visual Integration Considerations										
Median within 2% of the Mean?	92%	100%	96%	99%	85%	102%	108%	95%	103%	101%
RSD less than 20%?	15.8%	16.1%	14.6%	16.5%	36.2%	42.5%	30.5%	16.0%	30.5%	28.0%
Kurtosis less than 0.3?	1.2550	-0.7346	-0.0052	0.1406	-1.6861	-1.6263	2.8199	-0.4529	-0.9518	-0.7810
Skewness less than 0.2?	1.7775	0.0760	0.7157	-0.0059	0.2386	-0.2132	1.3343	0.6950	0.0558	0.1105
IQR less than 1.5xSD?	0.1666	1.5154	0.9400	1.1589	2.0248	2.0396	1.2560	1.5486	1.7776	1.5539

Colour Key

0 < value < 0.3	0.3 <= value <= 0.7 or if a question equals 'yes'	0.7 < value
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7.3.2 Narrow Space

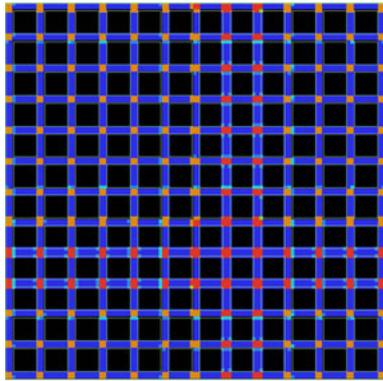


Figure 60: Visual Integration Narrow Grid

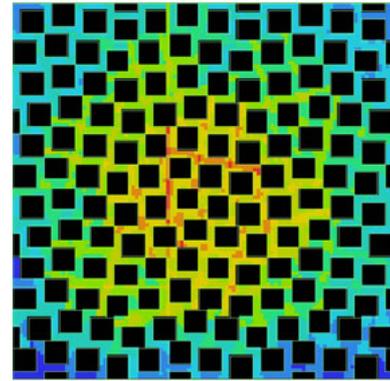


Figure 61: Visual Integration Randomized Grid

These two forms of geometry are the extreme alternative to a wide-open space and have a consistent grid, or randomized grid, to determine the opposing effects of consistent structure or a more organic form. This gives an extremity of geometry in order to discuss the implications as it is converted into intimate or prospect spaces.

The narrow grid environment has high correlations with visual integration across all measures except controllability and maximum radial with several correlations of over 0.9. It scores highest in correlation with visual clustering coefficient and compactness, as this is visibly the most definitively 'junctioned' environment.

The correlations with visual integration drop with the randomised narrow grid compared to those of the normal narrow grid. Visual clustering correlation drops drastically from 0.927 to 0.175 but the mean for the actual parameter of visual clustering coefficient has only dropped from 0.873 to 0.664. Therefore the strength of a parameter is not indicative to its strength as a correlating factor of visual integration.

A parameter that does not alter greatly between the two environments is visual controllability. This is because both environments do not have areas that may be easily dominated. The isovist characteristics that demonstrate the greatest reduction when randomizing are area, maximum radial and perimeter as breaking the normal narrow grid pattern prevents the creation of long isovists.

The VGA demonstrates how a grid distributes visual integration while a more organic effect will centralise integration.

Table 25: Narrow Spaces Grid and Random all metrics

Parameter	Visual Integration		Visual C.Coeff		Visual Control		Visual Controllability		Rel. Visual Entropy	
	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand
Mean	0.810	0.175	0.873	0.664	1.000	1.000	0.078	0.261	2.650	2.963
SD	0.128	0.028	0.169	0.135	0.299	0.260	0.013	0.065	0.148	0.185
Median	0.747	0.174	0.952	0.658	0.863	0.962	0.070	0.250	2.606	2.931
Relative SD	0.158	0.161	0.194	0.203	0.299	0.260	0.168	0.249	0.056	0.063
Kurtosis	1.255	-0.735	0.597	-0.348	1.242	-0.334	-0.367	3.494	1.341	-0.078
Skewness	1.777	0.076	-1.523	0.470	1.770	0.462	0.994	1.313	1.713	0.643
Interquartile Range	0.021	0.043	0.087	0.183	0.058	0.394	0.019	0.075	0.020	0.271
Visual Considerations										
Median within 2% of the Mean?	92.24%	99.53%	109.06%	98.96%	86.25%	96.17%	89.67%	95.85%	98.36%	98.92%
RSD less than 20%?	15.8%	16.1%	19.4%	20.3%	29.9%	26.0%	16.8%	24.9%	5.6%	6.3%
Kurtosis less than 0.3?	1.255	-0.735	0.597	-0.348	1.242	-0.334	-0.367	3.494	1.341	-0.078
Skewness less than 0.2?	1.777	0.076	-1.523	0.470	1.770	0.462	0.994	1.313	1.713	0.643
IQR less than 1.5xSD?	0.167	1.515	0.512	1.360	0.194	1.518	1.426	1.152	0.136	1.465
Parameter	Isovist Area		Isovist Compactness		Isovist Max Radial		Isovist Occlusivity		Isovist Perimeter	
	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand
Mean	234.560	44.936	0.053	0.158	74.924	15.844	59.537	33.645	241.682	63.761
SD	69.939	17.036	0.011	0.077	13.987	4.307	21.889	14.713	69.610	20.071
Median	201.583	45.164	0.059	0.142	75.819	16.176	53.286	31.953	207.048	61.589
Relative SD	0.298	0.379	0.197	0.486	0.187	0.272	0.368	0.437	0.288	0.315
Kurtosis	1.253	-0.526	0.302	3.698	-1.183	-0.166	5.285	-0.054	1.052	-0.172
Skewness	1.788	0.279	-1.429	1.667	-0.107	-0.186	1.688	0.302	1.708	0.285
Interquartile Range	10.208	23.905	0.007	0.081	24.299	4.866	9.158	19.481	18.523	24.722
Isovist Considerations										
Median within 2% of the Mean?	86%	101%	111%	90%	101%	102%	89%	95%	86%	97%
RSD less than 20%?	29.8%	37.9%	19.7%	48.6%	18.7%	27.2%	36.8%	43.7%	28.8%	31.5%
Kurtosis less than 0.3?	1.253	-0.526	0.302	3.698	-1.183	-0.166	5.285	-0.054	1.052	-0.172
Skewness less than 0.2?	1.788	0.279	-1.429	1.667	-0.107	-0.186	1.688	0.302	1.708	0.285
IQR less than 1.5xSD?	0.146	1.403	0.668	1.062	1.737	1.130	0.418	1.324	0.266	1.232

7.3.3 Intimate Space

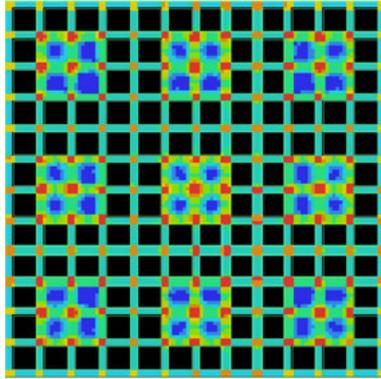


Figure 62: Visual Integration for intimate space with grid system.

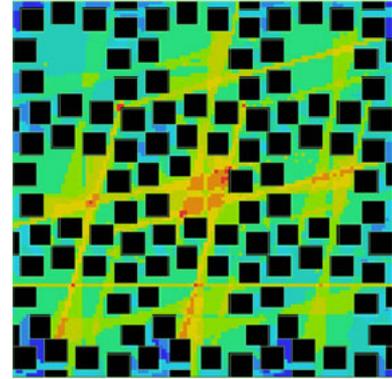


Figure 63: Visual Integration for random intimate space.

The removal of small areas of geometry creates intimate spaces within the environment. The statistical characteristics indicate the correlation of visual integration and visual clustering coefficient dropping for the random space even though the value of parameters are similar. The shape of the frequency for the visual clustering coefficient changes with the kurtosis increasing and skewness decreasing. This is expected with the means and medians differentiated because of the grid geometry but they are close in value with the randomised environment.

With the intimate grid the visual clustering coefficient and compactness correlations are very good but only compactness remains influential on visual integration with the randomised environment. The correlation with occlusivity rises with the randomised space while perimeter reduces to a similar level. Within their parameters the standard deviations are the same as with the grid but the mean values are lower. Correlation with maximum radial rises even though the parameter has halved with a small drop in standard deviation and kurtosis and skewness increasing.

These two environments appear to be at the balance of metrics for the FPS maps from game environments analysed in chapter 5. Visual integration differs greatly while other visual values are similar and isovist values are not. Correlations for pairs of isovist parameters are close to both being in the 0.3 to 0.7 values across environments. This indicates a level of tipping points in these environments where fine-tuning one parameter can influence the whole system.

Table 26: Intimate Space All Metrics

Parameter	Visual Integration		Visual C.Coeff		Visual Control		Visual Controllability		Rel. Visual Entropy	
	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand
Mean	0.8081	0.4261	0.7012	0.7278	1.0000	1.0000	0.1092	0.2458	2.5542	2.5376
SD	0.1177	0.0703	0.1795	0.1249	0.2718	0.2732	0.0393	0.1280	0.0984	0.1957
Median	0.7780	0.4231	0.6511	0.7341	0.9009	1.0622	0.1195	0.2399	2.5687	2.5076
Relative SD	0.1457	0.1650	0.2560	0.1716	0.2718	0.2732	0.3597	0.5207	0.0385	0.0771
Kurtosis	-0.0052	0.1406	-1.2208	-0.4361	-0.5644	-0.8131	-0.6923	-1.1598	-0.7038	0.8750
Skewness	0.7157	-0.0059	0.2864	-0.3020	0.4671	-0.3963	0.2496	0.1932	0.2116	0.8975
Interquartile Range	0.1107	0.0815	0.2887	0.1840	0.3714	0.4356	0.0632	0.2105	0.1730	0.2495
Visual Considerations										
Median within 2% of the Mean?	104%	101%	108%	99%	111%	94%	91%	102%	99%	101%
RSD less than 20%?	14.6%	16.5%	25.6%	17.2%	27.2%	27.3%	36.0%	52.1%	3.9%	7.7%
Kurtosis less than 0.3?	-0.0052	0.1406	-1.2208	-0.4361	-0.5644	-0.8131	-0.6923	-1.1598	-0.7038	0.8750
Skewness less than 0.2?	0.7157	-0.0059	0.2864	-0.3020	0.4671	-0.3963	0.2496	0.1932	0.2116	0.8975
IQR less than 1.5xSD?	0.9400	1.1589	1.6080	1.4728	1.3665	1.5944	1.6084	1.6448	1.7589	1.2750
Parameter	Isovist Area		Isovist Compactness		Isovist Max Radial		Isovist Occlusivity		Isovist Perimeter	
	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand
Mean	405.7065	260.8222	0.0743	0.1471	68.2828	34.3241	111.2668	88.6608	271.6455	156.2922
SD	149.3769	153.3029	0.0312	0.0798	19.7662	14.6769	48.2686	48.5096	76.7267	72.7085
Median	402.3547	326.9501	0.0678	0.1228	70.4243	32.6664	108.4341	87.5215	243.6363	159.1945
Relative SD	0.368	0.588	0.420	0.542	0.289	0.428	0.434	0.547	0.282	0.465
Kurtosis	-0.9958	-1.4907	2.8258	2.8050	-0.3948	0.4717	-0.1854	-0.5201	-0.7051	-0.8314
Skewness	0.1133	-0.3510	1.6667	1.5098	-0.5740	0.4379	0.2199	0.3380	0.7137	0.0223
Interquartile Range	272.7215	281.4573	0.0231	0.0927	30.5646	19.2877	67.2715	71.1250	107.2101	110.0229
Isovist Considerations										
Median within 2% of the Mean?	101%	80%	110%	120%	97%	105%	103%	101%	111%	98%
RSD less than 20%?	36.8%	58.8%	42.0%	54.2%	28.9%	42.8%	43.4%	54.7%	28.2%	46.5%
Kurtosis less than 0.3?	-0.9958	-1.4907	2.8258	2.8050	-0.3948	0.4717	-0.1854	-0.5201	-0.7051	-0.8314
Skewness less than 0.2?	0.1133	-0.3510	1.6667	1.5098	-0.5740	0.4379	0.2199	0.3380	0.7137	0.0223
IQR less than 1.5xSD?	1.8257	1.8360	0.7407	1.1623	1.5463	1.3142	1.3937	1.4662	1.3973	1.5132

7.3.4 Prospect Space

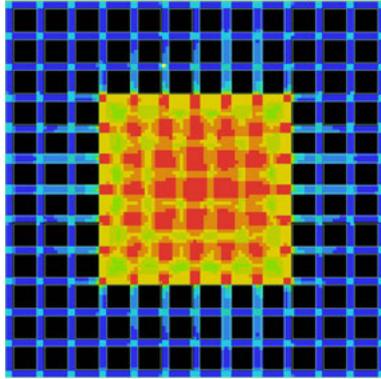


Figure 64: Visual Integration for prospect space with grid system.

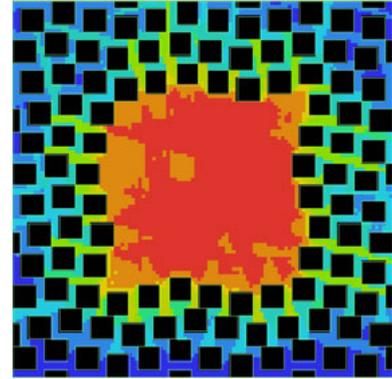


Figure 65: Visual Integration for random prospect space.

These prospect spaces are the narrow spaces with a large space removed from the centre so a player would arrive at the large open space from narrow paths.

The mean visual integration has increased for both prospect environments compared to the narrow environments as expected with the addition of a large open space. The correlation of relativised visual entropy with visual integration remains high as both systems offer even distributions of points due to such large central prospect spaces.

The correlation between visual integration and visual clustering coefficient has dropped considerably from 0.9269 to 0.0005 with the addition of the large prospect space to the normal narrow grid. The opposite happens with the randomised environment where the correlation rises from 0.1024 to 0.4920 when geometry is removed to create a large central space.

The parameters for visual clustering coefficient and relativised visual entropy change very little between the two prospect systems. The mean visual clustering coefficient remains similar across the maps but isovist compactness is considerably different.

The addition of a single large prospect space as is to be expected drastically affects certain visual parameters. Interestingly it is an inverse relationship for the correlation visual clustering coefficient depending on the uniform or organic nature of the environment. It is also an inverse relationship for visual clustering coefficient and compactness.

Table 27: Prospect Space Grid and Random all metrics

Parameter	Visual Integration		Visual C.Coeff		Visual Control		Visual Controllability		Rel. Visual Entropy	
	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand
Mean	1.2918	0.5613	0.8635	0.8102	1.0000	1.0000	0.2738	0.4616	2.3390	2.3343
SD	0.4671	0.2383	0.1170	0.1487	0.3561	0.2567	0.2209	0.2917	0.3759	0.4879
Median	1.0929	0.5752	0.8881	0.9130	1.1429	1.1228	0.1392	0.3982	2.4579	2.0755
Relative SD	0.3616	0.4245	0.1355	0.1835	0.3561	0.2567	0.8068	0.6319	0.1607	0.2090
Kurtosis	-1.6861	-1.6263	4.2181	-0.6926	-0.8150	-0.2107	-1.9153	-1.6669	-1.5182	-0.7348
Skewness	0.2386	-0.2132	-2.2021	-0.8493	-0.5022	-0.7602	0.1334	-0.1433	0.0706	0.7748
Interquartile Range	0.9457	0.4860	0.0563	0.2375	0.4786	0.3766	0.4611	0.5563	0.7273	0.8029
Visual Considerations										
Median within 2% of the Mean?	118%	98%	97%	89%	87%	89%	197%	116%	95%	112%
RSD less than 20%?	36.2%	42.5%	13.6%	18.3%	35.6%	25.7%	80.7%	63.2%	16.1%	20.9%
Kurtosis less than 0.3?	-1.6861	-1.6263	4.2181	-0.6926	-0.8150	-0.2107	-1.9153	-1.6669	-1.5182	-0.7348
Skewness less than 0.2?	0.2386	-0.2132	-2.2021	-0.8493	-0.5022	-0.7602	0.1334	-0.1433	0.0706	0.7748
IQR less than 1.5xSD?	2.0248	2.0396	0.4811	1.5977	1.3440	1.4671	2.0873	1.9075	1.9348	1.6456
Parameter	Isovist Area		Isovist Compactness		Isovist Max Radial		Isovist Occlusivity		Isovist Perimeter	
	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand	Grid	Rand
Mean	1431.5711	1291.7041	0.0916	0.1693	73.7137	42.3996	148.3303	126.6893	383.1928	257.3263
SD	1193.9968	1247.0760	0.0335	0.0678	12.4682	24.2050	75.4467	85.9967	154.2848	186.6637
Median	732.9764	645.5061	0.1032	0.1588	71.6537	53.1094	167.0905	161.7530	398.5180	230.9771
Relative SD	0.8340	0.9655	0.3654	0.4001	0.1691	0.5709	0.5086	0.6788	0.4026	0.7254
Kurtosis	-1.9251	-1.9380	-0.8762	3.8102	-0.9167	-1.6658	-1.3702	-1.7180	-1.8008	-1.7723
Skewness	0.1386	0.0937	0.0298	1.2821	0.2229	-0.2209	-0.2617	-0.1996	-0.0245	0.0390
Interquartile Range	2522.4458	2600.9023	0.0561	0.0589	19.7125	47.9319	151.8402	175.3854	335.3715	391.8187
Isovist Considerations										
Median within 2% of the Mean?	195%	200%	89%	107%	103%	80%	89%	78%	96%	111%
RSD less than 20%?	83.4%	96.5%	36.5%	40.0%	16.9%	57.1%	50.9%	67.9%	40.3%	72.5%
Kurtosis less than 0.3?	-1.9251	-1.9380	-0.8762	3.8102	-0.9167	-1.6658	-1.3702	-1.7180	-1.8008	-1.7723
Skewness less than 0.2?	0.1386	0.0937	0.0298	1.2821	0.2229	-0.2209	-0.2617	-0.1996	-0.0245	0.0390
IQR less than 1.5xSD?	2.1126	2.0856	1.6760	0.8694	1.5810	1.9802	2.0125	2.0394	2.1737	2.0991

7.3.5 Figure Eight

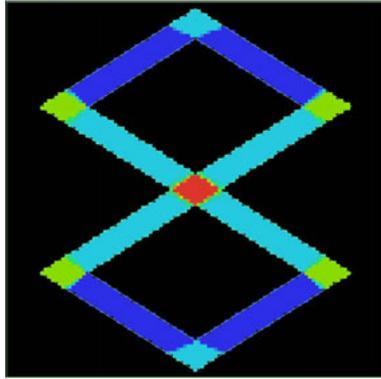


Figure 66: Visual Integration for figure of 8 space.

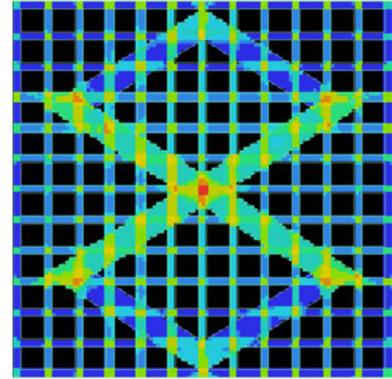


Figure 67: Visual Integration for figure of 8 space with grid.

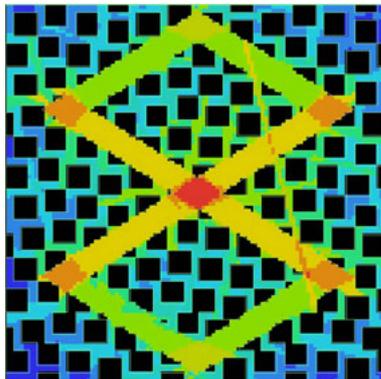


Figure 68: Visual Integration for random figure of 8 space.

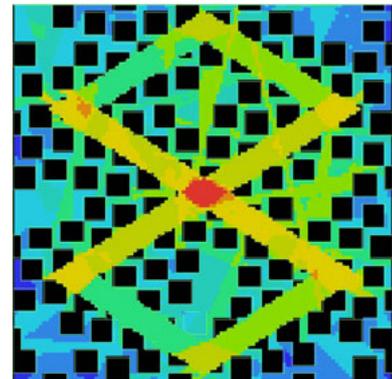


Figure 69: Visual Integration for figure of 8 with intimate space.

The use of a figure of eight indicates a balanced route around an environment as a basis for building a map. The figure of eight is a balanced geometry that shows good to strong correlations with visual integration in all parameters.

When a grid is added to the figure of eight geometry the correlation to visual integration of compactness, maximum radial and relativised visual entropy all decrease significantly. If it is a random grid that is added then the correlation of visual clustering coefficient, visual control and visual controllability decrease significantly.

The use of a central route around an environment to begin the structuring of intelligibility is a design possibility worthy of further investigation.

Table 28: Figure 8 Maps Visual Metrics

Parameter	Visual Integration				Visual Clustering Coefficient				Visual Control			
	8	8+Grid	8+Rand	8+Int	8	8+Grid	8+Rand	8+Int	8	8+Grid	8+Rand	8+Int
Mean	1.0081	0.8798	0.4162	0.4494	0.8763	0.7287	0.7101	0.7228	1.0000	1.0000	1.0000	1.0000
SD	0.3071	0.1410	0.1268	0.1260	0.1463	0.1878	0.1370	0.1333	0.2799	0.3817	0.3500	0.3299
Median	1.0873	0.8359	0.4273	0.4557	0.9523	0.7628	0.7182	0.7410	0.8859	0.8556	0.9861	1.0160
Relative SD	0.3046	0.1603	0.3048	0.2803	0.1669	0.2578	0.1929	0.1844	0.2799	0.3817	0.3499	0.3299
Kurtosis	2.8199	-0.4529	-0.9518	-0.7810	-0.3095	-1.3884	-0.8579	-0.8147	0.4895	0.5475	-0.0921	0.2494
Skewness	1.3343	0.6950	0.0558	0.1105	-1.1744	-0.1515	-0.0203	-0.2738	1.4618	1.0411	0.3904	0.2507
Interquartile Range	0.3857	0.2184	0.2255	0.1958	0.1464	0.3453	0.2296	0.2190	0.1552	0.5967	0.4711	0.4052
Visual Considerations												
Median within 2% of the Mean?	93%	105%	97%	99%	92%	96%	99%	98%	113%	117%	101%	98%
RSD less than 20%?	30.5%	16.0%	30.5%	28.0%	16.7%	25.8%	19.3%	18.4%	28.0%	38.2%	35.0%	33.0%
Kurtosis less than 0.3?	2.8199	-0.4529	-0.9518	-0.7810	-0.3095	-1.3884	-0.8579	-0.8147	0.4895	0.5475	-0.0921	0.2494
Skewness less than 0.2?	1.3343	0.6950	0.0558	0.1105	-1.1744	-0.1515	-0.0203	-0.2738	1.4618	1.0411	0.3904	0.2507
IQR less than 1.5xSD?	1.2560	1.5486	1.7776	1.5539	1.0004	1.8388	1.6761	1.6428	0.5545	1.5632	1.3462	1.2283
Parameter	Visual Controllability				Relativised Visual Entropy							
	8	8+Grid	8+Rand	8+Int	8	8+Grid	8+Rand	8+Int				
Mean	0.3508	0.1032	0.2182	0.2361	2.0416	2.5790	2.4056	2.4007				
SD	0.0602	0.0518	0.1009	0.1529	0.0547	0.1600	0.3648	0.3098				
Median	0.3582	0.0821	0.2438	0.2162	2.0274	2.5978	2.3372	2.3337				
Relative SD	0.1715	0.5018	0.4623	0.6477	0.0268	0.0620	0.1516	0.1290				
Kurtosis	0.7477	-0.0215	0.0127	1.4637	-0.5235	0.5484	-0.2148	-0.0477				
Skewness	0.9518	0.8840	0.0845	1.3649	-0.4821	0.2342	0.7282	0.7591				
Interquartile Range	0.0733	0.0752	0.1471	0.1333	0.0782	0.1751	0.5881	0.4780				
Isovist Considerations												
Median within 2% of the Mean?	98%	126%	90%	109%	101%	99%	103%	103%				
RSD less than 20%?	17.2%	50.2%	46.2%	64.8%	2.7%	6.2%	15.2%	12.9%				
Kurtosis less than 0.3?	0.7477	-0.0215	0.0127	1.4637	-0.5235	0.5484	-0.2148	-0.0477				
Skewness less than 0.2?	0.9518	0.8840	0.0845	1.3649	-0.4821	0.2342	0.7282	0.7591				
IQR less than 1.5xSD?	1.2179	1.4519	1.4583	0.8719	1.4304	1.0948	1.6123	1.5428				

Table 29: Figure 8 Maps Isovist Metrics

Parameter	Isovist Area				Isovist Compactness				Isovist Max Radial			
	8	8+Grid	8+Rand	8+Int	8	8+Grid	8+Rand	8+Int	8	8+Grid	8+Rand	8+Int
Mean	542.9942	450.0128	295.3387	325.8103	0.2287	0.0594	0.1337	0.1403	53.5968	72.5522	36.0782	38.1229
SD	199.2750	280.6280	304.5055	274.0553	0.0687	0.0217	0.0771	0.0845	19.2823	16.6858	24.0072	21.8121
Median	600.0073	374.1114	114.9008	224.8902	0.1992	0.0592	0.1148	0.1152	50.9375	74.4977	29.6512	31.9793
Relative SD	0.3670	0.6236	1.0310	0.8412	0.3003	0.3656	0.5767	0.6027	0.3598	0.2300	0.6654	0.5722
Kurtosis	0.1348	0.4773	-0.2921	0.2832	-1.3817	4.9389	6.0665	2.9347	-1.2449	-0.5300	-0.2854	0.0782
Skewness	0.6888	1.1210	0.9176	1.0234	0.2106	1.8085	2.1119	1.6174	0.2885	-0.4535	0.8832	0.9663
Interquartile Range	280.2295	420.1250	442.7731	335.2395	0.1215	0.0146	0.0755	0.0919	34.6952	26.4553	33.9002	27.4944
Visual Considerations												
Median within 2% of the Mean?	90%	120%	257%	145%	115%	100%	116%	122%	105%	97%	122%	119%
RSD less than 20%?	36.7%	62.4%	103.1%	84.1%	30.0%	36.6%	57.7%	60.3%	36.0%	23.0%	66.5%	57.2%
Kurtosis less than 0.3?	0.1348	0.4773	-0.2921	0.2832	-1.3817	4.9389	6.0665	2.9347	-1.2449	-0.5300	-0.2854	0.0782
Skewness less than 0.2?	0.6888	1.1210	0.9176	1.0234	0.2106	1.8085	2.1119	1.6174	0.2885	-0.4535	0.8832	0.9663
IQR less than 1.5xSD?	1.4062	1.4971	1.4541	1.2233	1.7691	0.6733	0.9793	1.0876	1.7993	1.5855	1.4121	1.2605
Parameter	Isovist Occlusivity				Isovist Perimeter							
	8	8+Grid	8+Rand	8+Int	8	8+Grid	8+Rand	8+Int				
Mean	26.2717	135.4275	90.3803	99.5135	180.9176	311.1714	166.1672	181.4268				
SD	13.2471	72.3128	65.8609	65.4410	61.2108	120.5449	119.2831	111.4333				
Median	28.4212	116.4607	77.8455	87.6980	194.4360	256.4893	126.5154	155.8510				
Relative SD	0.5042	0.5340	0.7287	0.6576	0.3383	0.3874	0.7178	0.6142				
Kurtosis	10.9770	0.1538	-0.0936	0.4348	0.0066	0.5069	-0.3767	0.1913				
Skewness	2.6392	0.6510	0.7535	0.8231	0.6609	1.0538	0.7736	0.8538				
Interquartile Range	14.6755	95.1966	103.4552	99.7310	85.3724	188.2447	192.7223	159.7529				
Isovist Considerations												
Median within 2% of the Mean?	92%	116%	116%	113%	93%	121%	131%	116%				
RSD less than 20%?	50.4%	53.4%	72.9%	65.8%	33.8%	38.7%	71.8%	61.4%				
Kurtosis less than 0.3?	10.9770	0.1538	-0.0936	0.4348	0.0066	0.5069	-0.3767	0.1913				
Skewness less than 0.2?	2.6392	0.6510	0.7535	0.8231	0.6609	1.0538	0.7736	0.8538				
IQR less than 1.5xSD?	1.1078	1.3165	1.5708	1.5240	1.3947	1.5616	1.6157	1.4336				

7.3.6 Hierarchical Classification for Design

The hierarchical clustering of environments discussed in chapter 6.6.2 illustrated clear groups based on visual parameters. A hierarchical clustering of game environments, that included the first level architecture control maps, is shown in the dendrogram for visual integration Figure 70: Dendrogram of maps including test maps and groups for analysis.

Including the control maps is intended to determine how closely design patterns can be linked to existing game environments and correlated through the spatial metrics.

The investigation of these groups requires a consideration of how to interpret the statistical and the visual information. Using visual integration as the independent spatial metric there is the consideration of what the correlation of other metrics and design factors around visual integration mean to the design of the environment.

This discussion has to consider the dichotomy of the tacit design thinking of the designers who constructed these environments with the statistical analysis deconstructing the environment design. The groups do not indicate a cultural division but they do begin to determine design implementations led by both statistical measures and the visual interpretation of the visual graph of the environment.

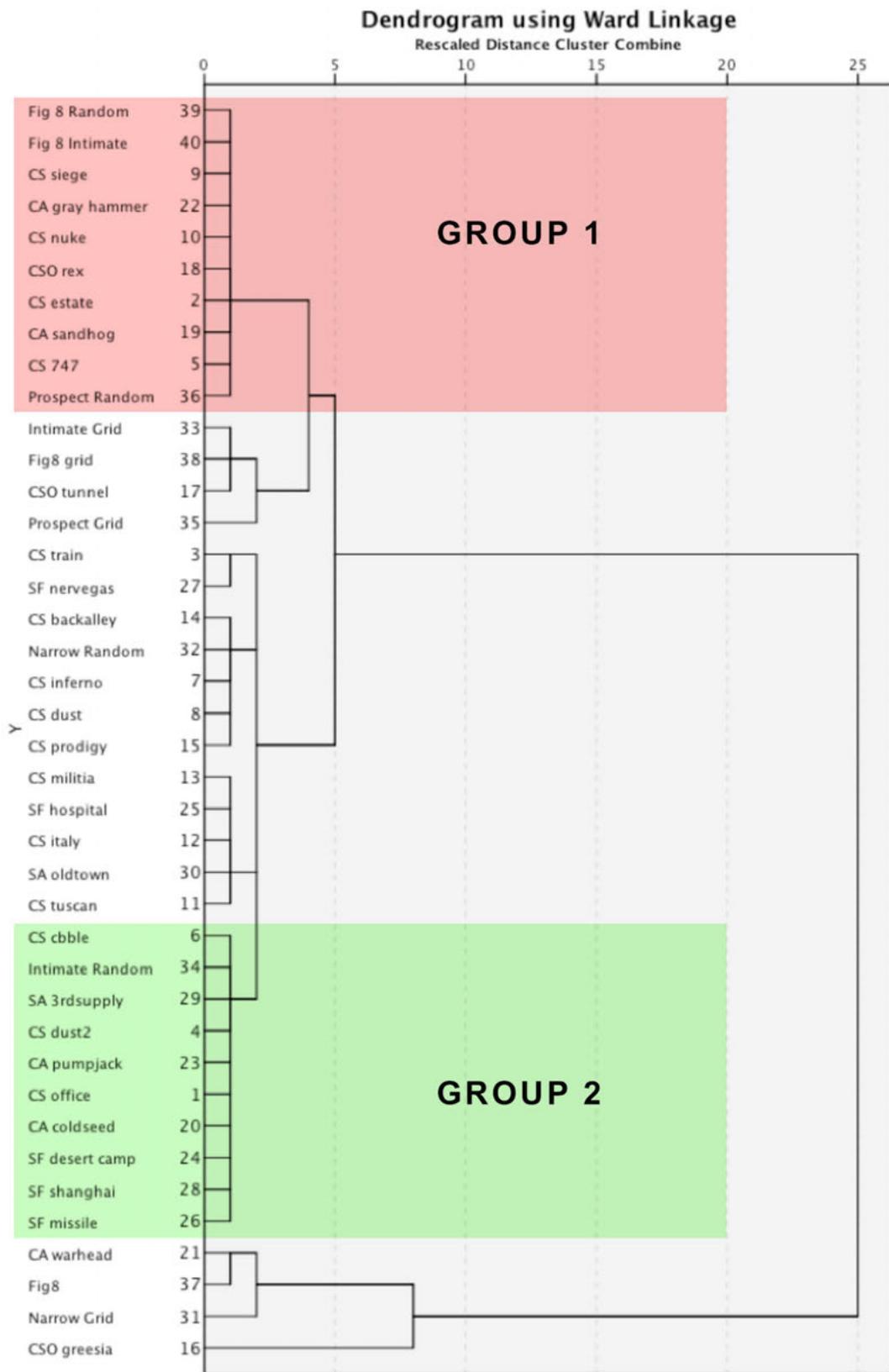


Figure 70: Dendrogram of maps including test maps and groups for analysis

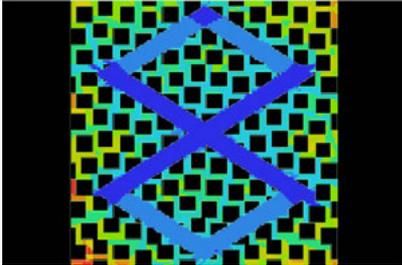
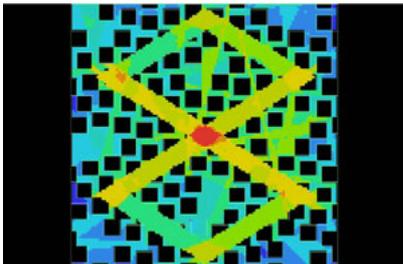
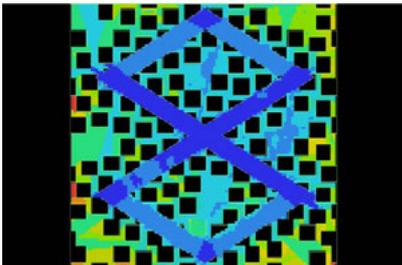
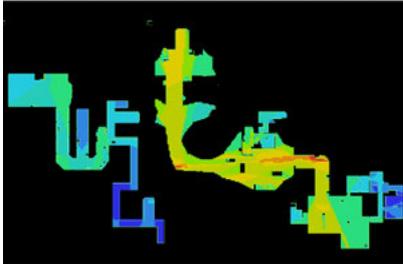
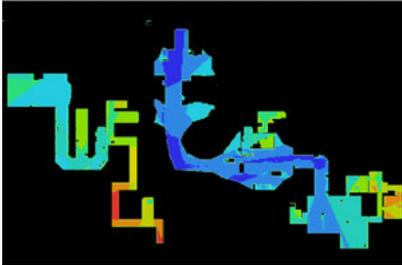
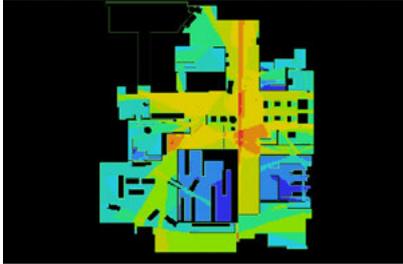
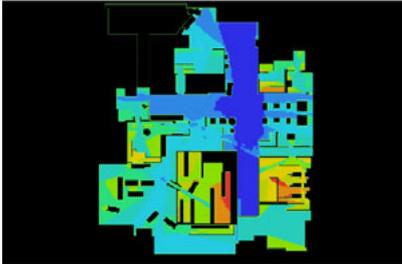
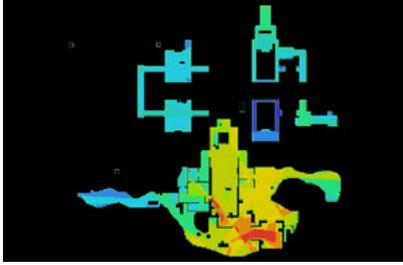
Table 30: Group 1 Metrics

R2 Correlation to Visual Integration	Fig 8 Random	Fig 8 Intimate	CS siege	CA gray hammer	CS nuke	CSO rex	CS estate	CA sandhog	CS 747	Prospect Random
Visual Clustering Coefficient	0.0030	0.0769	0.1791	0.0620	0.3605	0.1618	0.1613	0.2229	0.0444	0.4920
Visual Control	0.2401	0.2225	0.0886	0.1452	0.0506	0.0403	0.1084	0.0563	0.0418	0.1636
Visual Controllability	0.0020	0.0801	0.0034	0.0045	0.2025	0.1291	0.1218	0.0305	0.4281	0.6505
Relativised Visual Entropy	0.9188	0.8990	0.8659	0.8499	0.8964	0.9203	0.8430	0.8561	0.8978	0.9082
Perimeter	0.8645	0.8331	0.7285	0.7775	0.6427	0.6402	0.7657	0.6574	0.8234	0.9417
Occlusion	0.8286	0.7944	0.6318	0.7259	0.6551	0.5446	0.5569	0.6175	0.7235	0.9172
Compactness	0.3208	0.4094	0.2483	0.3126	0.2638	0.3681	0.1855	0.3802	0.1108	0.0239
Max Radial	0.7701	0.7313	0.6312	0.6426	0.3637	0.5531	0.7156	0.5990	0.6043	0.7049
Visual Integration										
Mean	0.4162	0.4494	0.3242	0.4478	0.3089	0.2744	0.5114	0.3681	0.4047	0.5613
SD	0.1268	0.1260	0.0759	0.1141	0.0793	0.0629	0.1429	0.0919	0.1218	0.2383
Median	0.4273	0.4557	0.3174	0.4544	0.3009	0.2760	0.5480	0.3781	0.4438	0.5752
Relative SD	0.3048	0.2803	0.2340	0.2549	0.2567	0.2293	0.2794	0.2497	0.3010	0.4245
Kurtosis	-0.9518	-0.7810	-0.8114	-0.9138	-1.1708	-0.9954	-0.7765	-0.5282	-1.4213	-1.6263
Skewness	0.0558	0.1105	-0.1784	-0.1759	-0.0216	-0.0025	-0.6020	-0.5198	-0.2664	-0.2132
Interquartile Range	0.2255	0.1958	0.1260	0.1843	0.1410	0.1139	0.2278	0.1322	0.2399	0.4860
Visual Integration Considerations										
Median within 2% of the Mean?	103%	101%	98%	101%	97%	101%	107%	103%	110%	102%
RSD less than 20%?	30.5%	28.0%	23.4%	25.5%	25.7%	22.9%	27.9%	25.0%	30.1%	42.5%
Kurtosis less than 0.3?	-0.9518	-0.7810	-0.8114	-0.9138	-1.1708	-0.9954	-0.7765	-0.5282	-1.4213	-1.6263
Skewness less than 0.2?	0.0558	0.1105	-0.1784	-0.1759	-0.0216	-0.0025	-0.6020	-0.5198	-0.2664	-0.2132
IQR less than 1.5xSD?	1.7776	1.5539	1.6615	1.6146	1.7781	1.8109	1.5945	1.4385	1.9699	2.0396

Colour Key

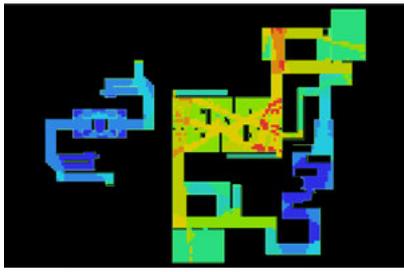
0 < value < 0.3	0.3 <= value <= 0.7 or if a question equals 'yes'	0.7 < value
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Table 31: Visual Graphs for Group 1

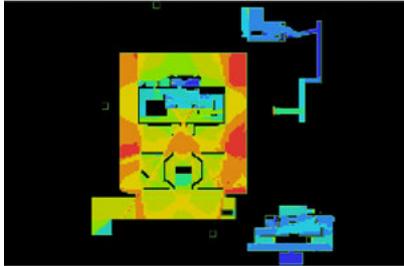
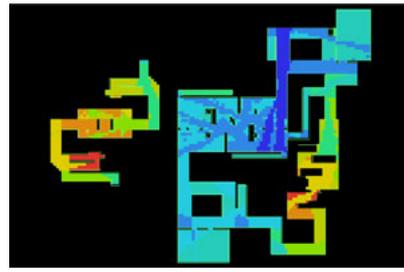
Visual Integration	Relativised Visual Entropy
 <p>Figure 8 Random</p>	
 <p>Figure 8 Intimate Spaces</p>	
 <p>Counter-Strike Siege</p>	
 <p>Combat Arms Gray Hammer</p>	
 <p>Counter-Strike Nuke</p>	

Visual Integration

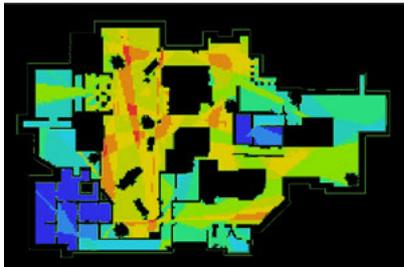
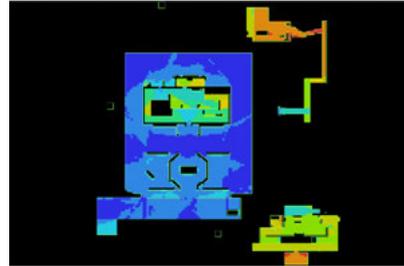
Relativised Visual Entropy



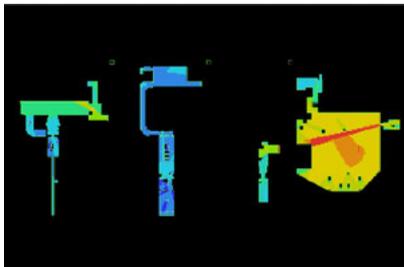
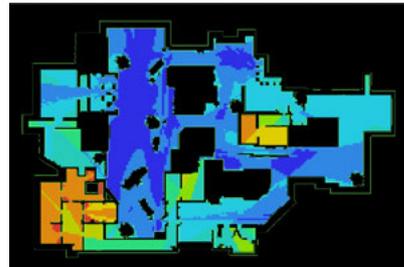
Counter-Strike Online Rex



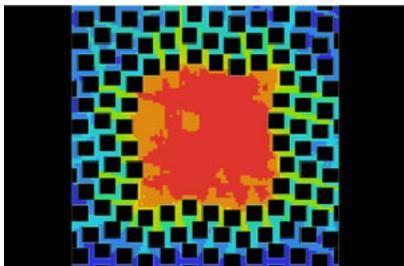
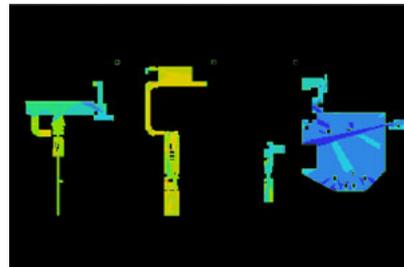
Counter-Strike Estate



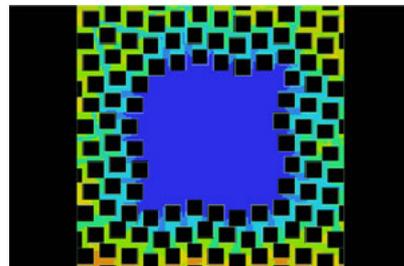
Counter-Strike Sandhog



Counter-Strike 747



Prospect Space Random



Group 1 shows a high correlation of relativised visual entropy with visual integration but without examining the VGA graphs the design context of this correlation would not be obvious. The colour values for both metrics are reversals of each other due to the system of measurement.

When examining the graphs for both metrics across the group it can be seen that the distribution of visually integrated areas and relativised visual entropy values for all maps are centrally located. This is clearest with the figure 8 control maps and the final prospect space control map.

Relativised visual entropy takes account of the expected distribution from the point considering that in a normal distribution the number of vertices encountered when moving through the graph would increase up to the mean depth and then decline afterwards. If the visual integration is focussed centrally then it follows that this will correlate well with relativised visual entropy as this measures the distribution of points and would indicate a central location because of the even distribution around these points.

The central tendency of visual integration within the environment is proven by the high correlation with relativised visual entropy. This means that a game designer can confirm central integration in a complex environment through this correlation and therefore expect a central balance to player movement within that environment.

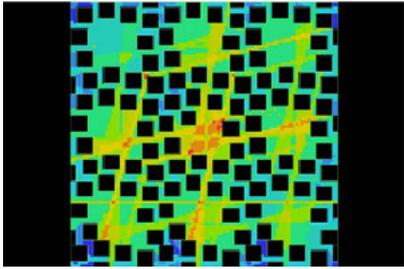
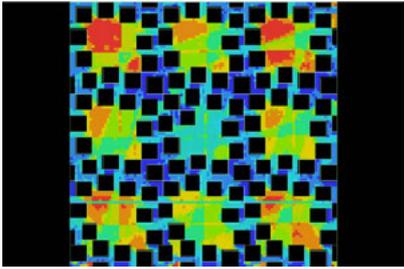
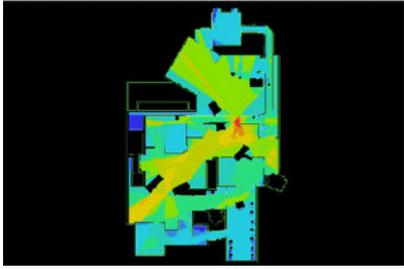
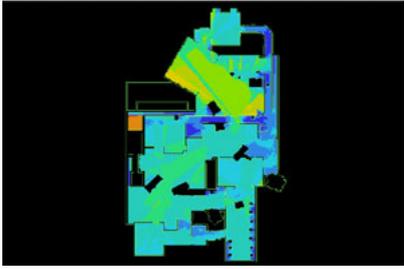
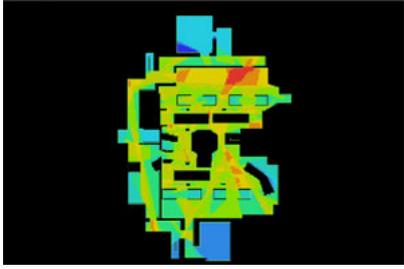
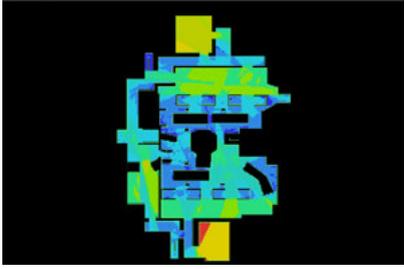
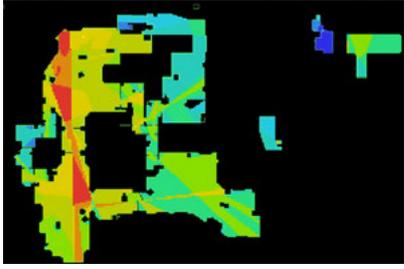
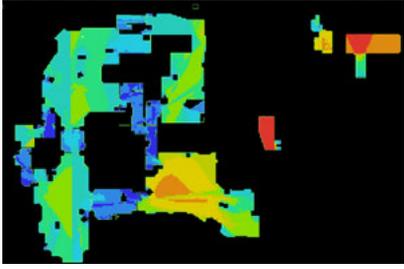
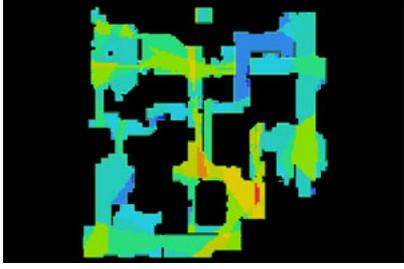
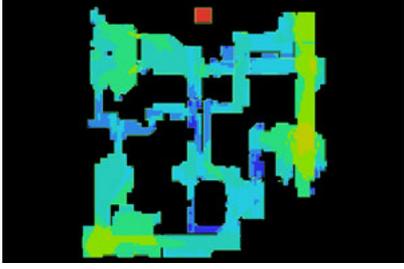
Table 32: Group 2 Metrics

R2 Correlation to Visual Integration	Intimate Random	CS cbble	SA 3rdsupply	CS dust2	CA pumpjack	CS office	CA coldseed	SF desert camp	SF shanghai	SF missile
Visual Clustering Coefficient	0.1422	0.3311	0.3228	0.4210	0.3621	0.1285	0.2410	0.3382	0.4876	0.3270
Visual Control	0.2662	0.1030	0.1890	0.2365	0.1792	0.2557	0.3462	0.2252	0.2435	0.1503
Visual Controllability	0.0025	0.0578	0.0703	0.0695	0.1224	0.0018	0.0318	0.0248	0.0292	0.0279
Relativised Visual Entropy	0.5527	0.8198	0.8284	0.5825	0.7166	0.6890	0.4927	0.3588	0.3994	0.7791
Perimeter	0.6336	0.6294	0.7138	0.5742	0.6773	0.8072	0.7186	0.6852	0.5871	0.5252
Occlusion	0.6904	0.6607	0.5383	0.6316	0.7193	0.7147	0.6227	0.6722	0.6013	0.5856
Compactness	0.3363	0.4814	0.3620	0.6461	0.6613	0.4431	0.2076	0.4313	0.3714	0.3743
Max Radial	0.5272	0.4901	0.4748	0.3694	0.4459	0.6607	0.5088	0.4250	0.3023	0.3265
Visual Integration										
Mean	0.4261	0.3908	0.4497	0.4320	0.4557	0.5359	0.6429	0.5293	0.5196	0.4043
SD	0.0703	0.0781	0.0925	0.0724	0.0821	0.1340	0.1453	0.1074	0.0995	0.0769
Median	0.4231	0.3848	0.4576	0.4326	0.4668	0.5473	0.6380	0.5377	0.5281	0.4056
Relative SD	0.1650	0.1999	0.2057	0.1677	0.1801	0.2501	0.2260	0.2029	0.1914	0.1902
Kurtosis	0.1406	0.1704	0.2482	-0.2628	-0.3140	-0.3688	-0.3609	-0.1959	-0.3404	-0.4789
Skewness	-0.0059	-0.0317	-0.5893	-0.1158	-0.3852	0.1680	0.0192	0.2404	0.0191	0.1601
Interquartile Range	0.0815	0.1043	0.1219	0.0976	0.0951	0.1940	0.2214	0.1375	0.1505	0.1139
Visual Integration Considerations										
Median within 2% of the Mean?	99%	98%	102%	100%	102%	102%	99%	102%	102%	100%
RSD less than 20%?	16.5%	20.0%	20.6%	16.8%	18.0%	25.0%	22.6%	20.3%	19.1%	19.0%
Kurtosis less than 0.3?	0.1406	0.1704	0.2482	-0.2628	-0.3140	-0.3688	-0.3609	-0.1959	-0.3404	-0.4789
Skewness less than 0.2?	-0.0059	-0.0317	-0.5893	-0.1158	-0.3852	0.1680	0.0192	0.2404	0.0191	0.1601
IQR less than 1.5xSD?	1.1589	1.3357	1.3180	1.3476	1.1589	1.4473	1.5240	1.2802	1.5134	1.4812

Colour Key

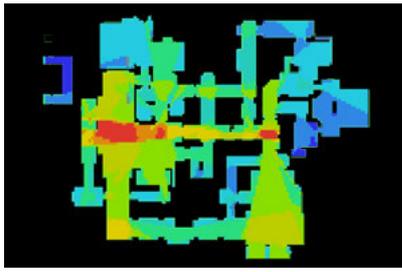
0 < value < 0.3	0.3 <= value <= 0.7 or if a question equals 'yes'	0.7 < value
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Table 33: Visual Graphs for Group 2

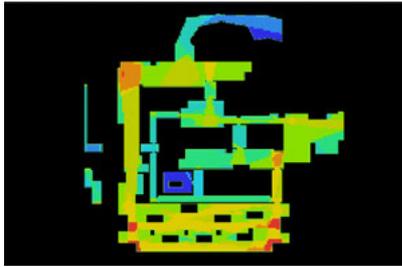
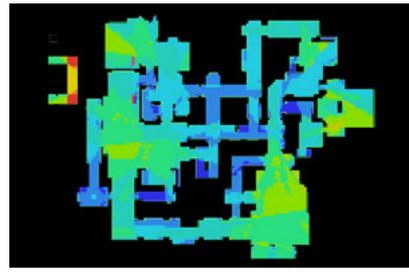
Visual Integration	Visual Controllability
 <p>Intimate Space Randomised</p>	
 <p>Combat Arms Cold Seed</p>	
 <p>Combat Arms Pumpjack</p>	
 <p>Counter-Strike Cobble</p>	
 <p>Counter-Strike Dust2</p>	

Visual Integration

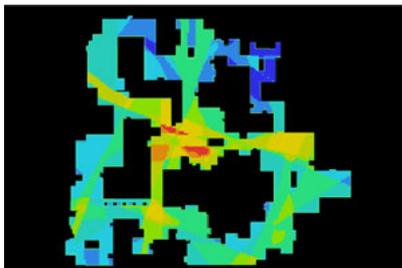
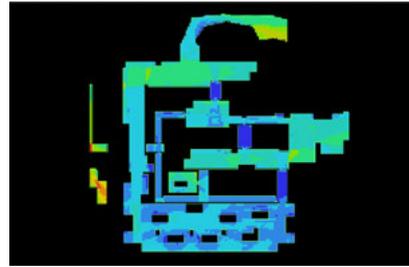
Visual Controllability



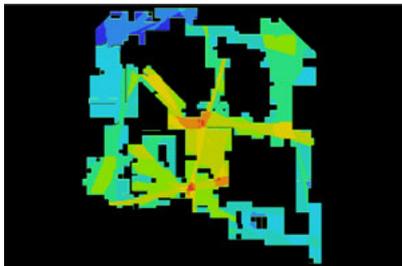
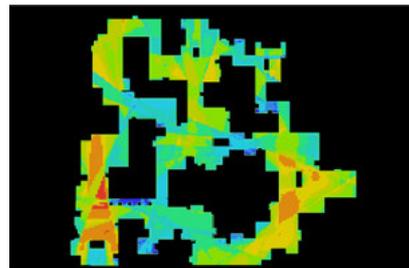
Counter-Strike Office



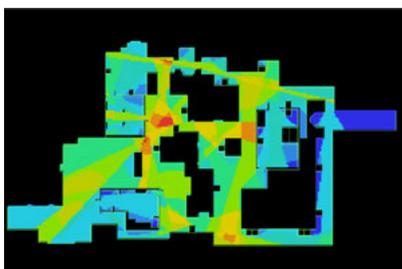
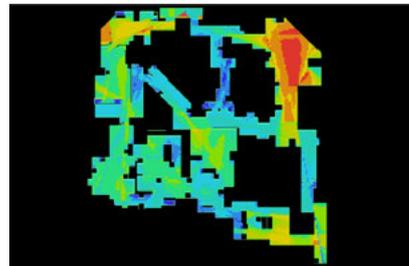
Sudden Attack 3rd Supply



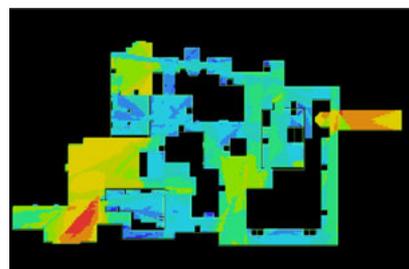
Special Force Desert Camp



Special Force Missile



Special Force Shanghai



Group 2 demonstrates minimal correlation between visual integration and visual controllability. This lack of a correlation can be seen clearly in the visual graphs where for each pair of graphs the high value areas, shown in red for both metrics, do not correspond with each other.

In this case a lack of correlation is actually important for elements of the game design. If a highly integrated area is also easily visually dominated then the player or team in control of this area could exert too much control over player movement. When the controllable areas are not highly visually integrated then these controllable areas may be key strategic points for gameplay but do not affect the movement to and from them.

In this instance the lack of correlation between metrics is important in balancing gameplay. This form of balancing the design elements within the environment is often only encountered in the design process when play testing begins.

7.4 Conclusions

Spatial metrics can be considered to offer a method of informing the design of game environments at the level of the large city environment, the immediate player viewfield and pedestrian size game map. They offer the designer a clear analytical approach to building and analysing the intelligibility of an environment at key stages during the design process.

This methodology enables the analysis of real world environments before their transfer into a virtual form in order to recognise design issues for gameplay. This could also indicate cultural spatial characteristics as determined in chapter 6 to ensure an intelligible structure for all players.

The characteristics of first level game architecture can be interpreted through the use of spatial metrics and the visual graph of the parameter within the environment. This possibility to develop known metrics for level design theories, such as the figure of eight route and balance the addition of extra geometry will add benefit to an otherwise predominantly subjective design process.

Hierarchical clustering of game maps can indicate new patterns for first level game architecture as the intelligibility of game environments can now be quantified. This also offers new insights into game geometry patterns and design theories that can lead to a more definitive taxonomy of game maps corroborated by spatial metrics.

In conclusion there are definite uses for spatial metrics in the building of game environments in a design methodology.

Chapter 8: Conclusions

The overall aims of this study were to develop a better understanding of the requirements and design implications of multicultural multiplayer 3D game spaces. This was undertaken using a two-stage reflective design research methodology recognising the ambiguity of the design problem. The specific aims of this study were:

1. Review interdisciplinary literature and knowledge relevant to the development of a multicultural multiplayer game design methodology.
2. To examine 3D environments and analyse where experiential knowledge and cultural knowledge influence the game environment.
3. Develop and determine the validity of an analytical design method for use in a comparative study of 3D environments.
4. Analyse current game environments to determine how cultural influences influence 3D environments.
5. Determine how the method may be applied in the production process for multicultural multiplayer environments.

The main results and conclusions are presented in the following sections.

8.1 Main Findings

8.1.1 Cultural Precedents for Gameplay

Historical perceptions of cultural gameplay preferences are not invalidated by this study's findings but they are now brought into question by the current context of the global game market place. Traditional sales charts no longer offer a true statistic to base cultural gameplay preferences upon, as they do not take into account new distribution models for games. Examining only game sales figures to try and establish current cultural preferences is now problematic.

The Japanese versus Western studies of gameplay preferences are also becoming redundant for moving game design forward when new Asian markets have developed.

What has proved of importance to the development of an analytical method to understand multicultural gameplay is the global popularity of the first person shooter genre of games. This smaller gameplay environment with minimal narrative enables the geometry of the environment to be comparatively analysed for cultural influence more easily than larger game environments. With its global popularity this genre should be able to offer more scope in future research studies.

8.1.2 Culturalisation

The games industry has a clear understanding of the need for more than localisation of language to convert a game to sell in another geographic region. Culturalisation processes understand this, and consider all the influences that may result in problems for a game when sold in another cultural region. The recent texts on cultural practices that target industry are evidence of this advancing area of knowledge (Chandler and Deming, 2011; O'Hagan and Mangiron, 2013). They deal with localisation and culturalisation but do not deal with multiplayer multicultural scenarios in any form directly affecting this study.

These processes are as yet, still a post-production method. They consider culturalisation as applied to game assets. With the development of multicultural multiplayer game environments there needs to be an embedding of culturalisation in the design of games. As Toshihiro Nagoshi demonstrated it is possible to think cross culturally throughout the game design process. This form of culturalisation must be careful not to reduce games to a culturally odourless form where all interesting cultural aesthetics are removed. The spatial design method developed by this study only effects geometry. It offers a demonstrable method for developing geometry and game spaces with measurable multicultural understanding. This leaves aesthetic as opposed to functional cultural considerations to still be present in the narrative textures of a game environment.

8.1.3 A New Comparative Analytical Method for Game Spaces

The reflective methodology of the study enabled the hypothesis of a connection between the knowledge in two disciplines. Nisbett's research discussed in section 3.5.3 defined cultural cognitive differences in the interpretation of images between Western and East Asian subjects. It indicated that the cultural background of the game designer and of the player must be considered within a design process. It also indicated screen based parameters based on the complexity of the screen display. Nisbett's model offers a direct correlation of intelligibility to the 2D screen image enabling an applied design approach to results.

Lynch's theory of imageability has been discussed in many game texts but there was no definitive literature found on its application within a game design methodology. Yet the identified characteristics of imageability were present in some form in most 3D environments.

A new analytical method was required separating geometry from the narrative texture and analysing an environment by its geometrical spaces not its structures. Normally a visual analysis would prioritise what the designer can see, but with this method it is easier to think about it as the spaces between what the designer can see. The field of spatial analysis based on early work by Lynch and the academic field of Space Syntax considers how people make way-finding decisions in urban environments offering a way forward to build this method.

Beginning with the properties of a single isovist the method of correlating the isovist metrics, as a player viewfield, with where changes in the 2D screen occur is a new direction for spatial analysis. Considering this for determining the cultural influence evident in a 3D space is also a new hypothesis.

This method as a comparative method is also relatively new, as space syntax has little requirement to compare spatial environments in a like for like scenario. After testing the method with control environments it is now possible to say from this study that the use of it in this form stands up to scrutiny.

An initial test of comparing the data from a group of amateur maps for *Counter-Strike* against a group of professional maps indicated design differences between them. The

professional maps were indicated better visual integration indicative of a more considered design approach.

8.1.4 A Method for Discussing Design Decisions

The investigation of the comparative control maps also indicated that the game designer is able to see how minor changes in the geometry of the environment will affect the balance of a game environment. The VGA colour maps applied to the plan view of an environment give spatial feedback on any design decisions that change elements in the game space. This form of visually balancing an environment will be of benefit to the game production process.

8.1.5 Transferring Real Environments into Game Worlds

The results of comparative studies of real world environments replicated in 3D worlds demonstrated spatial measurements indicative of the design functions of the environments in real life. Transferring these environments to game worlds will transfer these spatial characteristics that may not be suitable for specific forms of gameplay.

This analytical method will enable the consideration of appropriate spatial characteristics before or during the process of transferring real world environments.

The discussion of spatial metrics can also aid the design discussion of navigability in large game environments that might be transferred or modelled on real world systems. The analysis of appropriate urban layouts will be useful at the start of large environment design projects. The ability to consider smaller, beginner environments, and the stepping up of navigability challenges as areas open up to a player is a useful design tool.

8.1.5 An Analytical Method for Cultural Influence

Research in cognitive studies indicated how cultural differences between Western and East Asian subjects are evident in the perception of 2D images on screen. East Asian subjects are able to process more complex visual information across the screen space than Western subjects.

The hypothesis for the analysis of culture was that if the isovist viewfield of the player is a complex shape then this makes the screen display the player sees complex to

process cognitively. The isovist is a 360-degree viewfield so it does not matter which way the player turns it will still be a complex display.

If cultural influence is evident then an East Asian designer will be able to deal with complex 2D screen displays and this will convert into complex 3D environments. Accordingly Western designed environments would indicate less complexity in their spatial parameters, as the screen display of the 3D environment will be simpler.

The analysis of a group of Eastern and Western FPS environments indicated this hypothesis is correct. There were spatial parameters that are significantly statistically different between the two cultural groups of maps as indicated in the table below.

Table 34: Cultural difference in Spatial Metrics

Spatial Parameter	Western	Asian
Isovist Area	No Difference	No Difference
Isovist Perimeter	Lower	Higher
Isovist Occlusion	Lower	Higher
Isovist Maximum Radial	Lower	Higher
Isovist Compactness	Weaker influence on visual integration	Stronger influence on visual integration
Visual Integration	Lower	Higher
Relativised Visual Entropy	Higher	Lower
Visual Clustering Coefficient	Higher	Lower
Visual Control	No Difference	No Difference
Visual Controllability	Higher	Lower

On the characteristics of isovist viewfields across the environments Asian maps indicated higher perimeter, occlusion and maximum radial measurements, but with no difference in area. This established that even though the area of isovists is similar the shape couldn't be, as the perimeter is not. The issue that compactness did not indicate a significant difference to indicate spikiness became clear when a deeper level of spatial analysis was considered.

The stronger influence of compactness on the visual integration of Asian maps is to be expected if these maps are considered to be more complex. That it is only significant in the correlation to visual integration and is not significant when measuring the geometry implied tacit knowledge more than an explicit design strategy on the part of the designer.

In conclusion this indicates that the designers of the Asian environments were considering the complexity of the environments intuitively. This is because it is not possible to determine how compactness affects visual integration from a visual design approach.

These results have to be carefully considered, as they are the first set of observations from a relatively small sample of 30 environments. An important element of the study has been met and that is to be able to discuss if cultural differences can be identified through the methodology. A definite starting position for further studies has been established.

8.1.6 A Multicultural Multiplayer Game Environment

Dust2 was identified as being globally popular as an FPS game environment being run on 4 times as many servers as other *Counter-Strike* maps. The overall correlations of visual integration with isovist perimeter, occlusivity, complexity and maximum distance, in Dust2 were significantly higher than other maps. Dust2 fitted in the overlap of spatial characteristics in both Eastern and Western groups of maps.

The spatial values for this map in Table 12 indicate a starting point for the spatial values of multicultural multiplayer environments. The underlying spatial structure of an environment, the intelligibility, can now be quantified to produce environments with known gameplay characteristics. These are measures that could be used by designers of new environments within the design process as statistical measures to aim for before play testing is required. This is a first step towards space syntax measures for gameplay and with the overriding global popularity of Dust2 it is a statistically valid one.

8.1.7 Applying Spatial Patterns

To aim for spatial values, as with the Dust2 characteristics, requires a system of design knowledge on how space can be altered to change specific spatial measurements. VGA

parameters are not immediately obvious to the designer through the visual inspection of an environment and this means their applicability to the design process could be limited. In chapter 7 the combination of VGA analysis and first level game architectural principles of narrow space, intimate space and prospect space offer a visual and statistical approach for the designer. Understanding how VGA parameters change with the addition of grids, more organic subspaces or other design patterns provides design principles in order to aim for the VGA measurements required. Alongside the visual inspection of the VGA graph this enables the designer to form visual interpretations of the spatial parameters across the environment.

These design methods are at an early stage but the application of design patterns in order to adjust visual parameters is a new spatial method for designers. This approach will mean designers can create generate the required environments without their tacit cultural knowledge affecting the design process.

8.2 Limitations

This body of research has several limitations that are important to note at this point in both the development of the analytical method and its application.

Isovists are essentially a 2D viewfield and it is common practice to run two VGA analyses on a single environment, one at eye level and one at knee level. Changing the height of the analysis is a consideration of what can be seen and what is considered the freedom of movement within the space. In this study the environments have been stripped down to a movement model and this is discussed in section 5.5 but requires more consideration in future studies.

There are also issues with the application of a 2D method to a 3D space. The chosen environments for this study were not multilevel platform environments. With these it would have been necessary to run an analysis for each level and it is not possible to link levels in the sense that players can see each other. There are also elements of the spatial methodology such as single direction nodes discussed in chapter 5 that need to be addressed in further studies.

A limitation of the industry applicability of this study is that there has not been industry input into the development of the study. Whether this has been detrimental to the research and the study's progress is not clear yet. This has been a disappointment in some respects as industry validity is essential in the further stages of the study. It is also understandable as in the early stages of research there was not enough substance to convince industry of the nature of the study and later results became too complex to discuss in the limited timeslots when informal contact was made.

A final point is the game environments tested where mostly early designs and the homogeneity of culture discussed in chapter 3.1.2 may now be evident in current game design. This could mean cultural influence is now historical in some genres of game design. This might be seen to be a negative point to conclude a study looking for cultural evidence in game design but it is through the new spatial methodology developed in pursuit of how to measure cultural influence that it is possible to prove or disprove these new design questions. In this study it was always the applicability of the research to benefit the game design process that was most important and that is for the benefit of game designers from any culture.

8.3 Recommendations for Further Work

This study has taken the first steps in developing a new method that can inform design research into game environments as an applied method for the production and design of game environments. It is new knowledge within the field of game design and requires further validation within the game design process to see whether multicultural game spaces can be developed with this method.

Further work should start with the advancement of this method in terms of the analysis of more current game environments. *Counter-Strike* offered a range of environments for the breadth of requirements of this study. The limitations were also accessibility to other game environments. It is hoped that with these early results access to other game models may be forthcoming direct from industry.

The implementation of this method for the development of online game spaces using the spatial characteristics of *Dust2* is a key element to take forward. This is at the heart

of this study. Finding the spatial metrics to enable the development of multicultural multiplayer environments is a key step for the multiplayer online game industry.

Space Syntax is an advancing academic field and the problems of 3D isovists have been discussed for some time but not solved. The technologies in current game engines should be able to address this and solve limitations of the 2D isovist used in this study.

A study into spatial measures relevant to player decision-making is a logical next step for the application of spatial measures within a game design methodology. The development of spatially measured design patterns applied to game environments will inform the game design process prior to game testing.

The determination of cultural influence using spatial measures to explore real world artefacts outside of its original design context of urban design could extend understanding of cultural cognitive differences in other design fields as well as game design.

This spatial methodology offers interesting possibilities to understand design thinking in virtual environments and while understanding cultural influence was the starting point to develop the methodology it is definitely not its only application.

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Glossary of Terms

Affordance: Originally defined by the perceptual psychologist J. J. Gibson it refers to the actionable properties between objects and users. For Gibson these affordances did not have to be visible or known to the user.

Axial Lines: These represent the fewest and longest lines of sight that pass through every space in an environment.

Clustering Coefficient: How convex, or alternatively, spiky a neighbourhood is for a vertex. It measures how many vertices within the neighbourhood can see each other against how many are in the neighbourhood.

Compactness: An isovist measure of how convex or spiky the isovist perimeter is.

First Person Shooter (FPS): A 3D weapon based combat game played through the first person perspective.

Flow: The balancing of challenge and the ability of the player to create an engaging and immersive gameplay pattern without unexpected inconsistencies in expectations that would ruin the flow of a player's immersion in the game world.

Imageability: Originally defined by Lynch as areas of high imageability have distinctive landmarks, clearly defined edges, often with major nodes where busy paths joined. Low imageability is marked by a lack of landmarks with vague and indistinct paths and edges.

Intelligibility: Defined by Bill Hillier and Julienne Hanson as the connection and integration of the spaces that form an environment.

Intimate Space: A game space that is neither too small nor overly large and the player feels they have a control over it.

Isovists: This is the viewfield from a single point in an environment drawn as a polygon, usually at eye level.

Massively Multiplayer Online Role-Playing Game (MMORPG): A genre of game in which very large number of players may interact within the same game space.

Maximum Radial: This measure is the maximum distance to the perimeter of the isovist polygon determined from the viewpoint.

Mis-en-scène: Used to describe the design and arrangement of all elements within the field of view of the camera.

Mod / Modding: A mod or modification to a game changing its original form.

Narrow Space: This game space creates a sense of vulnerability as the occupant feels confined and realises that movement is limited.

Neighbourhood: Within visibility graph analysis the neighbourhood of a vertex is the set of vertices immediately connected to that vertex, those sharing an edge.

Oclusivity: This is a measure of how much of an isovist perimeter is occluded as opposed to a fixed boundary, such as a wall.

Prospect Space: A game space that is a wide-open area where the occupant feels exposed.

Relativised Visual Entropy: A relativised measure of order considering the distribution of vertices in the visibility graph in terms of their visual depth from an individual vertex rather than their depth in the system.

Space Syntax: A set of theories and methods for the analysis of spatial configurations conceived by Bill Hillier and Julienne Hanson.

Visibility Graph Analysis (VGA): This is the calculation of the relationship between vertices drawn at regular points across the navigable space and their visibility to each other.

Visual Control: A local spatial measurement that picks out areas which are visually dominant within the overall grid by comparing the size of the current neighbourhood with the size of the adjoining neighbourhoods.

Visual Controllability: A local spatial measurement that indicates areas within the grid that may be visually dominated

Visual integration: This is the reciprocal of the mean depth for a vertex compared to all other vertices in the system. The mean depth is how deep or shallow the vertex is within the graph compared to how deep or shallow it could be. This measure is also called Relative Asymmetry and it eliminates the effect of the number of vertices in the system.

Appendices

Appendix 1: *Spatial Design for Multicultural Online Game Environments* presented at the 5th International Congress of International Association of Societies of Design Research in Tokyo, 26th -30th August, 2013.

Spatial Design for Multicultural Online Game Environments

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Abstract: Current gaming technologies enable players from different cultures to communicate and participate in gameplay within a single game environment. A player from one culture may now inhabit a three-dimensional game environment developed by designers from a different culture. These game environments bypass geographic and cultural boundaries and question differences in Eastern and Western gameplay preferences recognized by the games industry. This paper discusses the effect of cultural knowledge on the spatial design of three-dimensional game environments. A new methodology for the comparative analysis of the design of three-dimensional game environments is established considering cultural models as applied to design thinking. Based on spatial analysis it offers game designers and researchers metrics correlated to human way-finding in the real world that are directly relevant to the forms of game play in these environments. The initial analysis of internationally popular, and culturally specific, game environments indicate areas where cultural differences may be considered through spatial considerations within a design methodology. Recognized cognitive differences between Eastern and Western cultures and the interpretation of the two dimensional visual field are considered within findings that determine the use of spatial metrics is a methodology that can be used by design researchers and game designers as a toolset within the design cycle of online multicultural three-dimensional game environments.

Key words: *Game design, culture, spatial analysis, cross-cultural, design methods*

1. Introduction

The digital games industry has developed formats for online multiplayer games where players from different cultures can play alongside each other within the same online game world. This is despite a history of anecdotal evidence from the games industry of cultural differences in gameplay preferences between Eastern and Western game players. Significantly there has been no investigation of this perceived notion of cross-cultural differences that might inform Eastern and Western game designers in the design of these new multicultural game spaces.

As players from one culture may now inhabit a game environment developed by a designer from a different culture the question of how cultural knowledge affects gameplay preferences and the game design process is now of importance to future advances in game development.

The predominant industry design model for the production of games relies on the play testing of games to understand and correct design issues prior to a games release. This is a tried and tested design model relying on the tacit knowledge of the experienced designer and the intuitive knowledge of the tester. Both

recognise what they feel is right with the product and use a feedback loop to form an iterative process of design refinement.

The theory of *flow*, “the state in which people are so involved in an activity that nothing else seems to matter” [1], is cited by game designers in the balancing of challenge and the ability of the player to create an engaging and immersive gameplay pattern. This is inherently intuitive within the design process, recognised as a design skill with no clear measurement except through the subjective responses from game testers informing design decisions.

The games industry has recognised cultural differences in game play and are designing game worlds that players from other cultures may look to achieve *flow* in but if play testers and game designers are from the same culture then there is a weakness in the design model.

This study does not attempt to produce a new multicultural production model for industry but considers how tacit cultural influences within the design process may be determined and discussed by designers in order to consider the cultural differences of game players. It is the author’s opinion, as a designer and researcher, that *flow* may remain predominantly intuitive within the game design process but a methodology for the consideration of cultural influence and player preference upon the design elements involved is an industry requirement.

In order to begin to understand the issue this study first outlines industry perceptions of cultural differences and then considers the application of different cultural models to contextualise Eastern and Western gameplay preferences. Nisbett’s [2] cultural model establishes a design led context determining the separation of game narrative and game geometry. This facilitates the development of an analytical methodology using spatial analysis toolsets to analyse game environments for indicative cultural differences within their design.

This study analyses three-dimensional game spaces as it recognises how designers and players correlate their knowledge of real world movement with movement in these game worlds. The designer of these game environments relies on a player’s tacit knowledge of movement and interaction in the real world to begin to understand gameplay mechanics in the game world. This transfer of experiential knowledge is a common design theory in game design practice with Huizenga’s theory of ‘The Magic Circle’ [3], representing a boundary between the real world and the world of the game discussed by many game theorists [4][5][6]. It offers a basis for analysing where a player and a designer’s implicit knowledge, common across cultures, become more culturally specific knowledge affecting design decisions.

This paper is part of an on-going investigation into the influence of cultural knowledge on player behaviour within game environments and on the design of those environments [7]. It does not assume to have solved the issue but to have taken the first steps to consider how design researchers and game designers can begin to address it and inform industry practices.

2. Industry Context

Game development in industry is most often based on knowledge from the prior development of games, the success of game genres, or commercially successful sequels. This is an expected industry model as the development and production of games is increasingly expensive and industry is naturally averse to commercial risks on experimental game designs. The commercial economic markets for games have been roughly delineated by continent and the release of a game may be confined to a single market

due to sales data on game play preferences for particular markets. When games are released across different regions they may be localized not only for language, but also for gameplay and aesthetics to fit industry knowledge of different markets [8].

A consequence of this model is that over time market divisions in game sales may have developed because of the influence of risk adverse marketing teams relying on historical sales figures. This study does not intend to statistically analyse historical sales data in depth but it is wise to consider why some cultural preferences are so pronounced and still resonate in today's marketplace.

The First Person Shooter (FPS) genre has traditionally been seen as a popular Western game with Role Playing Games (RPG) as more traditional to the Japanese market. This has been stated as recently as 2011 by Naoki Aoyagi, CEO of Japan's largest mobile social games network, when asked about its move to develop Western markets. *"I think some content works globally. Some content is very local, so it's a combination. For example, even in traditional gaming, I use an example, some content like sports games they are popular in the worldwide, but some contents are very local -- like Japanese RPGs, or the FPS in the U.S. and Europe. The sports game in, say, each country."* [9]

This traditional notion is now brought into question through online multiplayer games and the increasing accessibility to the FPS genre through the online free to play game mode that has increased the number of FPS players globally. The South Korean developed Cross Fire [10] reached three million concurrent users in China in September 2011 [11]. Special Force [12], also developed in South Korea, accumulated 4 million registered users in Japan historically identified as not a commercially significant market for FPS.

Due to the limitations of network data transfer initial developments in multiplayer games used server technologies that kept players from different geographic regions from encountering each other. The increase in data transfer speeds meant FPS could enable small numbers of players, around 2 to 32, to access game servers in any part of the world.

Massively multiplayer online role-playing games (MMORPG) use server technologies to create persistent worlds where thousands of players may inhabit the same environment. Initial developments used separate servers for different geographic locations but Eve Online [13] uses multiple servers to create a single game universe for all players from around the world. World of Warcraft [14] was developed with separate servers for Chinese players though some players prefer to access foreign servers. Cultural gameplay differences have been demonstrated with the transfer of the real world cultural practice of *guanxi* into World of Warcraft [15]. These unexpected cultural gameplay behaviors indicate the need for more culturally diverse thinking within game design processes.

2. Cultural Models Applied to Game Design

The use of cultural models is prevalent across academic fields so the consideration of how they might inform an understanding of historical game preferences is essential in order to determine a methodology.

Hall's cultural model defined the concept of high-low context cultures examining messages and the flow of information within a culture. High context cultures use messages that are expressly implicit where information is contained within the context of the message. Low context cultures use explicit messages and the meaning of the message is clearly realised within the message itself with little or no hidden meanings. The design of gameplay goals within games requires different levels of context in order to pass a message to the player of what gameplay actions they should take. FPS games require low context

messages easily read while moving around the environment at speed. Role playing games use high context messages contained in visual clues and knowledge referenced within game environments. Low context cultures include North America, England, and Germany while high context cultures include China, Japan and South Korea. If historical game sales statistics and boundaries were considered then this model would support the preference of FPS over RPG games in Western game markets.

Hofstede's cultural model is commonly used in studies across different academic disciplines and discusses culture as a collective phenomenon where the "collective programming of the mind" [16] differentiates groups or categories of people. It has a core area of values that classify nationality and culture through a Value Survey Module questionnaire exploring six dimensions. In this model the USA and Great Britain exhibit significantly higher individuality values than Japan, South Korea or China, indicating a preference for looser social frameworks. This *may* relate to the success of the FPS genre within the USA and Great Britain, as there is inherently more freedom in these fast competitive games and less need for structure within team play. Japan has a higher individuality than South Korea and China with a much more significant difference in Masculinity vs Femininity (MAS) values representing a preference for heroism and reward. This *could* relate to the success of narrative based heroic RPG's that have been hugely successful in Japan but not fared as well in other markets. Higher Long Term Short Term Orientation values also indicate a possible propensity for greater context in game narratives that comes with RPG's. Higher MAS property alongside the high uncertainty avoidance property would indicate an avoidance of FPS with their quick fire and random team play.

Nisbett's model of culture does not offer key measurable dimensions with nationality but concerns itself with how Eastern and Western cultures differ. Mental processes including areas of thought, perception, attention, organisation of knowledge and understanding are used to define Eastern and Western cultural differences [2]. Nisbett suggests that Westerners are analytic and see their world in terms of goals and individual elements, looking for the rules that govern these in order for them to control events. Eastern thinking is holistic: it considers inter-connection, in order to understand a part you must understand the whole because everything is in a state of constant change and each part has an effect on all of the others. It could be considered that a Western player may prefer more goal driven games and an Eastern player more narrative based gameplay. Game design balances goals within encompassing narratives so a game's design may result in different cultural interpretations of a single game depending on how it balances these to create *flow*.

Nisbett and others [17] [18] evidence how these cognitive differences directly affect the interpretation of the visual field and objects within it. Subjects from Western and Eastern cultural backgrounds perceived the relationship of objects within test images in different ways. They offered different narratives for the structure of the elements within the image. Nisbett's original study has evolved into studies using single images, photographs of city environments, animation and web sites. This indicates the interpretation of the game environment, a two-dimensional display on screen of three-dimensional data, will also be affected by these cultural differences.

Faiola et al [19] suggest from their study using web pages that web design should be carried out according to Nisbett's cognitive theory in order to enhance perception and usage. Users performed better when using a website developed by a designer from their own cultural background than a comparable website designed by a designer with a different cultural knowledge. A study by Boduroglu et al [20] offers a practical issue for the design of screen composition as they demonstrate that East Asians are

better than Americans at detecting colour changes when a layout of a set of coloured blocks is expanded to cover a wider region and worse when it is shrunk. East Asians are also slower than Americans are at detecting changes in the centre of the screen.

These cultural cognitive differences in the interpretation of images require recognition if designing multi-cultural game spaces as cultural differences in the interpretation of the screen may offer differing game experiences. It is essential to consider how the two-dimensional screen image of a three-dimensional environment is to be interpreted without offering gameplay advantages due to cultural differences.

In conclusion Hall's high–low context and Hofstede's VSM may, to some extent, correlate nationality characteristics, organisational characteristics at the individual level in relation to game sales. It is however Nisbett's model, indicating cultural differences in the interpretation of the visual field, that is directly applicable to design practices and possible cultural differences in the interpretation of images on screens. If it is possible to analyse game environments for the elements that construct a player's visual field, extrapolating visual parameters within the image, then design elements may be determined in order to balance the visual field as seen by players from different cultures.

3. Imageability versus Intelligibility: Developing a methodology

A method for the deconstruction and comparison of the elements that form the screen image for a player from any point in the three-dimensional game environment is required in order to begin to understand what may influence gameplay decisions. Analytical methods developed within the academic fields of architecture and the built environments, exploring how people navigate real world environments, prove useful in this as they correlate with the application of real world knowledge used in game environments.

Lynch developed the theory of imageability [9] based on how the visible elements in an environment will affect a person's navigation through it and is referenced by several game designers [21][22][23] as offering design methods useful in the construction of game environments. Initial investigations correlate with Lynch's interpretations as game environments contain the same elements; paths, edges, districts, nodes and landmarks as referenced by Lynch to develop theories on imageability. Professional game designers use these elements to contain and direct players around an environment. This correlation of the criteria for reading a real world environment with the game environments examined in this study makes sense when considering Lynch has identified the key elements a person uses consciously or subconsciously while navigating an environment. These will be the elements a professional designer will at some point focus on when recreating a real world environment.

In the development of game environments it must then be considered how the imageability of a player's view from a location affects their actions and how this might be analyzed. A game environment consisting of three-dimensional geometry textured with a narrative aesthetic has already been influenced by the cultural references of the designer. In order to analyze the influence of elements within the environment a methodology to extract geometric information from the narrative aesthetic is required to allow their separate analysis.

Intelligibility is defined by Hillier [24] as the connection and integration of the spaces that form an environment. Intelligibility and imageability were considered as unrelated methodologies by their

respective fields until the paper *The syntactical image of the city: A reciprocal definition of spatial elements and spatial syntaxes* by Conroy-Dalton [25] explored the relationship between them.

It can be seen why they were considered different when you consider their approaches. Imageability focuses on the visual qualities of an environment elicited from the users of the environment while intelligibility is concerned with the underlying structure in relation to observable behaviour of users in the environment.

In comparing the two systems Conroy Dalton & Bafna concluded there is a relationship between imageability and intelligibility. The hypothesis was that an imageable environment is also intelligible but an intelligible environment does not have to be imageable. A simplistic explanation is to say that an underlying structure in an environment may be seen within the visual differentiation of elements but importantly a structure itself is not dependent on visual elements indicating it.

Intelligibility can be considered to relate to game design functions of the structure and control of player movement within the environment and imageability offers an understanding of game design functions in terms of the subjective response to an environment affecting player movement. These methodologies are proven within their respective fields when applied to real world environments correlating directly to how a person navigates an environment. This meets key criteria for the investigation of the transfer of implicit cultural knowledge into the design and implementation of three-dimensional game environments.

Intelligibility, seen through the perspective of imageability, offers a methodology that can bridge primary game architecture in terms of geometry and the more subjective secondary game architecture in terms of elements such as narrative texture.

4. Intelligibility Through Space Syntax Measures

Space syntax examines the structure of an environment and this field of study has developed methodologies for the measurement of urban layouts that correlate with the way people navigate environments [26]. Metrics relating to the information used when making navigational decisions have been proven to be a method for quantifying spatial relationships and for modeling how users will navigate environments [11].

Space syntax offers a methodology for the statistical analysis and interpretation of the geometry in a game environment. It can offer information based on measurements across the whole environment or from a single viewpoint. This offers a comparative methodology of the spatial properties of environments in order to highlight cultural differences in the design and navigation of the geometry that makes up the field of view in a game environment.

An isovist is a measure of the field of view from a single point within an environment. It is calculated by creating a two dimensional polygon of the visible area which may then be used to calculate individual isovist properties. These properties include; the isovist area, the length of the isovist perimeter, how much of an isovist perimeter is occluded and how complex a perimeter shape is.

It is important to consider how any measurement may be interpreted within the design process for a game environment and its relationship to the gameplay within the environment. In terms of game design and the analysis of an environment isovist properties equate to certain spatial values that may affect gameplay. A large isovist area may indicate a large open area or an apparently smaller area that may be seen from a greater distance. Any occlusion in an isovist perimeter indicates unseen danger, as it is a

point of entry that an opposing player may enter from. The larger the occlusion value of the isovist perimeter the more likely it is that an opposing player can enter unseen into the isovist. Isovist compactness measures how jagged a perimeter shape is equating to the complexity of a boundary that may prove difficult for a player to interpret visually within fast paced gameplay. In figure 1 the position of player 1 demonstrates a complicated isovist view field with occluded edges in red and Player 2 hidden from the field of view of Player 1.

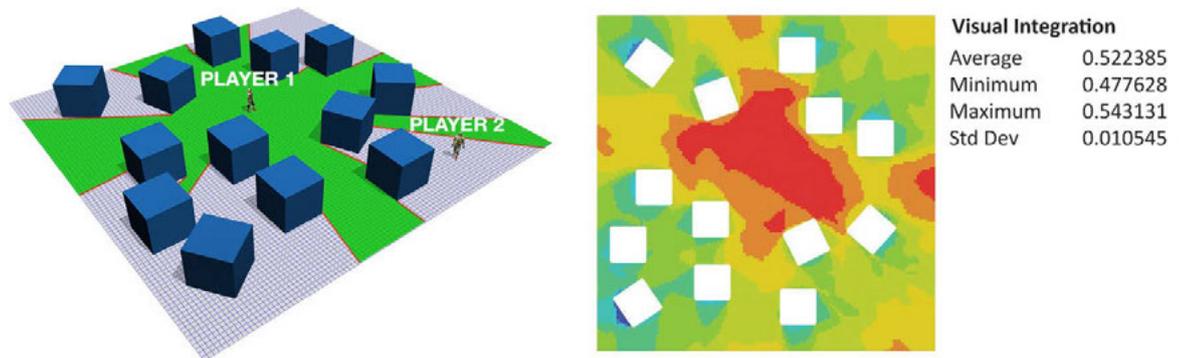


Fig. 1. Players within an environment and a Visual Graph Analysis (VGA) of the same environment.

When these isovist properties are interpreted alongside each other they offer statistical interpretations valuable to analyzing gameplay spaces and their design. A large area coupled with a high occlusion and a jagged perimeter means this is not a safe area for a player to remain in, though if the designer then places within this area an object may offer a player some form of protection it becomes a tactically important area.

Individual isovist data is useful for singular locations in a game environment but the development of visual graph analysis (VGA) takes the understanding of isovists and applies it across an environment to create values for the whole environment. A grid is applied to the environment. An isovist is drawn from the central point of each grid square. A statistical value can be calculated across the grid. Each cell of the grid can be coloured in order to provide the designer with a simple visual representation of the characteristics of the map. In this way a pattern of visual relationships across the space is revealed which will indicate areas of interest to the game designer. Statistical analysis of individual areas and comparisons of environmental characteristics is possible and way-finding algorithms using this information have been proven to estimate human movement patterns through space [12] that may inform the design process.

A property of the grid system is the ability to calculate relationships between different points and the relevant view fields within the environment. The calculation of visual integration analyses the number of visual steps required to reach other points in the environment. This can be used to calculate a range of statistics, including the mean depth of a point within the environment or the number of visual steps, for example turns a player may need to make, to other points in the environment. The use of the number of turns as an analytical property equates with the nature of a game environment because distance is often not taken into account by a player as their in-game speed is not realistic. In a fast paced game a player may make the minimum number of turns while moving quickly around an environment. The visual integration property indicates within a game environment the areas that a player, moving quickly around a map and using minimum turns, is most likely to move through and keep returning to. This may also indicate an area where players are most likely to encounter each other. The statistical property of visual

integration based on the shortest number of turns to any other point in the environment can be normalized so comparison across multiple environments is possible.

In conclusion spatial analysis offers many parameters that can directly inform the game design process and enable the analysis of individual locations in an environment or the whole environment for comparative studies across different environments.

5. Experiment: Spatial Analysis of *Counter-Strike* Environments

Initial investigations use environments from *Counter-Strike* [13], chosen due to its long history after being first released in 1999. It offers the opportunity to study several categories of game maps; professionally designed environments, player designed environments, environments used in the World Cyber Games and environments focused on an Asian market.

Counter-Strike server details were collected every hour over a period of seven days from an international game-monitoring site to assess the most popular maps for *Counter-Strike*. The results of this data enabled a choice of fifty maps that were then researched to establish their authorship as professionally designed or from the mod (amateur) community. The analysis of amateur environments is deemed important when considering cultural practices as these environments are free from economic influences, or industry constraints, so may demonstrate clearer cultural differences. *De_dust2* was the most popular map from the server sample with 2,572,870 servers running the environment. This was nearly four times greater than the next map *de_inferno* at 659,430 servers.

In 2008 a version of *Counter-Strike*, called *Counter-Strike Online*, was released [14]. It had been developed specifically for the Asian market by Nexon Corporation, who are based in South Korea. This game contained several exclusive maps designed for its target market by Nexon along with some pre-existing maps.

The groups for analysis were fifteen professional maps, fifteen mod maps, five maps from the Asian release of which three are completely new maps and five of the professional maps that are used in the World Cyber Games. *De_dust2* was also analyzed as a comparative measure to examine possible design characteristics that make it so significantly popular globally.

5.1. Initial Results

The data collected from each map was assembled to examine both the average value and as the data is non-parametric the median of each spatial variable. A Mann-Whitney U test was conducted to evaluate the hypothesis that there is no difference in spatial properties between the sample of professional and the sample of amateur designed maps. This was carried out to test the validity and robustness of this methodology.

H_0 : The two samples come from identical populations

H_a : The two samples come from different populations

The results of the test were significant within the property of visual integration for both the average and median values, the results of the test where in the expected direction:

Averages: $z = -2.841, p < 0.05$ ($p = 0.004$)

Medians: $z = -2.551, p < 0.05$ ($p = 0.011$)

The visual integration value for professionally designed maps indicated a more complex environment than found in the selection of amateur maps.

When the maps are examined by game type the mod maps include ‘awp’ and ‘fy’ forms of gameplay. These are gameplay types developed by amateur mapmakers independent of professional developers. These were not traditionally packaged with the game until the development of Counter-Strike Online for the Asian market. An ‘awp’ map is where the players are limited to using long-range gameplay mechanisms. In order to accommodate this form of gameplay most maps contain larger open areas and greater distances in order to test the player’s skill. This is evident within the data with high values for visual integration, isovist area and for the isovist maximum radial property (the maximum distance from the center of an isovist to its perimeter).

The ‘fy’ map is known as a fight yard where weapons are scattered around a small map allowing players to practice with different weapons. Within the sample analyzed these maps are the second most integrated after the ‘awp’ maps as they contain open spaces containing a range of objects for cover. The size of these maps for gameplay is indicated in the below average maximum and minimum radial measurements indicating smaller areas with closer gameplay. Without ‘awp’ and ‘fy’ maps the alternative hypothesis of a difference between professional and amateur maps is still significant with $z=-2.176$ and $p<0.05$ ($p=0.03$).

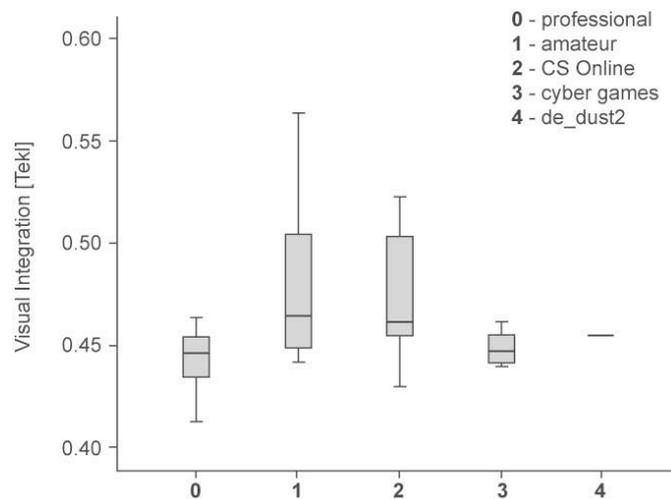


Figure.3 Visual Integration across the 5 sample sets

Figure.3 illustrates the visual integration values using a box plot across five sample map categories. The professional maps demonstrate more complexity in their environments than other categories indicated by the lower integration values. The World Cyber Games category shows a narrow integration range: as would be expected in order to offer a parity of experience across all maps used in the competition. The Counter-Strike Online map pack reflects the popularity of more open environments encountered in current amateur maps. De_dust2 on its own in category 4 but contained in categories 0, 2 and 3 appears to reflect the overlap in the categories.

The difference between the numbers of servers running the de_dust2 map compared to any other map indicates a preference for the gameplay de_dust2 supports that is not just the defuse, ‘de’ prefix, game format as servers for other ‘de’ maps were recorded in much lower quantities.

A scatter plot analysis of de_dust2’s spatial characteristics was undertaken in order to examine the correlation between visual integration values and other variables identified as relevant to gameplay

mechanics. The variables examined were isovist perimeter, isovist occlusion, maximum isovist radial and the compactness of the isovist.

The scatter plots showed a visual trend for de_dust2 where values appear to be grouped tighter than the other maps examined. A comparison of the R^2 values demonstrated that de_dust2 is more consistent in the correlation of visual integration to the four spatial variables than the other maps tested. This balance of isovist size, occlusivity, complexity and maximum distance for de_dust2 compared to other maps may offer an insight into gameplay preferences for an international market as opposed to cultural differences.

Table 1. R^2 values across maps

Map	Occlusivity	Perimeter	Max Radial	Compactness	Mean
de_dust2	0.617	0.568	0.367	0.684	0.5590
de_nuke	0.619	0.606	0.353	0.252	0.4575
de_clan1_mill	0.44	0.513	0.371	0.247	0.3928
de_inferno	0.189	0.262	0.253	0.23	0.2335
de_dust	0.259	0.214	0.147	0.227	0.2118
de_train	0.007	0.14	0.273	0.088	0.1270

The map awp_greesia distributed with Counter-Strike Online for the Asian market is a slightly altered version of an amateur map awp_india. The immediate visual difference between the two maps is the placement and size of several blocks within the large open game space. A spatial analysis of the two maps demonstrates how the relatively small alterations change the overall correlation between visual integration and the other spatial measures.

Table 2. Demonstrating the small spatial alterations to awp_india to create awp_greesia

Map	Occlusivity	Perimeter	Max Radial	Compactness	Mean
awp_greesia	0.67	0.796	0.544	0.576	0.6465
awp_india	0.585	0.804	0.721	0.316	0.6065

The defuse maps distributed with Counter-Strike Online contain several maps created specifically for this release and an analysis of two maps de_tunnel and de_rex comparing their average correlation with visual integration in the four spatial properties places them higher than all the popular maps analyzed except de_dust2.

Table 3. Analysis of the defuse 'de' maps

Map	Occlusivity	Perimeter	Max Radial	Compactness	Mean
de_dust2	0.617	0.568	0.367	0.684	0.5590
de_tunnel	0.809	0.857	0.016	0.461	0.5358
de_rex	0.503	0.602	0.529	0.342	0.4940
de_nuke	0.619	0.606	0.353	0.252	0.4575
de_inferno	0.189	0.262	0.253	0.23	0.2335
de_dust	0.259	0.214	0.147	0.227	0.2118
de_train	0.007	0.14	0.273	0.088	0.1270

The analysis of how to design game environments using these measurements could prove useful in developing theories for the design of environments that meet the global preferences demonstrated by the international popularity of de_dust2.

6. Conclusion

This paper is part of an ongoing study into this area and the first goal was to establish appropriate design research methodologies for the analysis of game environments that are relevant for design interpretation and feed back into a design cycle. Cultural models have led to a valid methodology for the analysis of game environments where spatial metrics can statistically inform the design of environments through metrics directly applicable to gameplay.

The analysis of maps developed specifically for the Asian market provides a starting point to correlate data with Nisbett's model of cultural cognitive differences but this needs to be investigated further through a larger sample. These maps are smaller than other maps with more complex and detailed player view fields while earlier maps were larger with more open spaces. The ability for East Asian players to process more complex screen environments may indicate a preference for the smaller more intense gameplay involved in these environments where there may be a lot of pixel movement at the periphery of the screen.

The development of gameplay in larger open environments allows more focused gameplay where the center of a player's view field is the primary concern and large isovist radials encourage this tunnel vision. This would be preferential for Western players using this cultural model with the larger playing area allowing a player to focus on the center of the screen while still picking up pixel changes such as other player movement at the periphery of the screen due to the more consistent image when large distances are involved.

The map de_dust2 is globally the most popular map played and analyzing the spatial characteristics of the map offers clues as to its popularity and further to the possible requirements for globally popular game environments. The map is characterised by enclosed areas, simple visual fields, low occlusion and smaller isovists. These could be said to be design characteristics that balance the visual field requirements of both Eastern and Western players. The analysis of de_dust2 equates to a particular set of gameplay characteristics: it is safer to move quickly and there are distinct areas that a player must move between but long visual fields which allow the player to see further.

It remains to be seen through ongoing studies if this methodology for the analysis of game maps offers more evidence for the hypotheses that cultural cognitive differences will be evident in the design of game environments. The next stages for this study are the further analysis of different environments and to explore metrics in measured test environments in order to inform designers of values suitable for cross-cultural gameplay.

What this study has proven so far is that spatial metrics is a methodology that can be used by design researchers but that it can also be used as a toolset within the design cycle by game designers.

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