IT University of Copenhagen

Kinesthesia and Game Spaces

– A study of how space affects player perception of movement in games

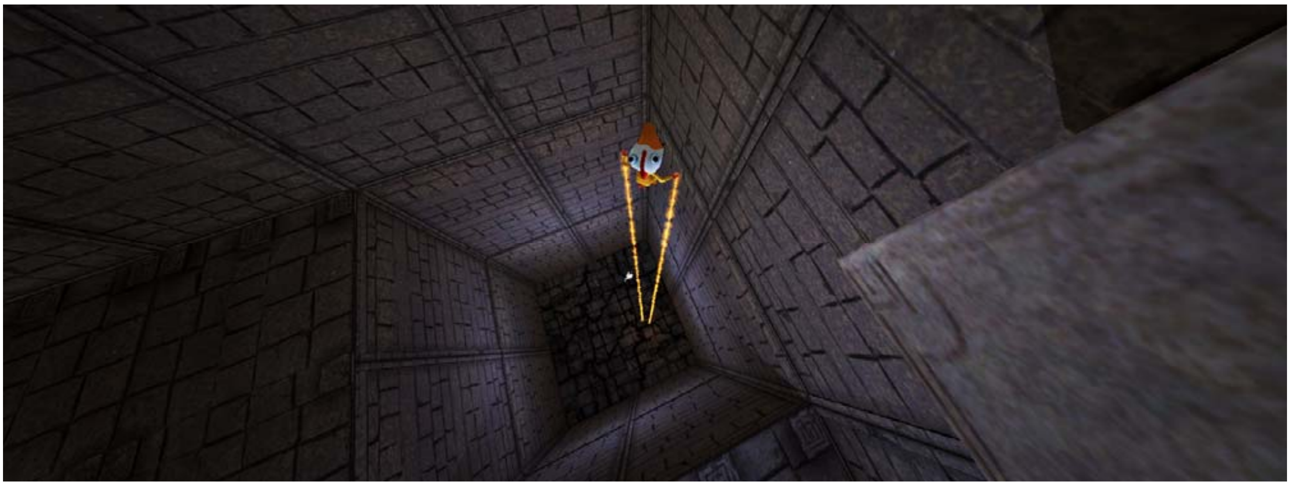
Jonas Herløv Wæver

jhwa@itu.dk

Supervisors:
Pippin Barr
Miguel Sicart

Abstract

The design of the game space is a major factor in shaping the player's movement patterns and the player's perception of movement (kinesthesia) in computer- and videogames, but very little research has been done into which aspects of the game world affect movement in what ways. Understanding the specifics of how space shapes movement is important in designing varied game worlds that affect the play experience in particular ways. This thesis analyses how different spatial structures give rise to different movement patterns in games with or without context-sensitive controls. The thesis analyses the dynamics between the game world, the controls, and the rules, and employs methods from user experience research to gather qualitative data about how players experience changes to each of these aspects of a game. The results demonstrate concrete relationships between different types of game space and different movement patterns and explain the player behaviour underlying these relationships, which will be especially valuable to those seeking to design environments for games where movement is a central part of the play experience.



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1. Introduction

Movement is and has always been an important part of digital games, from *Pong* (Atari, 1972) – where the player controlled the movement of a "paddle" in an abstract tennis game – and *Donkey Kong* (Nintendo, 1981) and the "platform" genre it pioneered, to *Tomb Raider* (Eidos, 1996) and similar games built around direct interaction with a 3D environment. Movement in games comes in many forms and patterns, and each implementation of movement has a certain "feel" to it – this feeling of movement is known as kinesthesia.

Fig. 1: *Tomb Raider* let the player climb walls and scenery. This screenshot is from the 2007 remake.

The concept of the kinesthetic sense in computer and video games is only just starting to gain attention in the more HCI-inspired areas of game studies. In his book *Game Feel*, Steve Swink (2009) goes a long way towards defining, analysing, and establishing metrics for the feeling of movement in games – one of the aspects of game feel that Swink outlines is the "context" for the player's interactions with the game, ie. the layout and design of the game world and its objects. Swink argues that concepts such as size or speed cannot exist without multiple entities that can be compared to each other. Indeed, he specifies that it is a prerequisite for game feel to even exist that a game features some sort of spatial simulation. Though Swink does suggest a few ways in which the layout of the game space might affect the game feel, his purpose is to establish a broad theory of game feel, and so he doesn't delve far into the specifics of game feel context.

This thesis builds on Swink's work by specifically researching the importance of context, its effect on overall game feel and especially players' perception of movement, and its relationship to some of the other aspects that Swink has identified, particularly input, response, and rules. The thesis will isolate three aspects of a game's spatial simulation that are significant to the player's sense of movement and test how variations in these concepts influence the player's virtual kinesthetic sense and related aspects of the play experience.

1.1 Objectives

Game feel is so under-researched that no academic tradition can be said to exist within the area. At best, it has been covered in scattered works on other subjects, approaching it from different angles such as immersion or human cognitive processing. Though Swink's work is well argued and supported by hard data from neuropsychological research, it barely qualifies as academic. This thesis involves works from related areas within game studies, namely avatar embodiment and the study of space in games, pulling them together to illuminate the intersection of these subjects: the significance of the game space to the player's experience of the movement of the avatar. The thesis takes a user experience-based approach to game feel in acknowledgement that the most interesting dimension is what the player gets out of it.

The primary research question of the thesis is how virtual environments shape the player's feeling of the movement of the avatar in an avatar-based game. The thesis has found that the distance, the number of objects in the space, and the sizes of the objects have the most immediate impact on the player's movement. The feel of movement primarily depends on the level of interactivity required to navigate it, which can be improved by adding more obstacles to avoid or more things to aim for; how automated the movement is; the efficiency of different methods of movement in relation to different spatial structures; and the perceived difficulty and danger of different movement patterns.


Fig. 2: *Assassin's Creed: Brotherhood* (Ubisoft, 2010). Object sizes and density must suit the controls.

Secondarily, the thesis recognises that not just context, but also to a high degree player input, the game's response to this input, and the rules of the game influence movement patterns and the feel of movement. The thesis has analysed how these other aspects of game feel relate to context in this respect. The game's response to player input must be calibrated to fit the game space (or vice versa) such that the sizes of objects match the avatar's jump height, the density of obstacles suits the manoeuvrability of the avatar, etc. Players' movement patterns will noticeably change depending on whether the controls match the space. Rules can either work with or against the game space, which will change the movement in different ways – when the context supports the rules, everything comes together in the player's favour and the movement feels fluid and effective. When the context contrasts the rules, the situation will seem to work against the player and the movement may feel frustrating or desperate (which is not necessarily bad).

Finally, the project has found two high-level approaches to player interaction in games: context-sensitive interaction is when the game contains a broad set of possible interactions each of which is only available to the player depending on the current state of the game (typically where in the game world the player avatar is located). Context-insensitive interaction is when all of the possible options are available to the player regardless of the state of the game. Due to the scope of the project, the thesis will only be able to test changes to the player's perception of movement within a game that uses context-insensitive interaction. However, in the interest of comprehensiveness, the thesis will also analyse a few mainly context-sensitive games to account for differences in how changes to movement patterns are perceived in a context-sensitive game compared to a context-insensitive one.

1.2 Method

As explained above, the thesis is to some extent charting new territory. This calls first of all for a thorough definition of the main concepts of kinesthesia, simulated space, and game feel in general, based on a literature review of Swink (2009) and involving writings on embodiment, presence and immersion, game spaces and their structures, what Salen and Zimmerman (2004) have classified as "the play of pleasure", and so on. After a review of the existing literature, the thesis will analyse a selection of existing videogames where the basic movement of the avatar is a prominent factor of the gameplay, with an eye to how specific elements of their level or world design complement their movement mechanics and shape the play experience. The games will be selected to cover different approaches to player interaction design: two different implementations of context-sensitive interaction as well as one mainly context-insensitive game.

The literature review and the game analyses will inform a set of design principles. Based on these principles, a game will be created with three relevant variations of the game space, with the purpose of formally distinguishing between three aspects of spatial structure and evaluating their individual relevance to game feel. The tests will use qualitative methods to evaluate these game variations, using a group of 10 test players with an acceptable amount of game literacy. The players will be recorded while testing each of the games and afterwards they will be interviewed about their experience. The interview will focus primarily on the changing movement patterns and the player's perceptions of them, but will also account for related aspects of the player experience that may change as a side effect of the level variations.

1.3 Synopsis

The next chapter will lay the theoretical foundation for the project, establishing game feel as the over-arching perspective from which the research question will be approached, and narrowing it down to only the particular type of game feel which is relevant to this project. Next, the chapter will define an often used but seldom explained term in game studies: kinesthesia. The common confusion between kinesthesia and proprioception will be untangled, and the chapter will examine the main ways in which kinesthesia has previously been used in game studies. Finally, the chapter will go through several different typologies of space in games in order to narrow down the type of game space which is relevant to the paper. All this will make it possible to select a few game examples to analyse, and it will provide a foundation for establishing some design principles for the test levels.

Chapter 3 will lay down the design principles for a game to be used for gathering empirical data about the influence of the game space on the player's kinesthetic perception. First, three existing games are selected for analysis based on the scope defined in chapter 2. The selected games will not necessarily be similar to the test game, but will be selected for how clearly they demonstrate causality between changes to the game space and effects on the feel of movement. From these analyses, a set of central themes will be extracted for further study in a specially designed set of test levels. Finally, chapter 3 will discuss what sort of results can be expected based on the combined lessons from the literature review and the game analyses.

Chapter 4 describes *Broken Dimensions*, the original game that the test levels were based on. The development of the game will be summarised in order to expose and explain the various design decisions made throughout, and the role of space within the game will be analysed. Chapter 5 then lays the foundation for the empirical part of the project, explaining the overall methodology chosen and discussing its pros and cons. Chapter 5 will explain how the tests were designed and executed and how the following interviews were conducted. Chapter 6 presents the findings of the tests, organizing them by themes and leading into Chapter 7, which will summarise the conclusions and contributions of the thesis, discuss the important takeaways, and reflect on any weaknesses in the project and what might be done to build on the results of this paper.

2. Literature review

This chapter will introduce the two central areas within computer game studies that must be understood in order to answer the research question: virtual movement, more precisely kinesthetics/proprioception, and game spaces, more accurately the study of simulated 3D spaces. The chapter will focus on the aspects of each area which are most relevant to the others: the movement section will revolve around the player's perceptions of an avatar's movement through simulated 3D space, while the section on game spaces will focus on how the structure of virtual environments shape the avatar's movement. As movement in games is a largely unresearched area, literature about embodiment and basic human-computer interaction has been included in order to find out how humans perceive virtual movement in the first place. Both sections will also address the concepts of immersion and presence/embodiment as they are central to explaining why players are engaged by videogames, and by extension why movement and space in games even matter.

Movement and space are both broad concepts that can be approached from many different angles, but this project is primarily concerned with how they impact the *feel* of playing the game. As game feel is a broad and vaguely defined concept in games studies, the first order of business is to pin down what game feel means and how it is used in the project. Like virtual movement, game feel is largely unresearched, so the section will be extrapolating from very limited literature.

2.1 Game feel

The central topic of this project is game feel. Every other term and concept that the paper deals with is approached with game feel in mind and dealt with from that perspective. For example, movement can be many things in game studies – it can be a question of navigation, narrative pacing, social communication, difficulty – but this project is first and foremost interested in how movement *feels* in a game. However, game feel is not yet a well established concept in game studies; it can refer to interfaces or simulated 3D spaces or even narrative meaning. Therefore, before movement or space or any other aspect of a game can be analysed from the perspective of game feel, it must be firmly established what game feel means in this work. Once the meaning of game feel is understood, the chapter can move on to defining virtual movement and simulated space only in the desired context, without confusing the matter with any unrelated connotations. Furthermore, defining the type of game feel used in this project, and identifying the specific aspects of game feel most relevant to movement and space, will help to determine what type of games should be analysed, developed, and tested in order to answer the research question.

Game feel is an underdeveloped area of game studies that deals with players' perceptions of certain aspects of their fundamental interactions with videogames. The central work on game feel is Steve Swink's book *Game Feel* (2009). Swink defines game feel thus:

> Real-time control of virtual objects in a simulated space, with interactions emphasized by polish (2009: 6).

By restricting his work to real-time games, Swink rules out all turn-based games spanning many different genres including strategy games, management games, and puzzle games. Turn-based games and similar can be said to have a different type of feel, for example interface feel (which would be something that can be found in most real-time games as well), but Swink focuses specifically on the feel of controlling objects "directly", in such a way that the player's input generates immediate response from the object being controlled. Swink further narrows down his understanding of real-time control to include a necessity for continuous control, which disqualifies typical real-time strategy games: "Each click is a momentary impulse of control that ends as quickly as it starts. You set the destination but don't guide the journey" (ibid.: 9).

Fig. 3: ***SpaceChem*** **(Zachtronics Industries, 2011) has no movement feel because it features no simulated 3D space. Instead, it could be said to have** ***interface feel*****.**

Perhaps "game feel" isn't the best term to use for what Swink is doing. Game feel is a very broad term that might be expected to encompass all types of feel in all types of games, whereas Swink has chosen to focus on a very specific category of games. This delineation may seem a little arbitrary, but attempting to include all other types of game feel would be very ambitious, so narrowing the focus down to these criteria is a useful way to retain a certain depth in the analysis. It might be more accurate to call it "real time 3D movement control feel" or simply "movement feel", but as nobody has written a broad typology of the feel of control in games, and perhaps because Swink is not an academic but a game designer, Swink has chosen to stake out the broader term instead. To avoid confusion – as Swink's work will be frequently referenced in this thesis – the word "game feel" will be adopted to describe "real time 3D movement control feel" throughout this project as well. Section 3 will analyse a few examples of games that fit Swink's criteria.

In order to ensure that the games analysed and used to gather data for this project correctly lives up to the definition of true game feel, each parameter of the definition must be disambiguated. First, Swink delves into human perception and response time to find three thresholds that a computer game must be able to sustain over time in order to qualify as having real-time control. These are very quantifiable properties, but delving into definitions of "real-time" in computer science terms will not be necessary for this project. Suffice to say explicitly turn-based games or games with non-continuous input/response are excluded.

The second part of Swink's definition forms the core of this thesis: the game must feature a simulated space. The two major dimensions of simulated space are collision detection and everything that follows from it, and level design – "the construction and spacing of objects relative to the speed of the avatar's movements" (2009: 4). A key thing to note here is that the space must be a simulation and not an abstraction[1]. This will be revisited in section 2.3. Swink further specifies that for game feel to exist, players must directly experience the game's collision systems, which again disqualifies real-time strategy games.

The third parameter of Swink's definition seems by his own treatment of it to be less crucial. Rather than a strict requirement for game feel to exist, polish "artificially enhances simulation" and effects "add appeal and emphasize the physical nature of interactions". Polish does, however, make up a large part of the feel in

[1] Though it could be argued that all game spaces are abstractions in some sense, it's rarely difficult to distinguish between games that strive to simulate physical 3-dimensional worlds and games that don't.

games that have it, and is perhaps one of the most visible and identifiable parts of the game feel. Therefore, it must be accounted for when gathering and analysing the data for this project.

Swink isn't completely strict in his treatment of these criteria. Though he's chosen to narrow his analysis of game feel down to what he calls "true game feel", which is found in games that live up to his full definition, he does seem to acknowledge that partial game feel exists and that different types of feel can be equally important. Despite its narrow focus, Swink's book is the closest anyone has come to a completely thorough, unambiguous definition of game feel, and this project is intended to build on his work, so the thesis will follow Swink's example and restrict its analysis to games that fulfil all three criteria in his definition of game feel. Having defined what particular type of game feel this project is concerned with, the next section will look at the different aspects that constitute this type of feel, and then expand on the particular aspect that the research revolves around.

2.1.1 Aspects of game feel

A large part of Swink's work is dedicated to establishing metrics for game feel. In doing so, he identifies six aspects of game feel that he believes are most worthwhile to analyse and measure. This project focuses specifically on the aspect that Swink has termed "context", but it's worthwhile to look at the other five aspects of game feel in order to make it clear how they relate to the project, particularly input, response and rules, which closely influence context in many cases (as will also be shown later).

The six aspects are Input, Response, Context, Polish, Metaphor, and Rules. Input and Response both concern the basic activity of controlling the game – pushing buttons or waving your limbs and having some sort of result presented to you by the game. Designing controls that feel good (perhaps the most fundamental expression of game feel) is about choosing the physical input methods (starting with platform, then controller type, and down to which buttons or axes or sensors to use for what) and designing the game's response to the player's input to create the desired experience. As different kinds of game controllers and even different inputs on the same controller can have wildly different types of movement, different constraints on their movement, different amounts of sensitivity, even different tactile feedback, matching certain actions within the game world to certain physical actions on the controller has a considerable impact on the feel of controlling the game. This feel must further be calibrated against the context, or vice versa, and later chapters will demonstrate the importance of input/response to the player's perception of motion and the consequences of changing the context without adjusting these aspects as well.

Polish and metaphor are two sides of the same aesthetic/narrative coin. In very simple terms, the metaphor helps the player to predict how an object *is going to* respond to certain actions or behave in certain circumstances (in the future), while polish helps to communicate and emphasise how the objects *are interacting* (in the present). These two aspects should fit together in an intuitive way, and should also fit with the response and context aspects of the game feel. Swink subdivides polish into animation, visual effects, sound effects, cinematic effects, and tactile effects, all of which help to sell the idea that physical interactions are occurring in what is in fact an entirely unphysical world. Though polish is theoretically completely separable from input/output and context, its prominence in the play experience makes it impossible to ignore during testing, and must be accounted for in the results.

Rules are the incentives, rewards, and arbitrary structure of the game that add meaning to the players' actions and the interactions of the game objects: "a 'rule' is an arbitrary, designed relationship between parameters or objects in a game. Arbitrary because there is no higher order guiding the creation of such relationships and designed because it is a relationship intentionally created by a designer." (Swink, 2009: 179). Rules are subdivided into high-level rules consisting of broad sets of goals or game systems that focus and guide the player's behaviour, mid-level rules apply to specific objects and serve to give meaning to particular actions involving those objects, and low-level rules add extra gameplay-specific information to individual objects such as how much damage they take to destroy. Rules can change the feel of the game, for example by making it more satisfying to collide with a collectible object that counts towards completing a level or unlocking new content. As later chapters will show, rules can work with or against other aspects of game feel in interesting ways, adding new meaning to similar actions – a common example is how the addition of a time restriction (eg. a race or a chase) can completely change the feel of motion and the movement patterns of players by forcing them to prioritise speed and efficiency above all else.

With the rise of casual games and mobile games and the success of companies such as Pop-Cap that place polish front and centre in their design philosophy, related development concepts have become popular and important within game development communities such as *GamaSutra*. Though some large-budget games such as the identically acronym'd *Gears of War* (Epic Games, 2006) and *God of War* (SCE Santa Monica, 2005) are praised for their game feel, the idea that the level design can shape, support, or sabotage the feel of a game is nearly uncharted territory. The following section will look at how the context that the game provides for the player's actions (ie. the space within which they take place) contributes to defining the feel of those actions.

2.1.2 Context

Context is about the game world, its design and the way the player interacts with it. At the most basic level, movement cannot take place without a space to move within. A game's space provides affordances and constraints for the game mechanics, emphasising and supporting the mechanics as well as other aspects of the game through good level design. What follows is a summary of Swink's treatment of the game feel context with an aim to identify which level of context is best suited for testing.

Swink subdivides context into three levels: on the highest level, context is the impressions of space, speed, motion, and size. These impressions are all relative, and defined by each other – a cramped space feels cramped only by comparison to a wide open space or a large and/or poorly manoeuvrable avatar. A fast avatar feels fast only by comparison to a great space traversed quickly or another, much slower avatar. Any variations on this level will necessarily require drastic changes in the layout of a level, to the extent where the different variations may no longer bear many similarities to each other. This implies a high potential for unrelated factors to influence the play experience, and makes it difficult to directly compare the levels in detail. Worst of all, changes on this scale are very time-consuming to implement, making this level impractical for testing.

Low level context deals with the tactile interactions between objects, particularly collisions. Swink suggests simply comparing the collisions in the game with the physical objects in our everyday lives, paying attention to such physical properties as friction, buoyancy, rigidity, or weight. The low level analysis of context is more about the physics system and its implementation in the game world than the design and layout of the game world itself, which makes it only tangentially related to the focus of this project.

On the medium level, context is about the immediate space and the objects in it. Swink refers to this level as "the 'second set of knobs' for game feel tuning", where the first set is the programmed response to input described above. While an avatar can be made quick and manoeuvrable by mapping its orientation to the absolute direction of a thumb stick and making it change with very little delay, the game world needs sharp turns or many obstacles for this quality to come into its own. The factors of medium level context are the number of objects in the game world, the size of the objects, the nature of the objects, the layout of the objects, and the distance between the objects. This is where the details of the level design have the most direct impact on the game feel and particularly the feel of the avatar's movement, with relatively simple changes potentially making a great difference. The practicality and the impact of tweaking this level, along with the slightly more detailed metrics supplied by Swink, make this level the best suited for empirical testing.

In this section, the thesis discussed Swink's definition of game feel, acknowledging that limiting such a broad term so arbitrarily is problematic, but accepting Swink's particular delineation of games as pragmatic and keeping the term "game feel" to avoid confusion. Swink's typology of game feel was outlined and the most important relationships between input/response, context, and rules were introduced: input and response must be calibrated against each other and then calibrated against context, and rules can give new meaning to the context. Finally, the section picked apart game feel context and found that the medium level – the number, size, nature, layout, and distance between objects in the game world – was most well suited for analysis and testing.

In order to select the specific parameters of the medium-level context to tweak and compare in the test, the next section will first examine the concept of movement within virtual worlds in greater detail. If a better understanding is achieved of the embodiment felt by the player through the avatar and the player's perception of the avatar's movement in relation to the human sensory system, it will be possible to make a more informed decision about how to change a game level to shape the feel of the movement in certain ways. Having specified in this section what the paper means by game feel and from what angle the project is approaching the concept of movement, the following section will be able to define kinesthesia and explore what others have written about embodiment and movement in games from this perspective.

2.2 Kinesthesia, embodiment, and movement

It stands to reason that movement in a virtual world is not the same as movement in the real world. Just as some manner of translation takes place between our intensions to move and the execution of our physical movements, our movements in the real world (on the keyboard, gamepad, mouse, etc.) are translated in some way into the movement of an avatar in the game. We then experience this movement with significantly less sensory input, and somehow we perceive it both as our own movement and as somebody else's (the avatar's). In order to better understand that relationship, this section will review some of what has been written about kinesthetic perception and the phenomenon of avatar embodiment.

2.2.1 Kinesthesia and proprioception

Kinesthesia is not a very commonly used word, so it merits a formal definition to begin with. Little has been written on the topic, partially because the proprioceptive sense is often referred to interchangeably with the kinesthetic sense - indeed *Wikipedia* redirects any search related to kinesthesia at the time of writing to their article on proprioception, which states "Kinesthesia is another term that is often used interchangeably with proprioception, though use of the term 'kinesthesia' can place a greater emphasis on motion." Ask.com's *Dictionary.com* gives the following single sentence definition of kinesthesia: "the ability to feel movements of the limbs and body."

A similar definition is provided by *Encyclopædia Britannica*: "Even with the eyes closed, one is aware of the positions of his legs and arms and can perceive the movement of a limb and its direction. The term kinesthesis ('feeling of motion') has been coined for this sensibility." This is very similar to *Britannica's* definition of proprioception as "the perception by an animal of stimuli relating to its own position, posture, equilibrium, or internal condition." When looking up "the senses" on *Britannica*, a hierarchy of the senses emerges: senses are either somesthetic (relating to the whole body) or special (relating to particular organs such as the eyes or the ears). Somesthetic senses are then either exteroceptive (initiated by stimuli outside the body), proprioceptive (initiated within the body), or visceral (forebodingly described as "usually from internal organs and usually painful").

Jin Moen describes kinesthesia as a subcategory of haptic perception (processed input from the sense of touch). Kinesthetic perception is "based on information from muscles, tendons and joints, and thus reflects physical movement." (2006: 12). In her use of kinesthesia, Moen includes undefined exteroceptive sensations, but this thesis will regard kinesthesia as a proprioceptive sense, which rules out tactile stimuli such as rumble-devices in console gamepads.

Steve Swink writes the following about kinesthesia vs. proprioception: "Kinesthesia is the sense that detects body position; weight; or movement of the muscles, tendons and joints. To get fancier, we can talk about 'proprioception,' which is often used interchangeably with kinesthesia. Proprioception has the slightly more precise connotation of being a person's subconscious awareness of the position of his or her own body in space." (2009: 26). Although this explanation of proprioception doesn't seem to include movement, it's not a far leap to realise that movement is simply changing positions over time. Indeed Swink goes on to add the following about the translation of the minute movements of the player's fingers on a game controller into movements of virtual objects in virtual space: "It's like a megaphone for your thumbs. You're now concerned with how your real-world motion affects virtual objects; the process of motion and feedback is transposed. When we're controlling something in a game we're using not a debilitated proprioceptive sense, but an amplified one" (ibid.: 28).

It's not clear from where Swink has these definitions of kinesthesia and proprioception, and his description of an amplified proprioceptive sense doesn't entirely mesh with some of the cognitive research that will be used in the following section (Gregersen & Grodal, 2009). Since Swink's use of proprioception seems to be at odds with *Encyclopædia Britannica's* and Moen's definitions, this thesis will side with the latter in defining proprioception as all those senses that are initiated within the body, and kinesthesia as the feeling of motion. Perhaps more relevant to this project is how kinesthesia is relevant to games at all, and how it's been used by other academics in games studies. Kinesthetic perception is typically used in game studies to cover our combined knowledge of body position and movement resulting from all our sensory input, including sight and sound. Despite activating the body's internal sensory systems very little (such as the vestibular system and muscle stimuli), games can still create an impression of motion, impact, and similar. The next section will look at how this can be the case.

2.2.2 Kinesthesia in computer games

Based on the definitions above, kinesthesia has very limited significance in computer game studies at present - though some modern game systems (most noteably Microsoft's *Kinect*) accept or require input that involves players moving and positioning their limbs in a similar way to their avatars, most communication with the game is visual or in some cases tactile - the games detect the player's movement with cameras and do not stimulate the vestibular or muscle senses. Possibly the closest any game technology currently available on the market comes to communicating directly with the kinesthetic sense is the accelerometers in Nintendo's *Wii* controllers and Sony's *PlayStation Move* controllers, but this is still one-way communication going from the player to the game.

Instead, games rely on visual and aural output to stimulate the player's kinesthetic perception. The classic example is racing games or stealth games that make the player subconsciously lean with their physical body when their car turns around a track or when their avatar needs to peek around a corner to check for enemies. Such effects are typically achieved with camera movement, changes to the field of view, or simply by making the player empathise with a well animated avatar. More subtly, players can use visual clues to estimate distances or changes in speed and direction. One example of how this can work is *optic flow*, where objects ahead of a moving person appear to move away from each other as the person approaches, and objects in the periphery of a moving person's vision appear to move faster than objects located straight ahead (see figures 4 and 5). Such effects are greater in real life than on a video display, but have been shown to even work in slide shows (Hunt and Waller, 1999: 28).

Fig. 4: Optic flow in *Mirror's Edge*: At a distance, the second set of pillars is about 200 pixels apart on the screen.

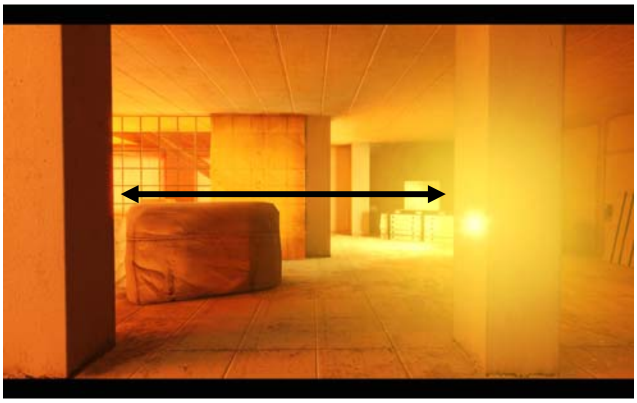

Fig. 5: The player moves forwards, and the pillars move apart: they are now just over 1000 pixels apart.

It is possible for players to get a sense of the avatar's movement even in games where the input only involves moving their fingers on a gamepad or a keyboard. This facility is due to two particular phenomena: first of all, aspects of the body image can be projected onto tools, vehicles, weapons, etc. to extend the body image. The classic everyday example used to demonstrate this is that of a small car collision that literally makes the driver wince as though physically injured, or exclaim "He hit me!" rather than the more accurate "He hit my car!" Secondly, the prefrontal motor cortex of the human brain has a special type of neurons known as mirror neurons that are activated when performing an action but also when observing an action performed by another. In this way, human beings are fundamentally attuned to the movements of other bodies. When experiencing embodiment in relation to virtual environments, players' proprioception expands to involve the game like a sort of virtual tool-use, and mirror neurons activate the players' own motor system in response to the observed motor patterns of the avatar (Gregersen & Grodal, 2009: 67).

Going even further, Moen writes that an ability of the human body is kinetic memory: "The kinaesthetic sense is tightly connected and intertwined with our other senses. When we watch movements the process of kinaesthetic memory works reversely, from (visual) image to muscle memory. People trained and skilled in specific types of movement, e.g. dancers and athletes do not have to physically see the movement in order to cause physical changes in their muscles, they have developed an ability to imagine anatomically and physically correct paths without actually moving, making use of their kinaesthetic sense and bodily memory." (Moen, 2006: 13) Though it can be assumed that this effect is considerably weaker in people who lack such training, it is telling that this manner of translation from visual to proprioceptive perception can take place.

Having established that kinesthetic perception is relevant in purely audio-visual media, and that the minute movements required to provide input to interactive media make kinesthesia especially relevant in relation to computer games, the following sections will look at a few different ways in which kinesthesia has been used in game studies.

Kinesthetic involvement

In his 2011 book *In-Game: from immersion to incorporation*, Gordon Calleja establishes his player involvement model as an alternative to the ambiguous terms "immersion" and "presence". One of the six types of involvement in this model is termed kinesthetic involvement, and deals with the basic control systems of the game:

> Kinesthetic involvement relates to all modes of avatar or game piece control in virtual environments, ranging from learning controls to the fluency of internalized movement. This dimension of involvement requires more conscious attention when the controls make themselves present either because the player hasn't fully mastered them or because a situation demands a complex sequence of actions that are challenging to the player. The freedom of action allowed and the difficulty of the learning curve of the controls involved have a major influence on the player's involvement in the game environment (Calleja, 2011: 43).

This use of kinesthesia pertains to the input/output loop of the game; the relationship between what the player does with the controls and what the avatar in the game does in response, and how this allows the player to exert agency in the game environment. Calleja describes this involvement as a scale between the conscious effort of learning the controls of a new game and the subconscious process of controlling an avatar in a long since mastered game. The controls are most noticeable when the player is just learning to play. As the controls are internalised, they come to be perceived as "movement" rather than controls.

Once this internalisation has happened, players often feel the movement of their avatar as though it is unmediated. At this level of familiarity, third-person games require a special type of spatial awareness to account for the separate - yet typically closely intertwined - movement of the camera and the avatar: "Players experience a double awareness in third-person perspective games. First, they are aware of the surrounding environment as portrayed by the camera. Second, they are also aware of the space as it relates to the avatar" (ibid.: 67). In testing the kinesthetic aspects of a third-person game, it is therefore important to distinguish between the feel of the camera and the feel of the avatar's movement, and to keep an eye out for differences in how and why they change.

The Play of Pleasure and Ilinx

Salen and Zimmerman dedicate a chapter of their book *Rules of Play* to "the Play of Pleasure" (2005: 329). Though this is quite a bit broader than game feel, they do touch on the idea that the fundamental interaction with games and the way games stimulate our senses can by itself give the player pleasure. Three different typologies of pleasure are summarised, by game designer Marc LeBlanc, psychologist Michael J. Apter, and anthropologist Roger Caillois. The very first type of pleasure according to LeBlanc's model is "Sensation: Game as sense-pleasure" – though this could be interpreted to cover the aesthetic appreciation of beautiful virtual landscapes or catchy soundtracks, it also covers the virtual sense of movement that players can experience eg. in racing games or fast-paced shooters through their extended proprioceptive sense. Likewise, the very first type of cognitive arousal that Apter describes is "Exposure to Arousing Stimulation", paraphrased in *Rules of Play* as "intense and overwhelming sensation" (Salen & Zimmerman, 2005: 335).

It is Caillois' model of play categories based on research into children's playground games which is most relevant to this project. The fourth category in his model is "Ilinx: vertigo and physical sensation" (ibid.). Though Caillois' concept of Ilinx was developed to describe actual physical activities, Salen and Zimmerman believe it also applies to videogames to some extent: "Unreal and games of its ilk are well known for representing physical movement through three-dimensional space in real-time, often creating vertigo in the form of motion sickness" (ibid.). Ilinx is about movement and physical sensation for its own sake, and deriving enjoyment from it. Most of Caillois' examples deal with extreme forms of movement meant to cause vertigo and disorientation, but he also links Ilinx to "the desire for disorder and destruction" (Caillois, 2006: 139) which he suggests manifests itself in such indulgences as "creating an avalanche of the snow on a rooftop" or "noisily banging garbage cans" (ibid.).

Fig. 6: *Just Cause 2* (Eidos, 2010) has plenty of disorder and destruction, but also infinite parachutes and a grappling hook for players to enjoy Ilinx.

Caillois further points to the existence of machines designed specifically to allow for exhilarating movement: skis, sports cars, and stimulating contraptions in amusement parks. Of course an important quality of such devices is the physicality of the experience – the feeling of the gravitational forces, the confusion of the vestibular systems – but as per the above discussion of the ability of the human proprioceptive sense to extend to include tools and vehicles and to approximate the feeling of speed and motion purely through sight, sound, and very minimal kinesthetic input, it ought not be unreasonable to claim that similarly pleasurable senses of motion and vertigo can be derived from games, albeit perhaps to a smaller extent.

A modern example to support the claim that Ilinx is perfectly relevant to videogames is supplied by *Mirror's Edge* (Electronic Arts, 2009) which reportedly causes "simulation sickness" (motion sickness without motion) in many players, presumably because of all the polish that went into giving the player a powerful sense of movement. According to the game's Senior Producer Owen O'Brien, adding a small reticule-like dot in the centre of the screen and increasing the field of view helped to reduce this effect, presumably by providing a stable focal point with the dot and improving optic flow by expanding peripheral vision (Totilo, 2008).

This section has established usable definitions of kinesthesia and proprioception in relation to the human sensory system as well as in relation to computer games. Kinesthesia is the body's proprioceptive sense of motion, and is useful in videogames thanks to the human brain's faculties for extending the proprioceptive senses to include tools (and games), mirroring the actions of other bodies, and simulating motion based purely on visual input. Next, the section has looked at a few examples of how kinesthesia has been used in the literature, including its importance to the concepts of immersion and presence and the idea that kinesthetic sensation can be a source of pleasurable play in and of itself. The next section will look at the role of space in games, and the spatial aspects of players' involvement in the game.

2.3 Space

This project uses space in a very specific way, namely to describe simulated 3D environments. This is in accordance with Steve Swink's definition of game feel as "real-time control of virtual objects *in a simulated space*" (Swink, 2009: 5, italics added). It should be noted that the concept of space in game studies is not always used to literally describe game worlds, virtual environments traversed by avatars or other forms of characters under the control of a player. Bo Kampmann Walther, for example, distinguishes between three different forms of space: the concrete physical space of a monitor or screen, the illusion of a three-dimensional spatiality, and the social-semantic view of space as a construct players create around them-selves and other players – similar to what Salen and Zimmerman have termed "the magic circle" (Walther, 2005: 99). Here, however, the illusion of three-dimensional space is the one understanding of space which is relevant to the project, and this is what space should be taken to mean throughout the rest of the thesis.

2.3.1 Categorising space

Mark J. P. Wolf (2001) has identified eleven different overall types of space in games: purely text-based, one-screen contained, one-screen contained with wrap-around, scrolling on one axis, scrolling on two axes, adjacent spaces displayed one at a time, layers of independently moving planes, spaces allowing z-axis movement into and out of the frame, multiple nonadjacent spaces displayed on-screen simultaneously, interactive three-dimensional environments, and represented or "mapped" spaces.

The only one of Wolf's categories that fits the thesis' definition of simulated space is the interactive 3D environment. Wolf goes into some detail about methods to create the impression of 3D without the computational power required to render 3D spaces at the time when the game is played, which is mostly about changing the relative sizes and positions of 2D objects or pre-rendering 3D graphics into 2D backgrounds. When it comes to the discussion of simulated 3D worlds, Wolf's article betrays its age as no example from later than 1996 is used. Wolf does consider 3D spaces more "real" than 2D spaces that attempt to create the illusion of three dimensions, but notes that "reality" is a difficult term to apply when describing simulated space. The underlying assumption in using the word "simulated" is that these worlds strive to as closely as possible approximate the way the real physical world works. However, even the most state of the art games at the time of writing use a great deal of abstraction and obfuscation to create the illusion of reality rather than recreating genuine scientific models of how the physical world functions and is constructed[2]. Ultimately, in defining simulated 3D spaces, Swink's definition of spaces that the player can continuously traverse in three dimensions with real-time collision detection is the most useful.

Michael Nitsche (2008) proposes a simple model for dividing spatial structures in games into three categories: tracks and rails, labyrinths and mazes, and arenas. Tracks and rails obviously includes racing tracks in car games and similar, but less obviously also includes rail-shooters and linear games such as the *Medal of Honor* series (Electronic Arts, 1999), described as "a guided journey along which the individual points are important." (175). The defining feature of labyrinths is that they deprive the player of visual information important to orientation. Labyrinths can be *unicursal* in which case they are essentially obfuscated tracks, *multicursal* in which case they are mazes, *rhizomatic* in which case each point can be connected to any other point, or they can be *logic mazes* where conditions must be met to enable access to parts of the space (Fig. 7). Arenas are conspicuously enclosed spaces which "provide the canvas for a performance" by allowing a relatively high degree of visibility and freedom of movement.

Gordon Calleja (2011) is more concerned with traversable space rather than visible space, and so divides space along slightly different lines into five categories: Unicursal corridors or labyrinths, multicursal corridors or mazes, rhizomatic zones, open landscapes, and arenas. Dividing labyrinths and mazes into separate categories and merging labyrinths with tracks/rails (essentially labyrinths with signposting) puts the emphasis on movement, which makes these categories more relevant to the thesis. However, though the possibility space of player movement is directly applicable to the context aspect of game feel, visibility is an important factor to game feel as a whole, and so the distinction between tracks and labyrinths is worth keeping in mind when analysing the results of the tests below – it's very possible that altering certain aspects of the game space in order to change the feel of the movement may also affect the

Fig. 7: The levels in *Deus Ex: Human Revolution* (Square Enix, 2011) are a form of logic mazes: alternate paths can only be accessed if players have upgraded their character in certain ways.

[2] For example, "raytracing" is a technique used to light 3D scenes that simulates the travel of photons, but doing this properly in real-time is far too computationally demanding for current PC hardware. Instead, raytracing is done when the game space is created and used to pre-generate "lightmaps" that can later be mixed with highly simplified real-time raytracing for special effects. This technique is improved by other feats of smoke and mirrors such as "normal maps" that cause completely flat surfaces to look like they are full of bumps, cracks, holes, and other irregularity.

visibility significantly enough that the space should be considered a labyrinth rather than a track.

The importance of space and spatial structures is that different types of spaces foster certain forms of interaction (Nitsche, 2008: 187). Nitsche calls this the “space-driven model for content assembly.” The idea is that narrative elements come together within, and are partially shaped by, the spatial context. Since level designers have the luxury to define the functionality of the game spaces in a way that architects and engineers do not, events and potential engagements can be built into the spatial structure to form the so-called possibility space. The possibility space encompasses everything the players must deal with as well as every means the players have to execute their solutions. It’s clear that the design and construction of a virtual space has a great deal of influence on how the game will be perceived and interacted with.

2.3.2 Presence and immersion

When it comes to the term presence and the question of the player’s presence within the game world, this thesis takes the position of Michael Nitsche (2008). Presence is typically used as one form of what is popularly known as immersion. Where Salen and Zimmerman (2005) describe two levels of a player’s consciousness that exist within “the magic circle”, the *player* level and the *character* level, Nitsche similarly differentiates between *immersion* in the game and a sense of *presence* within the game world. Nitsche likens the concept of immersion to the psychological state of “flow” introduced by psychologist Mihaly Csikszentmihalyi, being a condition of utter focus on the activity (in this case playing a game) resulting from a suitable balance between the challenge posed by the game in relation to the player’s skill at playing (Nitsche, 2008: 204). Immersion and flow are about unbroken concentration on a specific activity, which doesn’t necessarily require a sense of presence within a virtual environment. Though presence does to some extent depend on “levels of interactivity”, it relates more to aspects of the presentation such as graphical fidelity, narrative, or interface.

Adopting a categorisation of forms of presence by Carrie Heeter, Nitsche analyses three different types of presence: personal presence, social presence, and environmental presence (ibid.: 205). Personal presence has narrative and freedom of movement at its core – to feel present in a game space on a personal level, players should have an idea of how their avatar relates to the environment, and they should be able to explore the environment with the avatar. Nitsche highlights the importance of the presentation supporting the functionality of the game space to effectively dramatise the player’s personal presence. Social presence comes from being acknowledged as existing within the game space, either by other players in a multiplayer game or by non-player characters scripted to greet the player, exhibit outrage at rude behaviour, etc. Imbuing the game space with social meaning through differentiating between private and personal space is one way to do this in singleplayer as well as multiplayer games. Finally, environmental presence hinges on interactivity with the world, letting players affect the environment and leave their mark on it by moving objects around, destroying things, or simply having the avatar leave footprints in snow. The more permanent these changes, the better, as they visually connect the player to the game world via the avatar.

From this summary, it’s evident that personal presence is where the two core topics of this thesis intersect: designing players’ movement through space is fundamental to creating a sense of physical presence within the game’s environment. To further illuminate players’ involvement in the game space, it’s fruitful to return to Gordon Calleja’s model for player involvement.

2.3.3 Spatial involvement

Calleja writes that the key prerequisite of presence in virtual environments is involvement. Section 2.2.2 dealt with kinesthetic involvement, but another form of involvement analysed by Calleja is *spatial* involvement:

> The spatial involvement dimension, which is the focus of chapter 5, concerns players' engagement with the spatial qualities of a virtual environment in terms of spatial control, navigation, and exploration. It accounts for the process of internalizing game spaces that is a powerful factor in engaging players and giving them the sense that they are inhabiting a place, rather than merely perceiving a representation of space (Calleja, 2011).

Spatial involvement is about aesthetics and navigation. It is only is tangentially related to the topic of the thesis, but it serves to clarify why movement and space are closely interrelated and how important this relationship is to the player experience. Many of the examples from Calleja's research highlight the importance of captivating scenery in getting players involved in the game space, especially in openly structured games where exploration is a major form of gameplay. However, challenging navigation seems to have a great impact on the meaningfulness of reaching a particularly beautiful view in a virtual world.

Similarly to how controls can be internalised and become movement, spaces can be internalised and become places. Whereas a space is conceptual, a place is familiar, and players are more likely to become involved in spaces that they feel like they inhabit. One of the things that help people internalise spaces in the real world is kinesthetic experience – the perception of relative distances created by physically moving through an area. With reference to the previous discussion of the ability of humans to judge speed and distance purely from visual cues such as optic flow, it should be safe to conclude that virtual movement through a space plays a similarly important role in helping the player to form cognitive maps of game environments and thus become more involved in the game space.

All of this shows that space informs movement but that movement also informs space. The dynamic between movement and space is a constant dialogue – the design of a game space opens and closes paths, enables or disables movement patterns, and the paths and movement patterns available to the player imbues the space with meaning and fosters presence, which is integral to the experience of digital games (Calleja, 2008: 25).

In this chapter, game feel was established as the core approach of the project and Steve Swink's particular understanding of game feel, which has been adopted by the thesis, was outlined and discussed. One particular aspect of game feel was singled out, namely the context that the environment provides for the player's actions, and the medium level of context – the dimensional properties of objects in the game world – was selected for further study. Having narrowed down the concept of game feel, and having specified the thesis' approach to the study of movement in games, kinesthesia was introduced as a core term and defined as the human perception of movement or a cognitive simulation of such based purely on audio-visual input. Kinesthesia was then analysed within the purview of game studies, placing it within existing typologies of pleasure and comparing it to the concept of Ilinx, the play of sense-pleasure (Caillois, 2006). The chapter then proceeded to examine space in games, selecting Calleja's categorisation as the typology most relevant to the project (2008), and describing the close relationship between space and movement and their important role in fostering player involvement in games.

The next chapter is going to apply the theory presented above to a few case studies of videogames with particularly interesting use of movement and space. The chapter will then define a set of central themes that will be used as the foundation for the empirical part of the project.

3. Design principles

Based on the literature outlined above, this chapter aims to define the objectives of the empirical research. First, the concepts from the previous chapter will be applied to a small selection of existing games to explore how they may work in practice, and based on this, a set of themes will be established for designing the test levels that will be used for gathering research data.

3.1 Game examples

This section will analyse movement and movement-related game feel in three different games. The purpose is to identify those aspects of game spaces that most significantly affect players' movement patterns and kinesthetic perception. By analysing the effects of variations in these parameters, the section will lay the foundation for how best to design the test levels.

Assassin's Creed: Brotherhood (Ubisoft, 2010) and *Mirror's Edge* have been selected for their similar focus on movement through varying game spaces as well as for the differences in their spatial structures, objectives, and the types of challenges they pose to the player. Both games are context-sensitive in different ways and make excellent use of kinesthesia to connect the player to their virtual environments. *Jurassic Park: Trespasser* (Electronic Arts, 1998) has been selected as an example of a deliberately context-insensitive game where a problematic relationship between input and response has rendered otherwise nicely varied context largely irrelevant. This example shows that poor input/response mapping can completely overshadow context, which provides valuable perspective on the position of context within the overall ecology of game feel.

Assassin's Creed: Brotherhood and *Mirror's Edge* have both been played to completion, and then certain sections were played again while notes were taken. Various video materials recorded by other players and published on *YouTube* were cross-referenced to broaden the empirical foundation of the analyses. These videos mainly took the form of "speed run" videos wherein players attempted to beat sections of the games as fast as possible, and "trick jump" videos were players showed off particularly impressive and difficult moves. With *Jurassic Park: Trespasser*, only the first level of the game was played while taking notes. A series of "Let's Play" videos were also consulted, wherein other players played the game from start to finish while commenting on their experiences.

3.1.1 *Assassin's Creed: Brotherhood*

Fig. 8: ***Assassin's Creed: Brotherhood*.**

Assassin's Creed: Brotherhood (henceforth *Brotherhood*) is a third-person open-world game primarily set in Rome in the 14th century. The game's controls are inspired by the sport of Le Parkour, which teaches practitioners to move around obstacles with speed and efficiency by using acrobatic moves to traverse unorthodox paths. *Brotherhood* is the second game in a trilogy within a larger planned trilogy, but is the first installation in the series which takes place in a single continuous world (with certain missions taking place in smaller isolated levels that can be unicursal, multicursal, or completely open themselves).

Like Le Parkour, *Brotherhood* places an emphasis on freedom of movement, implemented equally through uniquely flexible movement controls and a go-anywhere, climb-anything open-world design. As with most modern open world games[3], players are only allowed to explore and familiarise themselves with a limited part of the game world in the beginning, but as they progress through the main storyline, new parts of the city are opened up until the entire game world is eventually available for players to roam freely. As section 2.3 found, the spatial structure of the world is a major factor in shaping the movement in the game, and the context-sensitive control scheme in *Brotherhood* connects movement even closer to space. Within the portion of the game world which is traversable at any point, the world design is such that the player has a nearly unparalleled amount of freedom of movement.

Despite the importance of movement in Brotherhood, the control scheme dedicates very few buttons to movement-related input. A "high-profile" button switches between two modes of movement: an inconspicuous saunter where jumping and climbing is disabled, and a run that enables all forms of movement but may draw unwanted attention. Two directional inputs are used to control the movement of the player character and the facing of the camera (a pair of thumb sticks or the WASD keys and the mouse). Finally, a "legs" button can be held to sprint or jump. All variety in how movement feels or functions is achieved by changing how the inputs behave in different contexts.

Movement in *Brotherhood* can be divided into three major categories defined by the spatial structures they are meant to traverse: vertical structures (such as towers) can be climbed, adjacent horizontal structures (such as rooftops) can be navigated with free-running, and wide-open spaces can be covered on horse-back. These structural categories are not clearly delineated in the game world – for example, vertical spaces connect horizontal spaces and horses can be used (ineffectively) in narrow city streets – but climbing, running, and riding are discrete states defined by differences in speed, acceleration, and manoeuvrability.

[3] For example: *Grand Theft Auto 4* (Rockstar, 2008), *inFamous* (SCE, 2009), *Red Dead Redemption* (Rockstar, 2010), or *Far Cry 2* (Ubisoft, 2008). Examples to the contrary include *Mercenaries 2* (EA, 2008), *Just Cause 2* (Eidos, 2010), and every game made by Bethesda Game Studios.

This section will analyse how *Brotherhood's* game space has been designed to make the player's movement feel different in different parts of the game world despite the very limited amount of movement-related input available to the player. Each of the three major forms of movement in the game will be treated individually. Four further forms of movement each appear in a single mission, and will be examined at the end of the section.

Climbing

Most vertical surfaces in the game are covered in ledges and hand-holds for the player character to climb. Climbing happens all but automatically: the player holds down the "High profile" button and the "Legs" button and moves towards the structure to be climbed (eg. a house wall). The player character will automatically jump and climb up the wall as long as there is something to hold onto further up. The climbing direction can be influenced by using the movement keys to climb sideways or to reverse the direction of the climbing.

Some structures are more complicated to scale, as they have less hand-holds or rely on slightly more advanced forms of movement. For example, a recurring challenge in *Brotherhood* is to climb towers which are designed with fewer and fewer hand-holds as the player climbs higher, requiring the player to exert more direct control over the avatar, making him climb sideways around the tower, making him swing around a corner hanging from a lamp, or dropping to grab a lower ledge (Fig. 10).

Fig. 9: Regular houses have plenty of hand-holds.

Fig. 10: Sparse hand-holds on towers channel the player.

The player character will never attempt to reach a hold that is too far away, and the player character will never miss or lose his grip. If the "Legs" button is released once the player has started climbing, the player character will never jump off a surface either, making it completely safe to climb. The player character is also capable of some truly physics-defying moves such as jumping out from a wall to grab a ledge protruding from the wall above him. Apart from the towers and a few other structures with limited hand-holds, the only real challenge appears when the rules are changed to add time pressure. In certain missions or dynamically occurring events, players will either be chasing enemies, chased by enemies, or subject to some other form of time pressure (for example a timer in a foot race).

These situations emphasise the layouts of the hand-holds and ledges as the player attempts to find the most direct, fastest route possible, and as some climbing moves are faster if the legs button is held down, the risk of making a wrong jump increases. The most important aspect that shapes the feel of climbing is the number of hand-holds available and the distance between them. Reducing the number of hand-holds reduces the players' freedom to climb a structure, making the placement of the hand-holds more important as they channel players through certain chokepoints or routes. Greater distance between the hand-holds requires more jumping, which is either slower or significantly more dangerous than normal climbing (or both). On the other hand, climbing in Brotherhood doesn't change significantly in a different high-level context– climbing inside a building can be a little more three-dimensional as players jump between walls or swing in chandeliers, but ultimately, the game feel of climbing is most relevant to the medium-level context.

What this shows is that the placement of objects becomes most noticeable when it has an impact on the player's success, which if achieved if the rules support the context. Requiring the player to scale a certain building and then reducing the number of ways in which this is possible (by reducing the number of objects that facilitate movement) is one example of this. Making speed essential is another way to do it.

Free running

Climbing and free running in *Brotherhood* are closely connected, but they invoke quite different kinesthetic sensations, and few of the spatial parameters that structure the climbing also have an impact on the free running, and vice versa. Roughly, climbing is typically about navigating a building whilst free running is used for moving from building to building (or bypassing buildings altogether).

What makes it free running, and not just plain old running, is the incorporation of jumps, vaults, swings, balancing, and other feats of swashbuckling. *Brotherhood's* rendition of Rome offers several environmental parameters that have been tweaked to offer different kinesthetic experiences in different parts of the city. Most fundamentally, the city can be regarded as consisting of two different layers: the street layer and the rooftop layer. The rooftops are more complicated to navigate effectively – they feature frequent height changes and routes are constantly interrupted by the gaps between buildings. On the other hand, rooftops have no civilians. Civilians in Brotherhood are pedestrians, merchants, minstrels and so on who all obstruct the player character's movement. Hitting a civilian while running makes the avatar stumble, and hitting a person at a sprint will cause the avatar to trip and fall, slowing the player down. Further, while rooftop routes are interrupted by streets and courtyards, the streets tend to twist between the buildings rather than offering direct paths to travel.

Fig. 11: The dense ruins facilitate free movement.

Fig. 12: Wide inner-city streets restrict the player's movement.

This has the interesting result that some areas favour rooftop movement while others favour street running. The ruined areas of Rome in particular (the southern part of the *Centro* district and the west part of the *Campagna* district) consist of large networks of dilapidated buildings very close to each other (Fig. 11).

Traversing the rooftops here is mostly a matter of holding down the Legs button and pointing in the direction you want to go, the player character will run and jump from roof to roof more or less unobstructed. At street level, however, the narrow twisting alleys feature many sharp turns, obstruct the players' sight lines, and constantly lead into dead ends, causing much backtracking, detours around buildings, and swearing.

This is in complete contrast to the upscale inner city areas (the *Vaticano* district and the north part of the *Centro* district) where the broad streets are straight for long passages between gentle turns and have next to no dead ends. Here, on the other hand, those very same broad streets divide the buildings into blocks too far apart for the player character to simply jump, necessitating detours to find connecting features such as scaffolds, cranes, and clotheslines (Fig. 12). The spacing and layout of the objects (in this case buildings as well as connecting features) transform the feel of the free running from direct fluid movement to persistently interrupted navigation – notably without enabling or disabling any movement mechanics or input types at the player's disposal. That means this difference would almost certainly be the same if *Brotherhood* were context-insensitive, which implies good prospects for getting strong results out of the test game.

Horseback riding

Fig. 13: Horses are clearly designed for the open spaces.

Horseback riding requires space to be useful. As horses cannot climb onto the rooftops and the city streets are full of pedestrians, horses are almost exclusively used to move quickly around the outskirts of Rome (the *Antico* and *Campagna* districts), visiting the outlying farms and boroughs. While on horseback, the player accelerates much more slowly than on foot and turns more laboriously, making a large circle proportional to the current speed of the horse. Jumping is possible, but only over small obstacles such as fences. Due to the low manoeuvrability of horses, they are incredibly clumsy to use in tight spaces such as city streets, which demonstrates the relationship between input/response and context: the outskirt districts feel large and open by comparison to the running speed, which makes the horse feel fast, and the high object density of the inner city district makes the running seem adroit and accurate in comparison to the clumsy horse.

Further observations

Brotherhood's rendition of Rome is cut through by several canals and rivers that can be navigated either by swimming (Fig. 14) or by commandeering a gondola (Fig. 15). The former is quite slow, and is most useful as a means of escape, jumping into the water and diving to hide from pursuers. It can also be used as a stealthy way to infiltrate mission areas in certain missions. The gondola is faster if the right rhythm is achieved with the paddle, but turns very slowly. Thus, the relationship between swimming and boating is similar to the relationship between free running and horseback riding: one is suitable for precise movement through confined spaces, the other is better for open spaces with few obstacles.

Fig. 14: Swimming is slow but affords sharp turns.

Fig. 15: Boating is fast as long as you're going straight.

Four of the game's missions feature special vehicles: a horse carriage, a sort of mechanical tank, a hang-glider with bombs, and a catamaran gondola with a cannon[4]. Each of these contraptions is controlled in different ways, with the same key bindings mapped to slightly different behaviours. The levels are carefully designed to facilitate the movement of the particular vehicle, such that the glider is used in a large open landscape with plenty of space to manoeuvre, the carriage is driven along a track through the mountains, and the gunboat is set loose on three warships in an expanse of water along the coast. Though the player is given no chance to test these vehicles outside of their dedicated levels, it's easy to imagine what a complete mess it would be to try to fly the hang-glider in a much smaller level or to drive the tank through the city. This shows the importance of tuning the context to the game's movement mechanics in order to create the desired game feel, and indicates that strong results might be expected if the medium-level context of the test levels is changed without adjusting the input and response accordingly.

It's clear that the medium-level context is crucial in shaping the kinesthetic feel of *Assassin's Creed: Brotherhood*, and the simple number and spacing of the objects go a long way towards giving each area of the game world its own distinct kinesthetic identity. The question is precisely how such differences are perceived by different players, and whether they will retain their impact in a game without the same contextual interaction that *Brotherhood's* climbing is based on. It's interesting to note that the number of objects appears to change the significance of the object layouts: if there are less hand-holds on a wall, it will call more attention to the placement of the hand-holds, as they channel the player along a certain route. Similarly, if the buildings are less connected because they stand further apart, their connections become far more important to the player's navigation of the game space. This indicates that the number of objects is an important parameter to test. The fact that many of the differences observed in *Brotherhood* are independent of its context-sensitive movement controls bodes well for the test level. Finally, the fact that Brotherhood features many different movement mechanics clearly designed for (and often restricted to) different contexts introduces the idea of testing different input/response dynamics in the same contexts.

[4] Yes, really.

3.1.2 *Mirror's Edge*

Mirror's Edge is a first-person game about running and climbing through semi-futuristic cityscapes. Games that tackle climbing are typically third-person[5], so *Mirror's Edge* stands out by staying in the first-person perspective at all times, using animation and camera effects to strengthen the player's sense of embodiment and communicate what type of motion is occurring at any point. The levels in *Mirror's Edge* are typically unicursal corridors, but feature many shortcuts or secondary passages used to outrun or bypass enemies or to shave time off the run in the game's enemy-free time trial mode. The game constantly combines different types of challenge with different spatial structures to vary the difficulty or feel of playing. To facilitate and diversify players' interaction with the game space, *Mirror's Edge* features many different movement mechanics, some of which are faster than others, and which can often be used in the same area.

Fig. 16: *Mirror's Edge*.

The following movement mechanics are at the player's disposal in *Mirror's Edge*:

- Walk/run/sprint (a sliding scale which depends on the fast but gradual build-up of momentum)
- Jump (longer jump the faster the run-up)
- Crawl (moving while crouched)
- Slide (crouching while sprinting)
- Vault (jumping over a low obstacle)
- Jump to ledge
- Barely jump to ledge (a near-miss that takes slightly longer to recover from)
- Pull-up (pressing jump while hanging from a ledge)
- Wall-jump (vertical jump that includes a 180 degree turn)
- Wall-run (jumping while sprinting next to a wall allows briefly running along the wall)
- Landing roll (pressing crouch when hitting the ground to roll and preserve momentum)
- Climbing a ladder
- Climbing a pipe
- Jumping from a pipe
- Shimmying along a ledge
- Jumping while hanging from a ledge
- Swinging on a horizontal pole
- Using a zip-line
- Balancing across a narrow object

[5] Eg. *Tomb Raider* (Eidos, 1996), *Assassin's Creed* (Ubisoft, 2007), *The Saboteur* (EA, 2009), *inFamous* (SCE, 2009), *Splinter Cell* (Ubisoft, 2002), or *Hitman: Blood Money* (Eidos, 2006). Some modern first-person games even switch to third-person for climbing, eg. *Rainbow Six: Vegas* (Ubisoft, 2006) or *Deus Ex: Human Revolution* (Eidos, 2011).

The majority of these different types of movement are “context-sensitive”, ie. they can only be activated or are only useful in relation to certain objects or structures in the environment. For example, vaulting is only possible when running towards a low obstacle, and a landing roll can only be activated at the end of a long fall. This is an effective way to imbue the game space with functionality, strengthening the player’s personal presence. The game also features a few martial arts moves that are activated by using the “Attack” button in conjunction with certain movement mechanics, namely a sliding kick executed by sliding into an enemy, a jump kick executed by jumping into an enemy, and a drop kick executed by falling onto an enemy. These interactions all rely on medium-level context, making the number of objects and the distance between them the most important aspect of the game’s space.

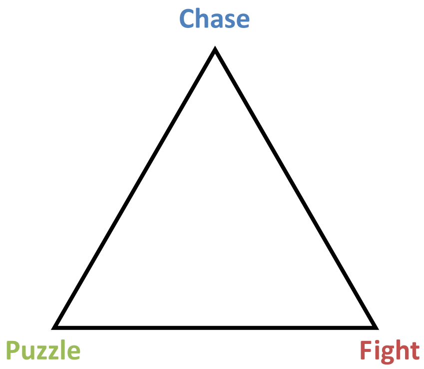

Fig. 17: Challenge types in *Mirror’s Edge*.

The types of challenge in *Mirror’s Edge* can be roughly divided into three main categories: chase, puzzle, or fight. These categories exist on a sort of triangular scale where each area typically fits on one edge of the triangle but not necessarily at the tip. For example, players will run into ambushes while being pursued by enemies or have to puzzle their way out of an area covered by enemy snipers. The following sections will analyse the common traits of each challenge type and the differences that set them apart, and examine what movement mechanics are used in the world to create and support kinesthetic perception.

Chases

Chases are about speed, danger, momentum, and acting on instinct. Chases are typically signposted for easy navigation, using lighting to draw the player’s attention towards the correct way forward, instantly obvious dead ends – for example fences topped by barbed wire – to let the player quickly rule out wrong paths, and of course an optional (but enabled by default) “runner vision” that dynamically colours certain objects red to make them stand out if they’re important to the player’s progression. The defining feature of a chase is that players are being pursued, which forces them to keep moving and make snap decisions about which way to go and how to get there.

Chase sequences often use slides, vaults, wall runs, and ziplines – the fast types of movement that lets the player preserve momentum. Most of the movement mechanics that allow the player to gain altitude are quite slow to use (ladders, pipes, high ledges) and so chase sequences are mostly horizontal and/or downwards, and when the player *does* need to go higher during a chase, it is usually done by running up staircases. These sequences also tend to feature a lot of movement types that require a lot of momentum to execute successfully, such as wall runs or jumping over wide gaps.


Fig. 18: A mattress at the end of a very long drop.

Mattresses are sometimes used to end chase sequences by resetting the player's momentum in a spectacular way (Fig. 18). Landing on a mattress allows the player to fall very far without dying, but all momentum is lost as the fall stops in a crouching position before the player character gets back up. Other times, mattresses simply end one *part* of the chase sequence, by denoting that the player has escaped the first group of pursuers before escalating the chase with a new enemy, such as a helicopter.

This shows that momentum is essentially a resource in the chase sequences, and failing to preserve momentum too many times throughout a chase ends with the pursuers catching up and shooting the player character to death. Actions that typically cause the momentum to be reset include having to stop and turn around if you picked the wrong direction and ran into a dead end, timing a jump poorly so the player character grabs onto a ledge instead of landing on the other side of a gap with her momentum preserved, or failing to roll upon landing after a long jump.

Chase sequences often take place in outside areas, where it's easier to preserve momentum and easier to maintain an overview of the level so as to form an impression of the correct route in advance of each decision point. This constitutes a sort of synergy between the rules of the game (which force the player to be fast) and the context (which helps the player to be fast). When a chase does happen inside, it's often mixed with puzzle elements, as with *Chapter 1, Checkpoint B* where the player character has to escape an office building being raided by the police after a meeting with her sister.

Fig. 19: This vent must be reached while the police are battering down the door.

After a relatively unobstructed run, the player reaches a multi-story room where the only way out is a ventilation shaft near the ceiling (Fig. 19). Reaching this shaft requires a bit of jumping and climbing, but the game automatically shuts the door behind the players, affording them a brief respite in which to execute the necessary moves while the police is battering down the locked door. This is a noticeable change to the game feel of the sequence, as the rules require speed but the context provides contrast by limiting momentum, obstructs sight-lines, and makes intuitive decisions difficult. This change between contrasting or synergistic relationships between the rules and the context change the aesthetics and the difficulty considerably without using different movement mechanics.

Puzzles

Puzzles are about analysing an area, plotting a possible path from your starting position to the exit, and then carefully and deliberately executing the advanced moves required to get there. These are essentially first-person platforming sections (in reference to the old side-scrolling genre built around jumping from platform to platform), and as they almost never involve any time pressure, the sense of danger comes from the risk of falling down and having to start over. Puzzle areas are less thoroughly signposted than chase sequences, due to the fact that figuring out the correct route is a large part of the challenge in these sections.

Puzzle sections frequently make use of pipes, ladders, pull-ups, wall jumps, swinging poles, and shimmying. These are slower or more difficult forms of movement because they are traversed with a fixed speed instead of building up and preserving momentum like running and jumping. In many cases, they are also more difficult to execute – for example, jumping from one pipe to another pipe can be rather finicky and requires a bit of aiming, and the wall jump (in which you run a few steps up a wall, spin the view 180 degrees, and set off from the wall jumping upwards away from it) requires careful timing and is somewhat disorienting. The wall jump is also unsafe to use unless you take the time to prepare by aligning yourself with your intended destination before jumping, since the destination is behind you and out of view when you jump.

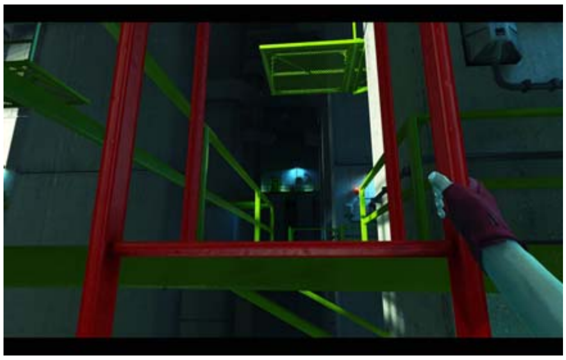
Fig. 20: A ladder in a typically vertical climbing puzzle.

The puzzle sections in *Mirror's Edge* are commonly laid out in such a way that even if the player understands in which direction the ultimate destination is, identifying the next step at each point along the way is a challenge. This, in combination with the frequency of laborious moves that reset the momentum, creates a sort of stop-and-go pattern where players must briefly gather momentum and jump to ladders, pipes, or ledges where the momentum is lost again. Just like in the jumps of a chase sequence, this is done with a run-up, but as puzzles often take place in-doors and in similar confined quarters, most run-ups are only barely as long as they need to be, which creates a sense of uncertainty about whether each jump is possible.

Fights

Fights are the least common type of gameplay in *Mirror's Edge*, and can either be bypassable or mandatory. Bypassable fights often happen in the middle of chase sequences where quick players can exploit their momentum to run past or around enemies that appear ahead of them and simply bypass the fight without confronting their ambushers. Mandatory fights are usually arranged in small arenas with an exit that remains locked until the player eliminates all the enemies in the area.

In both cases, areas where fights take place are usually designed as relatively large arenas with circulation paths that can be used to outrun and isolate enemies so they can be confronted and hopefully eliminated one by one. Fight areas use far less different forms of movement than chase or puzzle areas, and ladders or pipes are almost never found in a fight area because their use exposes the player character too much. Only the fastest types of movement are commonly used, such as vaulting, sliding, and jumping across gaps. Instead, enemies themselves constitute mobile contexts for new moves by enabling the attack moves.

During a fight, the game environment gains a new function: cover. To stay alive, the player must take into account their position relative to the enemies and the architecture of the arena, always making sure that there is some kind of obstacle between the player character and any enemy the player isn't currently dealing with. Enemies must be tackled one or at the very most two at a time, as the player character is quite vulnerable and will die quickly if exposed to enemy fire. If the player remains mobile, enemies tend to spread out, making it possible to isolate manageable groups of them.

Importantly, the player can disarm enemies with martial arts and take their weapons to use against other enemies, but carrying a weapon slows the player down significantly and disables most of the moves, including all moves related to climbing and grabbing (as the player character's hands are full). Furthermore, weapons cannot be reloaded, only fired until they're empty, at which point they will be thrown away automatically. As constant and fast movement is such an important way to stay alive in a fire fight, the safest course of action is to throw weapons away immediately and rely on mobility instead.

Further observations

Some places in *Mirror's Edge*, several different movement types can be used to reach the same spot. Frequently, a safe but slow option such as a ladder will lead to a platform that can also be reached with a riskier and more difficult but slightly faster wall jump. This dynamic also exploits the fact that ladders are easily recognisable elements that clearly point towards the forward path, while wall jumps are less obvious, and can be used wherever there is a high enough wall (though not always successfully, of course). Thus, a degree of player expression has been built into the level design, and greater mastery of the game can open faster or more satisfying paths, which is particularly important in time trial mode. Accommodating different skill levels further helps players to maintain their immersion by continuing to offer new layers of challenge to more skilful players.

Fig. 21: Rolling out of a fall preserves momentum but can be somewhat disorienting.

Once in a while, *Mirror's Edge* sends players through ventilation shafts. These are generally used to simply tie two different areas together, but slightly longer ventilation systems exist where players are crawling and climbing around in ventilation tunnels. These offer the most limited type of movement in the game, as no momentum can be gained from crawling and the only climbing to be done is pull-ups. Though brief, the vents provide a great example of how important high-level context can be to kinesthetic perception.

In summary, *Mirror's Edge* demonstrates one possible way for the game space to shape movement: by having many different moves that are contextually bound to certain objects or structures in the game world, very specific movement patterns can be designed into the levels, which can be used to alter the pacing, navigation, and above all the feel (particularly the kinesthetic perception) of playing the level. *Mirror's Edge* further shows how combining certain rules with certain contexts can create a great deal of variation in terms of difficulty and aesthetics through synergy (fast movement patterns combined with chasing enemies) or through contrast (the threat of encroaching enemies in a complex space with slow movement patterns). As this doesn't rely on context-sensitive interaction, it should apply equally well to the test level.

3.1.3 *Jurassic Park: Trespasser*

Jurassic Park: Trespasser (henceforth *Trespasser*) is a first-person action/adventure game in the *Jurassic Park* setting. Having been released in 1998, a year after Janet Murray's book *Hamlet on the Holodeck*, *Trespasser* was born out of the – popular at the time – belief that games were moving towards full immersion as simulated embodiment: "you would experience the environment through a virtual body to avoid the 'floating gun' feeling prevalent in the *Wolfenstein* breed of first-person games" (Wyckoff, 2003: 184). To realise this paradigm, the player is given an independently movable arm that protrudes from the lower right corner of the screen.

Fig. 22: *Jurassic Park: Trespasser*.

Almost all interaction in the game takes place via this arm, which can be moved around the screen by holding down the left mouse button while dragging the mouse, rotated in the shoulder by holding Ctrl, and rotated in the wrist by holding Shift. Right-clicking makes the arm pick up or grab onto objects, and pressing F throws the held object straight ahead.

Trespasser provides a counterpoint to *Brotherhood* and *Mirror's Edge* as a game that went in a completely different direction in its attempt to increase the player's embodiment and make the player feel more present in the game world. Where those modern games are built around two different approaches to context-sensitive movement, *Trespasser's* developers consciously decided to avoid context-sensitivity in the player's interaction with the game, instead emphasising direct interaction with a (for the time) state-of-the-art physics simulation (ibid.: 193).

Trespasser's most grating feature to a modern player is the arm. Watching players who are used to manipulating this arm play the game, it looks almost natural; especially lining up the iron sights of a weapon with a distant enemy seems very authentic: the independently movable front and rear sights must first be aligned with the player's view, and then with the target (Fig. 23). Being able to grab an object such as a box and drag it along the ground, or pick up a baseball bat and rotate it by rotating the wrist of the arm, or aim a throw by raising the arm without also raising your view, are all recognisable actions from the real world.

Fig. 23: When there's time to aim properly, it feels authentic, if not natural.

But the arm is perhaps one abstraction too far for the extension of the player's proprioceptive system. Where a baseball bat or a weapon might be included in our perception of our own body, and where a mouse controlling a baseball bat in a videogame might similarly be included, the hand in *Trespasser* never fails to feel like a tool rather than a limb under our direct control – wielding a weapon in *Trespasser* is closer to holding a rubber arm holding a gun than it is to holding the gun yourself. The lack of kinesthetic input from the game to the player becomes a noticeable disconnect: swinging a baseball bat at a dinosaur in *Trespasser*, the bat may connect and stop the arm moving further, but the player's hand continues to move the mouse across the desk unobstructed. Similarly, the arm has a physical weight of its own generating an inertia that doesn't correspond with the linear movement of the mouse. Giving the player an arm with a physical presence in the virtual environment creates an expectation that the movement of the arm will have a 1:1 relationship with the movement of the mouse, and defying this expectation sabotages the player's sense of presence in the game world.

It's telling to compare the simple act of pushing a button in *Mirror's Edge* to a similar action in *Trespasser*. In *Mirror's Edge*, pressing the "Use" key while facing an elevator button will cause the view to be locked in place while the player character's hand is shown punching the button – it's a quick and intuitive process. In *Trespasser*, the player must hold down the left mouse button and aim the player character's index finger by moving the mouse, and then press the "Use" key when the finger is aligned with the button. Due to the influence of inverse kinematics on the movement of the arm, this process is so unintuitive that punching the right code into a keypad is a challenge in itself, and players may miss the buttons they wish to press.

Fig. 24: With *Trespasser's* virtual arm, throwing a rock at a wooden box is a complicated procedure.

The player's input corresponds so poorly to the game's response that simple actions become laborious. Richard Wyckoff suggested that a higher degree of context-sensitivity could be used to make a virtual arm more intuitive and easy to control. He pointed out that the mouse is a two-dimensional input system being used to control movement in three dimensions, and only by making this translation between input and response more context-sensitive could it be improved (2003: 193).

Basic movement through the game space is not of major importance in *Trespasser*. The only movement inputs at the player's disposal are running forwards, walking forwards, walking backwards, sidestepping, crouching, and jumping. The game has only one context-sensitive move: a mantling that is automatically activated when jumping onto a surface of a certain height. *Trespasser* features the occasional navigation-based puzzle where the player must find the way to a certain location, which may require jumping out windows or climbing simple structures, but the interesting aspect of these puzzles is typically constructing or clearing the path by stacking boxes as a makeshift staircase or moving grates or debris out of the way.

Nevertheless, changing contexts in *Trespasser* do influence the feel of playing the game. The most clear-cut example is that large weapons such as a shotgun or an assault rifle are rather unwieldy in interior areas such as inside office buildings, because the weapons keep knocking into the walls and throwing off the player's aim. In these environments, pistols and sub-machineguns that don't extend as far into the world are easier to use. Unfortunately, *Trespasser's* general disagreement between input and response almost completely overshadows this, meaning only players who have put in the substantial time investment required to internalise the control of the virtual arm are likely to notice the difference. This suggests that the impact of context on game feel is secondary to the importance of the relationship between input and response. When testing the effects of changes to the context, input/response should therefore either be perfectly calibrated against each other or somehow given less importance in the play experience, for example by making the relationship between input and response more abstract rather than less.

3.2 Central themes

Several themes have emerged from the game analyses above. It would appear that when games use context-sensitive movement, the player's movement patterns become highly dependent on that part of game feel that Swink (2009) terms medium-level context. This is true in *Assassin's Creed: Brotherhood* where a small amount of movement-related inputs change meaning depending on the context, and it's true in *Mirror's Edge* where many different input combinations become active or inactive in different contexts.

One of the most interesting relationships between the structures of the game spaces and the player's movement patterns in *Mirror's Edge* is evident in the difference between interior and exterior sections. Sections that use precisely the same movement mechanics and precisely the same rules (ie. threats and objectives) feel significantly different to play depending on whether they take place inside a building or outside on the rooftops or in the streets. Though this approaches high-level context, interior and exterior areas still exist within the same city and are indeed mixed in the same levels. The game feel differences are more down to the distances between structures and the number and density of objects within the levels.

Fig. 25: Running from a police helicopter across building roofs in *Mirror's Edge* affords the player plenty of overview from most places. Interior sections have shorter sight-lines, which means more surprises along the way.

In *Brotherhood*, the most interesting difference is between the movement pattern in the slums and the movement pattern in the nice inner city neighbourhoods. The size and number of objects and structures that the player can use to climb on, run on, and jump between makes a great difference to how the player character feels to control. Unobstructed movement is fluid and easy, requiring little in the way of control input, while the more complex movement of navigating the streets in the slums or passing over the rooftops of the inner city is more challenging and requires more planning and more frequent course corrections.

Trespasser demonstrates the risk that problems with the relationship between input and response in the test game may remove the focus from variations in the context. By downplaying direct interactions with the environment in favour of bringing basic movement to the forefront of the game experience, the danger is reduced of potential input/response problems tainting the data. Additionally, focusing on indirect interactions can be expected to increase the importance of context compared to input/response in relation the overall game experience, despite the test game's lack of context-sensitive interaction.

Fig. 26: Climbing towers in *Brotherhood* is a challenge purely because of the scarcity of hand-holds.

The three central aspects of game feel context to emerge for testing are distance, size of objects, and number of objects. *Brotherhood* shows that distance is closely tied to input and response, with large open spaces requiring a fast but clumsy horse to navigate. Varying fall and jump distances are also used to great effect in *Mirror's Edge*, and it will be interesting to test how such distances are experienced through the different movement methods in the test game. Different numbers of objects have a considerable impact on the player's movement patterns in *Brotherhood*, with a higher density of hand-holds or buildings opening more paths for the player to climb and run, but also with dense crowds in the streets serving as obstructions. Finally, the size of objects in relation to the player character's jump height will be important, and may serve to highlight differences in the game's movement methods, as one type of movement may be used to circumnavigate obstacles too large to bypass with another type of movement, or larger objects easier to hit if the player is aiming for them.

Extreme examples of these aspects will be implemented in the same levels of a game, to be tested and compared side by side. Based on what Hunt and Waller (1999) wrote about the way people experience simulated movement based exclusively on visual input, the best approach to testing distance should be to only increase the size of a space along the axis of the player's movement, thus preserving the same optic flow. The size and number of objects are closely related, and will be combined: one version will have many small obstacles, another will have few large ones. The primary question is how these differences will manifest themselves in a game without context-sensitive movement, which is to say a game with two or more input/response modes that can be switched between in any context.

The next chapter will describe the game used as a basis for the test levels and summarise how it was developed. In developing the game, it was of little importance that the particular aspects to be tested would be fully represented, since the levels were expected to be adjusted for this purpose later. Instead, the focus was on creating a third-person avatar-based game that would live up to the full definition of game feel by having real-time control, simulated game space, and polish. Another major goal was that the game should include at least two different major modes of movement and that it should involve some manner of direct interaction with the game world. All of this was achieved to a satisfactory degree.

4. Broken Dimensions

This chapter is about *Broken Dimensions*, the game used in this project to gather empirical data about the effects of certain factors of a game space on the player's feeling of movement. The chapter will first describe what the game is about and how it is played, then briefly outline its development and the role of the author of this thesis. Next, the chapter will discuss the relevance of *Broken Dimensions* in terms of space and spatial manipulation, and how it ties into the theory presented previously. Finally, the chapter will outline the testing conducted with the game before it was modified for use in this thesis.

Fig. 27: ***Broken Dimensions*.**

4.1 The game

Broken Dimensions is a third-person puzzle game where players are given control of a small boy in a chicken costume (Theodor) who must escape the maze-like halls of an ancient, sentient pyramid. The pyramid manifests itself as a loving mother figure (Tonantzin), at first pretending to guide the boy through the pyramid, but in fact luring him further into its passages in order to consume him, and eventually revealing itself as the antagonist of the game when he refuses to take directions and survives despite the pyramid's instructions. In the end, Theodor confronts Tonantzin, tricks her into consuming herself, and then makes his way through a void filled with the fragmented structures of the pyramid. At the centre of the pyramid, the boy reaches the dark beating heart of the pyramid and shatters it, escaping and ending the game.

The central mechanic of the game is a "rotation mode" where the player character lifts off the ground, allowing players to rotate the world in 90 degree intervals around the player character. All gravity objects are suspended in time while in rotation mode, and will not fall down until players leave rotation mode again. The player character will also fall to the ground upon leaving rotation mode, but no fall damage is taken and players retain a high degree of control in the air. Half-way through the game, players acquires a new tool: the ability to “freeze” a certain type of gravity object, allowing it to defy gravity even outside of rotation mode. Though this ability is one of the ways in which players can interact directly with the environment, it was not selected to form a part of the thesis.

The game consists of 8 levels, each of which presents a small environmental puzzle that players must solve in order to progress. The first level is a tutorial where pop-ups teach players how to control the game and very simple navigational obstacles ensure that they understand. It ends with a simple object manipulation puzzle where players must rotate the world once to remove an obstacle from the exit, which demonstrates how gravity is affected by the world rotation. The next three levels introduce new types of obstacles: a breakable wall, a giant sliding statue, and deadly spikes. The breakable wall is designed to introduce slightly more involved indirect object manipulation as well as portray Theodor’s world rotation ability as very powerful; the sliding statue is designed to let players indirectly interact with a huge object which is more constrained in its movement than the typical moving boxes; and the spikes make up a return to the purely movement-based challenge of the tutorial, only this time, players are afforded much less leniency, as a wrong move may lead to Theodor’s death.


Fig. 28: Theodor and Tonantzin.

Players are guided through this first set of levels with glowing candy that disappears in a shower of stars when the avatar touches them. At the end of the fourth level, however, Theodor acquires the freeze power and Tonantzin reveals herself to be the antagonist, at which point the candy stops appearing and players are left to find their own way through the pyramid. The next three levels use similar obstacles as before, but the new puzzles can only be solved using the freeze ability – the first is two large boxes stuck together in such a way that the player must freeze one of them to create a passage between them, which all but ensures that players learn the use as well as the limitations of the freeze ability; the second at first appears to be a repetition of the third level with the large statue, but in this version a key object is no longer constrained in its movement, and must therefore be supported by another object frozen by the player; the third of these levels is a complex double door consisting of a piece that slides along one axis and must be blocked with a frozen box while the world is rotated in such a way that another piece will swing open. Solving these puzzles involves an element of timing as boxes must be frozen in mid-fall, and practiced players may find pleasure in doing this while their avatar is also falling.

The eighth and final level is the confrontation with Tonantzin, where the players must lure one of Tonantzin’s homing projectiles into herself, which is most easily accomplished by use of the freeze ability. As only one object can be frozen at a time, and new projectiles are constantly spawned at regular intervals and relentlessly chase Theodor until colliding with something and exploding, this sequence is designed to feel somewhat stressful. When Tonantzin is defeated, a simple platform sequence follows where players must use the rotation mode to fall from platform to platform until they reach the heart of the pyramid and the game ends.

4.2 Development

The development of *Broken Dimensions* was a 2 month project from conceptualisation to release, including 3 weeks of conceptualisation. The full team consisted of 13 developers: the management group was the game director, the game designer, the project manager, the assistant director, the lead programmer, and the art director; the rest of the team was made up of two programmers, two animators, two CG artists, and an audio designer. The author of this paper served as the game designer on the project.

The most basic form of the *Broken Dimensions* concept was put forth by the game director: a game where players could rotate the game world around them in three dimensions. There was some initial resistance to the idea due to the abundance of 2D games built on a similar mechanic, but as the concept was developed further, the team became confident that a new and interesting spin could be put on the mechanic during the translation into 3D.

During pre-production, the original concept - which was focused exclusively on gameplay and structure - was solidified into a full design including narrative and aesthetic direction. The director and the art team settled on a half-comedy, half-horror story about a boy who had wandered into an ancient Aztec pyramid while trick-or-treating for Halloween. The pyramid would be embodied as a ghostly mother figure (named Tonantzin during development) who would pretend to be leading the player character out of the pyramid while in fact luring him further into the dark centre of the pyramid where it would kill and consume him.

Meanwhile, it fell on the game designer to establish a series of design paradigms. The game would be a linear progression of puzzles accompanied by the ghostly and occasionally disembodied Tonantzin. The plot would be split into three acts: an extended tutorial where Tonantzin would pretend to be friendly by giving the player trustworthy advice, an escalation of conflict after Tonantzin was revealed to be evil where the puzzles would get trickier and no help would be offered, and a final denouement after the player fights and defeats Tonantzin which would be a pure navigation puzzle in a startlingly different environment. The puzzles themselves would be physics-based and should be designed with the goal of being fair and intuitive and making sense in hindsight - when solving a puzzle, the player should think "Oh, but of course!" rather than "Why is *that* the solution?"

Finally, in terms of game feel, the designer and director both agreed that the world rotation should feel powerful, magical, and satisfying. This became the focus of the lead programmer's world rotation prototype which was developed in close cooperation with the game designer throughout the pre-production week. The following steps were taken to optimise the feel of the rotation mechanic: the rotation keys were context sensitive in that their axes changed to reflect the orientation of the mouse, making them highly intuitive; the player character was lifted off the ground when entering rotation mode in order to emphasise the magical aspect and convey the idea that he is the point around which the world pivots; the world rotation was animated smoothly (a purely visual gimmick which doesn't correspond to the in fact instantaneous rotation of the world collision boxes); and the field of view on the main camera was increased in world rotation mode with a smooth transition, both as a way to give the player a better overview of the surroundings, and as a satisfying visual effect to make the transition more momentous and impressive. Further audio effects were added later.

In the second half of the pre-production week, the artists began to work on the 3D models for the two characters, the programmers consolidated their three prototypes (one for world rotation, one for basic movement control, and one for autosave checkpoints), and the game designer began to brainstorm puzzle ideas and draw concept schematics for levels. Through discussions with the game director, the following level structure was agreed upon:

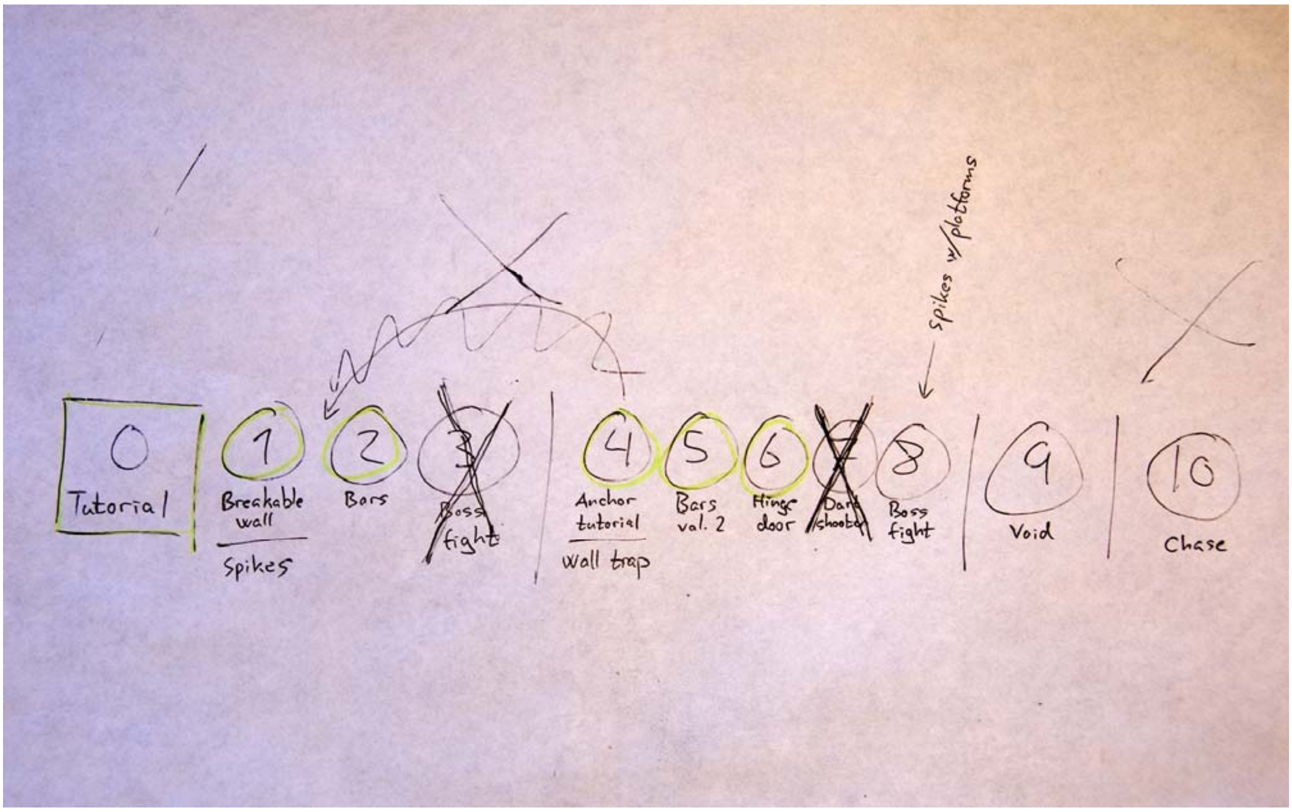

Fig. 29: ***Broken Dimensions*** **level structure.**

The most significant design question during production concerned the implementation of the world rotation mechanic. A primary goal was to make the rotation feel powerful and miraculous, and in accordance with this, the player was initially allowed to enter rotation mode at any point during the game, including in mid-air. This produced two problems: first of all, the puzzle design became extremely difficult, since the player was able to essentially fly through the levels by stopping and rotating the world mid-fall; almost every obstacle was easily bypassed this way. Secondly, initial play testers reported that they felt completely safe as long they were in the air, and as a result they would never touch the ground. One play tester likened the experience of playing the game to that of a space ship simulation. In light of these results, several different solutions were attempted, including a three-second delay between each time the player could enter rotation mode, but eventually it was decided to simply disable use of the rotation mode when the player character was airborne.

With this change to the core mechanic of the game, half a dozen level concepts that were previously useless due to the player being able to simply fly past any obstacle were now resurrected from the scrap pile and quickly implemented into the game. Thanks to the modular design of the environment art assets (entirely made up of rectangular and square wall pieces as well as cubic decoration objects), the game designer could construct levels very quickly and efficiently, and two weeks into the production period the game already had 10 functional levels.

The focus after this point was on the narrative and tutorial elements, mainly implementing Tonantzin and her dialogue as well as the pop-up messages in the first level teaching the player how to control the game. The lead programmer wrote a trigger that could make Tonantzin appear at a pre-defined point in the world and speak a certain line of dialogue, with audio and subtitle text defined by a dialogue object in the level. The game designer wrote the first draft of the script and then handed it over to the director, who edited it down to a more reasonable length and quality. Then the game designer implemented each line of dialogue into the game with Danish and English subtitles.

Once this was implemented, it was time for the second round of user experience tests. These tests were conducted with a handful of volunteers with little to no previous game-playing experience. The tests revealed some very severe accessibility issues, especially because the tutorial pop-ups had not yet been implemented. Players found it extremely difficult to navigate, and nobody made it past the first few levels. At the subsequent design meeting, several measures were outlined for aiding the player's navigation, such as more visible exits (using stark colours and high-contrast lighting) and shutting the "door" behind the players as they moved through the levels, preventing accidental backtracking. A set of goals were established for the tutorial, describing how it should work and what it should convey, and work began on it immediately.

The final round of tests had been scheduled for one week before the final deadline, giving the team another week to prepare for what was termed the beta test. Everything now was focused on making the game as playable as possible: finishing the game scripting, connecting everything from beginning to end, eliminating all the worst bugs and glitches, and implementing the most basic polish such as Tonantzin's animations, the dialogue audio, the particle effects for the rotation mode, and the murals on the walls.

The main cause of problems was the physics-based nature of the puzzles, especially combined with the player's ability to rotate the world. A fundamental conflict emerged between the emergent nature of physics simulations and the single-solution design pattern of typical puzzles. As team members constantly play tested and mastered the game levels, they discovered work-arounds and exploits that made it possible to skip entire puzzles. A few of these exploits were deemed too cheesy and fixed, but certain solutions were considered to be clever alternate solutions that advanced players might enjoy finding, and were left in.

The artists had by now finished all crucial assets such as walls, spikes, doors, movable boxes, or giant stone statues of lizards. This allowed them to start working on the murals that were to adorn the pyramid's walls and break up the monotony of its large, empty corridors. The game designer carefully arranged the murals in such a way as to always point towards the exit of the level. A few murals even hinted at the solution to certain puzzles (for example depicting humanoid creatures dropping boxes down the corridor towards the breakable wall where the player had to do likewise). Finally, all murals had a narrative purpose in that they were made to gradually change throughout the game to be increasingly horrific, building towards the climactic confrontation with Tonantzin at the end.

The third week of production was also the week of ruthless cuts and scope reductions as it became apparent that making the existing content work would take enough time and effort without also finishing and implementing the last remaining levels. The first confrontation against Tonantzin after level 4 had already been scrapped, but a few more puzzle concepts and set pieces were removed from the level structure at this point, including an elaborate chase sequence where the player would be followed through twisting passages by a rolling boulder à la *Raiders of the Lost Ark*. All of the team's effort instead went into finishing what was already in the game.

The final week of production began with the beta test, when the game designer and the assistant director visited Gammel Hellerup Gymnasium north of Copenhagen to test the game with five high school students. With the exception of some bugs and glitches in later levels, the game appeared finished, and the purpose of the test was very general but focused especially on the difficulty of the puzzles. Each tester played the game for 20-30 minutes, but only one of them managed to make it to level 3. Two of the testers barely managed to complete the tutorial in the given time. Though the testers spoke highly of the game, the results were unmistakable, and an emergency meeting was held for the full team upon returning to the office.

Among the many changes made to the game during the last week, some of the levels were simplified slightly to allow players a better overview of the rooms and puzzles, making it easier to navigate the game world without getting lost. One of the most significantly affected levels was the first puzzle level, which was eventually used for this thesis as will be described herein later. A few twists and turns were removed from the level, such that it would require at least four rotations less to solve the puzzle.

In order to further aid the player's navigation, small candy pickups were added throughout the first four levels of the game, guiding the player in the right direction and teaching him or her to recognise the exit doors. This new element was fairly well supported by the game's narrative, but it did introduce a potentially confusing inconsistency as the useless navigation pickups and the crucial power-up in level 4 that gives the player the freeze ability used the same model and textures.

The last design work to be done on *Broken Dimensions* before the deadline was the addition of particle effects to enhance the polish of the game. Particle effects are at an awkward intersection between programming and art, and like many other things that don't clearly belong in one certain area of expertise, the work fell on the game designer. The particle effects in *Broken Dimensions* serve two different purposes: they communicate the state of certain objects and they enhance the look and feel of the game. Every time a heavy object hits a surface, a ring of dust appears to inform the player of the collision and to make the collision feel more powerful. Orange sparks circling objects affected by the freeze ability help the players to identify the frozen object and hopefully make the freeze power feel more magical and mysterious. Smoke emanating from Tonantzin and her projectiles make them appear ethereal and menacing.

Polish in place, and after one long final day and night of bug hunting, the game was built, tested one last time, zipped up along with all the required documents and other files, and handed in.

4.3 Space in *Broken Dimensions*

The relevance of *Broken Dimensions* to this paper lies in the game's focus on its environment and the manipulation of space. In high-level terms, *Broken Dimensions* has two different types of movement, and two different types of challenge related to space. Players can either run and jump through the game world, or rotate it and fall through the levels. The former is always slower, but often safer - players have a high degree of control over the avatar while falling, but rotating in certain locations can result in unavoidable death or cause dangerous objects to fall as well, and potentially crush the player character. Due to the considerably different constraints and affordances of each type of movement, they also feel very different, and can be expected to change in different ways depending on changes in the environment.

Fig. 30: Concept art by the art director of *Broken Dimensions*.

All of the challenges in *Broken Dimensions* can be divided into two categories: navigation and object manipulation. Navigation is a challenge in every level - the environments are arranged such that the players can never just walk or jump through them, but must rotate the world to reach the exit. The challenge, however, isn't just the basic task of locating the exit and keeping track of where it is while rotating the world, but in moving safely through the environment. Many levels feature deadly spikes, walls that crush the avatar, or heavy obstacles that tumble through the rooms and may crush unfortunate players. Making a mistake when rotating the world may result in the death of the avatar and a setback to the player's progress. This type of challenge relates mainly to the movement of the player avatar, over which the player has direct control.

The second type of challenge in *Broken Dimensions* is using the world rotation to change the direction of the gravity in relation to the objects in the game, indirectly moving loose objects around the levels. This indirect interaction has a distinct feel compared to the more direct interaction of moving the avatar, and changes depending on the object in question - heavier objects bounce less on contact with other surfaces, irregular objects are harder to predict the movement of, and several objects throughout the game are constrained in their movement, eg. only able to slide along one axis of movement. Changes to the game world that impact the feel of the player's navigation in one way can be expected to have a very different impact on the feel of indirectly controlling other objects.

Though only a limited part of *Broken Dimensions* is used in the qualitative research for this thesis, the vertical slice chosen for testing and the type of modifications that were decided on are all designed to identify and compare changes in the feel of each type of movement and each type of challenge in the game. The tutorial mainly makes use of navigation challenges, with a single, very simple object manipulation challenge at the end (requiring only one rotation to solve). This level will be used to examine the impact of the chosen level modifications on the feel of simply moving through the game world. The second level is the first real puzzle of the game, and requires the player to make at least one of two boxes fall into a breakable wall to shatter it. This level will be used to examine the how the chosen level modifications change the feel of indirectly controlling objects in the game world.

The second level furthermore features a trap consisting of a large wall of deadly spikes which is free to move along a corridor that the player must traverse. This trap is designed to catch careless players unawares and crush them if they rotate the level to fall into the exit but miss. Unlike other physics objects in the world, this spike wall does not fall faster than the avatar, but rather moves at precisely the same speed, although it takes slightly less time to accelerate to this speed than Theodor. This makes the threat of the spiked wall largely an aesthetic, psychological factor: an increase in the length of the corridor will have no effect on the likelihood of Theodor becoming just another bloody smear on the wall. It will be interesting to see how any changes to this corridor alter the players' perception of the danger they are in.

Some of the levels not selected for testing here contain other features the feel of which might change in interesting ways in relation to the test modifications. For example, the abundance of spikes in level 4 raises the stakes of basic navigation considerably, which might alter the impact of adding more obstacles to the world. However, for the purposes of exploring the importance of the game world to the fundamental feeling of movement in the game, it is best to use the most basic forms of the gameplay.

In this chapter, *Broken Dimensions* was introduced as the game used to gather data for this thesis. The game's central mechanics of rotating the world to reach the exit or indirectly manipulate objects were explained, and the level structure was broken down into acts based on narrative developments and introductions of new mechanics and obstacles. The development of the game was summarised with a focus on the role of the game designer and those aspects of the work that were relevant to game feel and level design. Then, the importance of space in *Broken Dimensions* and the players' deliberate manipulation of it was analysed, with special attention paid to the first two levels, and an explanation of why these levels were chosen for the tests. The following chapter will describe the process of modifying the selected levels for the purpose of exploring the importance of the game world on players' feeling of movement in a game. The chapter will also describe and discuss the methods used for the tests proper.

5. Methodology

Unlike certain aspects of game feel outlined by Swink, context has no solid, objective metrics. While input can be analysed by comparing vectors and dimensions of the game controls to their effects in the game and response can be measured in relation to the speed of human perception, context is described in much more subjective and vague terms, using keywords such as "impression" and "conception". In order to thoroughly examine and define players' experience of kinesthesia in a video game, qualitative methods provide the most useful results.

Qualitative methods have several advantages over quantitative research in this regard. Allowing interviewees to have a conversation with the researcher suggests that the material obtained will be closer to the reality of the interviewee's life and gives the interviewee some control over the direction of the interview, which reduces the risk that the researcher's preconceptions set the agenda. Furthermore, the respondents' feelings and experiences can be explored in ways that go beyond traditional categories. If the method involves elements of observation, the researcher will be able to directly gather information about what the subject does instead of having to rely on their own descriptions and explanations of their actions, which reduces an important possible source of error (Davies, 2007: 140).

A disadvantage of qualitative research is that the results tend to be less broadly applicable. Though the reliability of statistical evidence is disputable, a study of 10 participants is intuitively less representative than a study of 1000 or even 100 participants. To improve upon the applicability of the results, the core sample studied can be selected to cover a wide range of relevant factors such as demographic or experience – in games research this might involve selecting participants covering the whole range of player skill from "newbie" to "professional". However, in selecting the 10 participants for this project, the goal was to only use experienced players who are used to discussing games and articulating their play experiences. Though this goal has been fulfilled, the diversity (particularly demographically) of the core sample has suffered, and care must be taken not to draw too broad conclusions based on the resulting data.

Ten tests have been conducted with different volunteers. The volunteers all have a common background in game studies, so do not represent an "average player", if such a person exists. Rather, the subjects have been chosen for their presumed ability to analyse their own play experience and verbalise it after the fact, and though their skill levels vary considerably, they should all be considered "hard core" game players. The participants were all males ranging from age 25 to 30. Three testers were Danish, two were Italian, and the other five testers were Indian, Maltese, Spanish, Greek, and French, but the tests were all conducted in English. The most significant difference in terms of how the tests and the interview were approached by each participant turned out to be according to their game development discipline: designers seemed to have one general perspective, while the programmers had a somewhat different approach. Four programmers participated, while six participants were of the design persuasion.

This chapter is divided into two sections: one describes the methodology of the tests themselves, how they were set up and what qualitative research tools were used to gather data during the tests, and the other describes the approach taken to interviewing the participants about their play experience after the fact.

5.1 The tests

Two tools were selected for gathering data based on the test levels: observation/think-aloud and interviews. Observation and think-aloud are very useful for collecting data about how test subjects conduct themselves in a certain activity or situation. This method originated in the field of ethnography, where it normally entails assuming a role other than that of a researcher within the environment or situation to be studied (Davies, 2007: 170). This project uses a more simple form of observation more common within the HCI field, where it simply means to observe how a subject interacts with a system. The advantage of think-aloud over pure fly-on-the-wall observation is that it provides further insight into the conscious thought-processes of a test subject.

The main potential problem with the think-aloud method is that having to narrate their thought processes while playing (concurrent think-aloud) can be experienced as stressful by the participants, which can disrupt the play experience, skewing the results. The alternative is retrospective think-aloud, where participants are recorded while playing and later watch the playback and verbalise the thoughts they had when playing (Hoonhout, 2008: 68). Due to time concerns, concurrent think-aloud was used for this project, at the risk of interfering with the play experience. Since the levels used for these tests include no time limits and few dangers, and all the test subjects are asked to play through the basic version of each level before the test begins, to ensure their familiarity with the layouts and puzzles, the risk is acceptable. The tests were conducted in a small, empty university computer room – chosen for being a convenient setting relatively free of distractions. Though the interview wasn't expected to stray into highly personal or emotional territory, it's also a benefit that the room was quite familiar to all the participants (Davies, 2007: 154).

The tests have been conducted with four different versions of the first two levels of *Broken Dimensions*. These two levels were chosen for their comparatively complicated spatial structure: whereas most of the game's levels consist of just one or two rooms, the tutorial and the first puzzle level have layouts that require several rotations of the world to navigate and where it is impossible to see the entire level from any single vantage point. Further, the puzzle aspects of both these levels are fairly simple, making them well suited for the test's focus on the sensation of basic movement through the game space. In addition to the original version of each level (labelled "Mod 0"), which has been used as a baseline, the variations are thus:

- **Mod 1:** Every room and hallway has been "lengthened" by a factor of 4, which is to say the size of the room has been quadrupled only along the axis that the player must travel to reach the exit of the level, preserving the optic flow (Fig. 31).

- **Mod 2:** A large number of small obstacles have been placed in the player's path in such a way that it is often (but not always) impossible to simply "fall" between the obstacles by rotating the world, without weaving between the obstacles (Fig. 32).

- **Mod 3:** A small number of large obstacles have been placed in the player's path in the same manner as the smaller obstacles in Mod 2. Each obstacle is four times as large as in Mod 2. Mod 2 and Mod 3 account for the number and size of objects in the game world, two major parameters of medium-level context (Fig. 33).


Fig. 31: Level 2 Mod 1.


Fig. 32: Level 2 Mod 2.


Fig. 33: Level 2 Mod 3.

Each test subject was first asked to play through Mod 0 of both levels in order to ensure that they were familiar with the layout of the level and the solution to the puzzle. Then, the subject was asked to complete the modified levels alternating between the tutorial (L1) and puzzle 1 (L2). The order of the variations was changed from subject to subject and from level to level. The specific variation sequence for each subject is thus:

Participant	Level sequence					
Participant 1	L1 M1	L2 M1	L1 M2	L2 M2	L1 M3	L2 M3
Participant 2	L1 M1	L2 M1	L1 M2	L2 M2	L1 M3	L2 M3
Participant 3	L1 M1	L2 M2	L1 M3	L2 M1	L1 M2	L2 M3
Participant 4	L1 M1	L2 M2	L1 M3	L2 M1	L1 M2	L2 M3
Participant 5	L1 M1	L2 M2	L1 M3	L2 M3	L1 M2	L2 M1
Participant 6	L1 M1	L2 M2	L1 M3	L2 M3	L1 M2	L2 M1
Participant 7	L1 M1	L2 M3	L1 M2	L2 M1	L1 M3	L2 M2
Participant 8	L1 M1	L2 M3	L1 M2	L2 M1	L1 M3	L2 M2
Participant 9	L1 M3	L2 M2	L1 M1	L2 M3	L1 M2	L2 M1
Participant 10	L1 M3	L2 M2	L1 M1	L2 M3	L1 M2	L2 M1

It's difficult to say how the results might have changed if the participants had played the same variations of both levels in a row, or indeed if all variations of the same level had been played back to back before repeating the same pattern with the second level. Ultimately, the more common technique of randomising the pattern was used in order to ensure that the results were independent of the order of the levels. Furthermore, by alternating between levels as well as modifications, more of the focus was shifted from the basic level layout to the variation type.

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It is necessary to note that important aspects of the game are inadvertently being varied despite not being deliberately tested, and may affect the aspects of the play experience at the heart of the test. For example, different objects cast different shadows, which may subconsciously influence the player's perception of the game space. The camera may act differently with more obstacles in the game to alter its path. The game may even suffer reduced performance when levels are larger or contain more objects to render. Care was taken to reduce the impact of these factors, and the test subjects were asked to comment on *any* aspect of the game that they feel was influencing their experience while they played.

5.2 The interviews

After the tests, each tester was subjected to a semi-structured interview. Interviews are very useful for collecting different kinds of data, but they have many possible sources of error. The greatest danger of interviews is that the phrasing of the questions and the manner in which they're asked (including every detail of the interviewer's attitude and disposition) greatly influence the answers. To reduce this risk, care has been taken to avoid value judgments in the questions, and the semi-structured interview type was chosen to allow the interviewee to exert almost equal control over the direction interview.

Another potential problem is that all the participants were aware that the interviewer had personally created the test game, which may have led them to omit negative feedback or exaggerate positive responses to please the interviewer. Fortunately, the thesis does not concern itself with whether the participants enjoyed or disliked certain aspects of the experience, but rather how the nature of the experience changed between the level modifications, so any people-pleasing bias of the participants' part should not be a problem. The final major concern is that the interviewer was very similar to the participants (both demographically and in terms of experience with the subject), which made it extra important that the interviewer approached the exercise as though he knew nothing and kept an open mind to interpretations and patterns that differed from his own expectations (Davies, 2007: 157).

The semi-structured interview uses a pre-written list of questions which is helpful in ensuring a degree of standardisation in the topics covered across several different interviews. Unlike a strictly structured interview, however, the semi-structured interview leaves room for answers to branch off into new directions if interesting new questions present themselves during the interview. The interview was structured with the most open questions first, allowing the tester to present their immediate thoughts and opinions with minimal influence or direction from the interviewer, followed by increasingly closed questions to extract certain important information (the questions can be found in *Appendix A*).

When structuring and processing the data collected from the interviews, key words and recurring phrases will be identified across all the interviews and sorted together to illuminate general themes and tendencies. This will be used to discuss various ways in which the modified qualities of the test levels may change the kinesthetic perception of the player.

5.3 Hypotheses

Thanks to the literature and the game analyses, some hypotheses can be formulated for what sort of results the tests are likely to produce. In general terms, the differences to the player's kinesthetic perception in the test levels are expected to be less noticeable than the differences produced by similar changes in the analysed games with context-sensitive movement mechanics. Enabling or disabling the mechanics depending on the context will tend to have more obvious effects on the game feel than simply tweaking the way each of those mechanics feel to use. Nevertheless, some changes to the game feel between the level variations should be noticeable, and some hypotheses can be established for how the feel will specifically change.

The longer level versions are expected to make running and jumping feel slow and boring, while increasing the sense of velocity and momentum when falling. Without rotating the world, players have to run longer to traverse each area, which is expected to make the avatar feel slow and cumbersome. As the rooms will be just as empty in this version as in the baseline, the frame of reference for the avatar's movement is quite simple, which may add to the feeling of slowness, and the player will be able to cross each room in a straight line, which should make it feel boring and detached. Players will probably want to rotate the world and fall through levels instead of just running – as the rooms have only been enlarged along the axis of movement, the surrounding walls will still be fairly close when falling, which should maintain the player's sense of speed as the walls zoom past the avatar. The longer drops are expected to create a sense of greater momentum. For players who don't enjoy the sheer vertigo of great falls, however, this level type offers less stimulation than the next two versions, as there is nothing to do here while falling other than enjoying the view.

The levels with many small objects may make the players feel clumsy and confused. The cubes disrupt the players' movement paths, forcing them to move along uneven, inefficient routes. When running and jumping, the player should feel slightly out of control, as their movement is very much constrained by the environment. The width of each object will be shorter than the avatar's jump, and the jumping will not be specifically calibrated for platforming, which may make it more difficult and less satisfying to jump from cube to cube. Weaving between the cubes while falling is expected to be at its most difficult in this version, but the players should have enough air control that accurately weaving between cubes is possible and may feel quite satisfying. As the rooms are full of obstacles, they should seem more cramped than in the original version, and it is expected that the avatar will seem faster in this version. The cubes in this version are smaller than the movable boxes, which may make them feel large and clumsy compared to the empty version. The high density of small obstacles will make the boxes move more erratically, making them harder to control. Apart from affecting the player's sense of kinesthesia, the cubes obscure the level structure, making it harder to navigate, and the camera may behave a little skittishly around intricate obstacle structures, which may be annoying or confusing.

The versions with fewer large objects should make the players feel more in control and facilitate better mastery of the avatar's different movement methods. The many large cubes will be arranged to obstruct direct fall lines from the entrance to exit of each room, so some weaving is necessary but not too difficult if the players wish to move as fast as possible through the levels. In some rooms, particularly in the puzzle level, the cubes will necessitate more world rotations than even the version with the smaller objects, but the effects of the cubes on the movement of the falling boxes will be easier to predict in this version - this is expected to make the player feel more precise and calculating, as it encourages and rewards planning over trial-and-error. The cubes will be scaled to match the jump distance of the avatar reasonably well, and their large surfaces make them easy to land on, which should make platforming less frustrating and more satisfying. The cubes are large enough in this version that they may seem like part of the fundamental room shape, in the same way as the walls, which may make navigation significantly harder.

6. Results

The two primary dichotomies that emerge from the think-aloud notes and interviews are running vs. falling and platforming vs. weaving. Running and falling are the two different types of movement in *Broken Dimensions*. Distinguishing between running and falling comes down to the player's use (or lack of use) of the game's world rotation mechanic: traversing a room horizontally is running, traversing it vertically is falling. Jumping on top of objects and then falling down off them again while running across a room is still considered running – turning the world around in such a way that the destination is downwards, and then dropping from object to object, running to the edge of each platform before falling to the next is still considered falling. Thanks to the very simple layouts of the test levels, this distinction is easy to make.

Platforming and weaving are this paper's terms for two different possible movement patterns while falling: landing on the intermediate objects on the way down or using air control to weave between the objects without hitting them. On a per-object basis, these are mutually exclusive (the player cannot land on an object and also avoid the object), but it is very possible to mix the two patterns while traversing an area (landing on some objects but avoiding others). It should be noted that platforming can also be used to describe jumping from object to object while running, and indeed some participants have used the word in this meaning.

Another section has been dedicated to the players' interaction with the movable boxes and the breakable wall. Movable boxes appear in all test levels, but are a critical part of completing level 2. In the test, they serve as an example of indirect interaction, as their movement cannot be directly controlled by the player, but must be influenced in broad strokes by rotating the world, effectively changing the direction of the gravity in relation to the environment. This allows the tests to cover some important questions about how changes in the game space affect the feel of the motion of objects that aren't under the player's direct control.

The final section of this chapter will account for three major tangential issues and side effects of changing the game environment. First, level 2 features a deadly spiked wall that falls towards the player if the world is turned the right way – will this seem more or less threatening if it has more time to chase the player, despite the fact that it always falls at the same speed as the avatar? Secondly, the third-person camera is scripted to zoom in or out as it's moved around, in order to avoid colliding with or being obstructed by obstacles – how will higher obstacle density affect the camera's motion, and will this interfere with the game feel? Last but not least, navigation is an inseparable part of level design, and major alterations to the game world are very likely to change the process of navigating it – how does this influence the player's perception of movement within the game?

6.1 Running vs. Falling

Overall, running was experienced as safe but slow and boring. In Mod 0 and Mod 1, players had to hold down a movement key for extended periods of time without anything else happening, which was seen as a lack of meaningful interaction. Interestingly, this was somewhat less of a problem while falling. Falling was experienced by most as fast and satisfying, especially in the extended corridors of Mod 1, but some saw it as slightly dangerous. In the Mod 2 and Mod 3 levels with obstacles to manoeuvre around, some players found that running became more enjoyable than falling: jumping from object to object to reach the exit was more satisfying than simply rotating the world and falling to the exit, and in some cases it was even perceived as faster or more immediate to run and jump past obstacles than to rotate due to the animation delay built into the rotation mechanic. Two major criticisms came up with the jumping when obstacles were involved: the length of the jump (input/response) was not calibrated to fit the distance between the small obstacles (context), resulting in participants often "overshooting" their target, and the camera restraints as well as the lack of a drop shadow made it difficult to judge where the player character would land.

The most common adjective used to describe the running overall was "slow", or synonyms for slow. "Running is a bit slow, but he's a kid so that's okay" (Participant 5). Especially in contrast to rotating the world to fall through the rooms, most participants found that they preferred falling because it was faster and more efficient: "Like when he has to walk a really long distance and it takes forever, that's annoying" (Participant 9). "In the very last level where you know you've finished the level and you just have to go to the end, but if you jump you're maybe gonna die [because of the spiked wall]. It seemed a little slow that you had to walk him all the way down there. So that's the only time I felt he's kinda slow, most of the other times you move around by rotating or jumping" (Participant 10).

6.1.1 Lack of interactivity

The most important difference between how the level modifications affected the feel of running vs. the feel of falling turned out to be in how interactive each movement type was perceived as and how the players dealt with that. In simple terms, adding more obstacles to the game space increased the amount of input required for basic movement no matter what type of movement was used. Less input required was usually experienced as less interesting, though the interviews found that having to hold down a button to move across a long, empty expanse was typically seen as adding injury to insult. Some participants managed to find something to enjoy in simply falling through empty space, whereas others invented small goals for themselves to give their input while falling some purpose. Not all players enjoyed navigating a space filled with obstacles, but the general consensus was that the same distance feels longer when there is nothing to do along the way.

Fig. 34: Long periods without meaningful interactivity is universally regarded as boring.

As expected, when the distance was increased in Mod 1, running became even less attractive compared to falling. Explicitly confirming perhaps the most clear and intuitive point that Steve Swink (2009) makes about the context of game feel, Participant 1 explained that the avatar felt slower in Mod 1: "it takes more time to do the same space that you actually do. It's like, that's physics. If you're in a car on a highway going straight, you feel slower than if you're in the same speed on a street full of curves. It's physics, man." Many participants played through the Mod 0 levels without rotating except when they couldn't reach an exit, but then started rotating and using falling as a form of basic movement once they were subjected to the longer corridors of Mod 1. "The run speed is fine, unless you have to run through all the corridors" (Participant 7). "In the corridor thing it just felt really slow" (Participant 9).

Participant 1 played through L1M1 and most of L2M1 before realising: "Oh is it faster this way? Now I'm gonna fall forever."

Some participants pointed to the lack of meaningful interaction when crossing long distances on foot: "[The problem with walking is] that it takes a while. Just pressing one key, there's no interaction, there's nothing going on. [...] There's too much waiting. [...] There's some interval in there where it's not a puzzle game, there's nothing... it's just empty area" (Participant 3). "You should never make players walk places, there should always be stuff to do" (Participant 6). When obstacles were added, running became interesting again as to navigating around them required constant input and constant micro-choices about which way to go around an obstacle: "Small blocks are nice. I like more interaction, more platform elements" (Participant 7). Participant 3 even felt that running felt faster when there were obstacles: "It doesn't feel like you're fast, but it feels like you're faster than the one with the long walks." He also noted a higher amount of interactivity in the basic movement through environments with higher object density: "I like the one with the big boxes because there's more interaction" (Participant 3). Obstructed movement requires more input from the player, which in *Broken Dimensions* is experienced as more engaging by some players.

Interestingly, however, the lack of interaction in empty corridors only seems to be a problem when walking, possibly because a key must be held down – when faced with L1M1, Participant 4 exclaimed "This is a long way I have to go. Too much." In the interview, he extrapolated: "The first level that I played which was long corridors and was like 'oh this is stupid I have to run for so much time!' and then like 'hmm maybe there's an easier solution' and then I could play with it much better because of the long spaces and no virtual danger in the level." Participant 8 similarly started out running through L1M1 ("I'm walking much more than the first one.") before rotating to fall through the last rooms of the level ("I should have done this from the beginning.") Later he said: "In the beginning I saw the long corridors I thought 'oh my God I have to walk this long distance', then I thought 'why am I walking? I can just rotate the room and drop down', it was much nicer."

6.1.2 The pleasure of falling

Watching the avatar traversing a long corridor without having to touch the keyboard at all is apparently more acceptable than having to hold down a key to run – though falling *is* faster than running, something else must be at work. Several participants pointed to the automated nature of the falling as a reason for enjoying it: "It was a bit spectacular. I guess it looks like a bit of an accomplishment, like you did something and you're going the right way, and that's that you're not pressing the button to walk it's kind of what you want, maybe" (Participant 8). "I could rotate and I knew where I was gonna land. Falling down is a faster means of travel so I don't have to do anything I just watch my avatar go to his location" (Participant 4). It's possible that no interaction is simply more acceptable than pointless or uninteresting interaction, but it may also be due to the feeling of surrendering to gravity, allowing the avatar to fall freely towards the destination, which can be traced back to Caillois' concept of Ilinx (2006).

Indeed, some participants pointed specifically to the feel and the momentum of the falling through the extended corridors of Mod 1 as their reasons for preferring this type of movement: "I think it feels really good. The controls are smooth and the kinaesthetic feeling of floating and everything feels really, really good." "Like I said before I really enjoyed the long level, but if that was every level I would definitely probably begin to find it a bit tedious because then you know this is how the game is" (Participant 10). "Yeah it has the highest momentum. You feel like more is happening when you fall, you progress more" (Participant 2). Participant 2 went so far as to ask whether the movement speed was increased in Mod 1: "I think it gave a sense of higher momentum, falling in the long versions, because more rushes by you." This can probably be attributed to the preservation of optic flow due to how the game world has been extended only along the axis of movement.

Participant 7 apparently derived no satisfaction from the speed or the automated nature of this form of movement: "If you have to run, it's boring. But even if you had to fall down, I don't feel this excitement of falling down." However, by setting small goals for himself, namely attempting to hit the candy pickups on the way down, Participant 7 found something to enjoy in falling through the regularly sized corridors: "When you fall down, it's perfectly fine I think. It's kind of fun I think, you can aim for the candies so you're not just going down like a rock; and you enjoy it." The important thing to note about these remarks is that rather than override or replace the kinesthetic sensation of falling, Participant 7's self-imposed goals and challenges apparently enhanced that sensation to the point where he enjoyed it – he needed a challenging purpose in order to enjoy the feel of falling. A similar observation was made by Participant 6: "Yeah I was trying to get the candy on the way down but I completely missed it." When asked whether he then simply rotated and walked over it, Participant 6 replied: "Oh no I just forgot about it, I was like 'whatever'." Why would some players go out of their way to pick up the candy while falling, but show no interest in walking back to pick it up if they miss it? It must be the combination of the falling motion and the goal of hitting the candy that engages them.

6.1.3 Input/response and context

When obstacles were introduced, most players made far less use of the rotation mechanic to move through the levels compared to Mod 0 and Mod 1, instead jumping from obstacle to obstacle to reach the exit. Describing his experience with L1M2, where there were no movable boxes to manipulate, Participant 9 said: "there was no big block or anything I just have to navigate my way through the small blocks; the jumping seemed to fit even better. It was just perfect because then when I was falling down slowly I could just look around, the jumping was perfect, it was really good." Whereas the basic jump has no real purpose when there are no obstacles, in Mod 2 it can be used to jump from object to object instead of falling.

This lead some of the participants to criticise the player character's jump distance in relation to the obstacles: "You have this really, really long jump even though you have to just jump on another platform, so sometimes it's annoying because you miss this platform, or it's annoying because it just takes too long to move from one platform to the other" (Participant 7). "[The jumping is] longer than you expect it to be; I didn't mind it but sometimes I did get into a little bit of trouble by jumping up a box and he would actually jump over it. But I do enjoy how you kinda jump and then you control it in the air, which is also quite smooth" (Participant 10). "I think the jump leaves something to desire in the game. The air time is a bit too long and the jumping is not really Mario fun" (Participant 2). The player character in Broken Dimensions jumps many times the width of each of the objects added in Mod 2, which means the players must "feather"[6] the forward move button to land where they want to. The thesis expected that changing the

[6] Press and release the key rapidly to adjust the distance of the jump despite the binary nature of the keyboard input.

context without adjusting the game controls would be problematic, and these results confirm that the way the game responds to player input must be carefully calibrated against the context, or vice versa.

It stands to reason that circumnavigating small objects requires more detailed control than traversing large, empty spaces, and apart from the challenge of falling into the exit with a wall of spikes chasing you at the end of Level 2, it never matters precisely where you're landing in Mod 0 and Mod 1. Once the rooms were full of smaller or larger obstacles, many players commented on the lack of precise control or the difficulty of determining precisely where the player character was located in the three-dimensional space: "It was safe, mostly, but not precise" "I would like, as I said during my play session, some sort of 'shift' button to slowly move over the edge so I can see where I'm going and be more careful in movements at some point, because I could see it was a dark level and it might be dangerous in terms of things falling down, but I couldn't really be careful with my avatar" (Participant 4). "There's something about the jumping that's weird. It's a bit hard to tell where... uhm..." [Where you're gonna land?] "Yeah" (Participant 6). One player suggested adding extra polish in the form of a drop shadow: a simple circular shadow that would always appear directly beneath the avatar. "The upwards motion is fine, but the landing is a bit slow and it's hard to show where he's gonna land. Maybe if he had a shadow that would indicate where he'd land, it would be easier to use it as a way of completing the level" (Participant 2).


Fig. 35: Navigating obstacles demands more input.

Not all players noticed a considerable difference between the movement of the avatar with or without obstacles: "It doesn't make that much difference whether you're falling or walking through the big stuff" (Participant 1). One outlier even preferred unobstructed movement: "one of the things I enjoyed was the movement through space, and you didn't have a lot of that in that level [with the obstacles]" (Participant 10). Overall, however, there was a definite observed difference between how most players moved in Mod 0 and Mod 1 (turning the world to fall across long distances), and how they moved in Mod 2 and Mod 3 (jumping from object to object instead of rotating the world). Some players saw the higher object density as enabling new movement patterns, similarly to how adding more handholds to a wall in *Assassin's Creed: Brotherhood* would create more paths for the player to take, while others found the opposite: "I didn't feel any difference on my character [in terms of] its parameters such as in this level I can run faster or something like that. Some constraints because of the environment, because of the boxes, more obstacles to pass around; like the two final levels I felt more constrained from the environment, if I wanted to take one object and move it to one place I had less options, it was more difficult" (Participant 8).

6.1.4 Perceived danger

Of further note are a few comments about the perceived danger of falling as compared to running. Participant 5 was concerned about potential dangers below that he might not be able to avoid falling into: "When you're falling it feels a little bit unsafe, and you have so much air control but you might still be falling onto spikes or something, so you don't really know." This didn't stop him from falling as his primary mode of movement, however, unlike Participant 6 who preferred running until he realised that the player character takes no damage from long falls: "It felt like he was going too fast, and he was gonna get squashed when he landed, under the force of his own fall. So it was like oh no am I gonna make it?" Participant 6 believed that he would refrain from falling if more dangers were added to the levels, such as spikes: "because I'm a conservative player, I wouldn't fall and try to avoid the spikes, I'd just rotate it and then just walk down instead I think." Of course it should come as no surprise that altering the rules (in this case to make falling more dangerous) can cause players to change their movement patterns, but it's interesting to note that some players might select a less exciting or expedient method of movement if it's safer than the faster alternative.

6.2 Platforming vs. Weaving

The objects added to the test levels in Mod 2 and Mod 3 can equally be regarded as obstacles or as platforms on which to land when falling through a level. Almost all players viewed them as obstacles and preferred to weave between objects. While some participants focused on the speed and efficiency of uninterrupted falls, others appreciated the playful satisfaction of using the player character's high air control to manoeuvre around obstacles, even going so far as to invent their own spatial challenges to imbue their falling with purpose. A general tendency was observed in players being more prone to platforming in Mod 3 where the objects were larger, either because they were easier to hit or because they were more difficult to see behind. This was in spite of the fact that the lower density and greater distance between the larger obstacles makes it significantly easier to avoid them than the smaller and denser objects in Mod 2. Apparently the speed and fluidity of motion achieved by weaving makes its difficulty worthwhile.

6.2.1 Spatial challenges

It wasn't just in Mod 2 and Mod 3 that weaving was observed – some players aimed very deliberately for the exits when the corridors were extended in Mod 1; said Participant 10: "I think these long falls are very cool, especially if there's something to aim for below." He later extrapolated on this: "There was a few areas where you had a big distance you were jumping and then you could see one of the candy wraps somewhere in the space, and it felt good to try to go in through a narrow space to hit them." Participant 2 referred to weaving as though it were mandatory when faced with the long empty corridors of L1M1: "Whee--! [misses the exit] Ah, damn! Cool modification that you have to fall through the hole." The especially remarkable thing about his choice of words in this context ("have to") is that this was said right after Participant 2 had failed to fall directly into the exit, with no negative consequences, and yet he still spoke about this self-imposed goal as though it were intrinsic to the game, so strong was his compulsion to choose a target to aim for while falling.

Again the greater degree of interaction, the greater frequency of input required to fall around obstacles seemed to be a major factor in its appeal: "it seems different because you don't just fall down and wait, you have to move also your character in the air, so you do something else, not just waiting for the character to get to the floor and then change again" (Participant 3). When asked whether he thought this made him feel more or less in control, Participant 3 replied "more in control. I think it's funny actually to get the candy on the way, flying. Trying to reach." Emphasising that the choice between weaving or platforming was entirely an aesthetic matter, Participant 1 said: "I prefer to try to fall between them. […] There's much more satisfaction, the feeling of falling is much more satisfying than landing and jumping again. But it doesn't add anything to the gameplay, it's just a way to move around."


Fig. 36: Weaving between obstacles towards candy.

The pure enjoyment of aiming for something and either hitting or missing it came up in most of the interviews: "maybe it's something in your brain just that hitting something that you're aiming for, especially if there's a candy wrap or something, if you hit it, it just feels good – it's a good feedback. Also if there's something chasing you and you just make it and it doesn't smash you, it feels really good. That's why it's also annoying to hit the edge" (Participant 10). "I like this feeling of falling and also avoiding the obstacles. It felt like a race somehow; and I could navigate myself while I was falling and reach the bottom without reaching other levels before" (Participant 8). "It presented a different challenge within the game, I made the challenge-- or I tried to fall through all the holes and just avoid stopping basically, and that was a bit… it was almost a free level with the mechanic" (Participant 2).

6.2.2 Efficiency of movement

Participant 9's first description of weaving focused on the basic enjoyment of it: "it is fun, in the game it's kind of that whole thing, floating down and choosing the right direction, I think that's really fun." Upon further reflection, however, Participant 9 added that his wish to optimise his movement speed also factored into it: "but I was also trying to go further and further really fast." Unlike most other players, who preferred the increased interactivity added by the obstacles, Participant 9 didn't believe he'd enjoyed weaving around objects more than falling through the empty corridors of Mod 1: "I like both. I think the falling was really fun, both ways so even like avoiding stuff, and even just like - even seeing the acceleration, it was always interesting."

Speed and efficiency was also the reason Participant 9 gave for jumping from object to object instead of simply right-clicking to rotate the world and falling to the exit: "it seemed to me like the fastest thing because when I press the right click thing it is a bit slow [...] that's why I started running and jumping because I found it easier." This was echoed by Participant 6: "Yeah I guess it was because it was more immediate, I'm more used to doing that." Rotating the world is almost certainly the easier option, as falling down from an object may require players to repeat their last several actions if they don't simply turn the world around, but these players seemed to put a lot of emphasis on the animation delay that occurs when transitioning in and out of rotation mode, as Participant 9 described the jumping thus: "just really, really fast, and I'm all about finishing it quickly in puzzle games, I think most people are."

Two of the participants quite simply didn't see any reason for landing on the platforms on the way down: "In the beginning I did it more just to see… because also I didn't properly understand that you wouldn't fall into something and die unless there's a box after you, so you might as well just see it to the end. I really enjoyed the kinesthetics and the controls of it" (Participant 10). "Yeah well I don't see anything dangerous at the bottom so I just go down; and the exit is always at the bottom, they don't stick out in the middle, like there could be an exit or portal in the middle of the room that you would have to see from the top, but here the exits are always at the edges of the world, so you could always operate just by going all the way to the edge" (Participant 5). Such culling of actions that have no perceived purpose is another kind of efficiency – Participant 10 and Participant 5 saw no explicit reason to land on the platforms, so they weaved around them instead, even though this required more input from them.

6.2.3 Difficulty

Players were observed to land more often on the large platforms than the small ones. One explanation given for that was the difficulty of hitting the smaller objects and not falling off: "I just wanted to do min-maxing on my movements, and then it was like 'okay I get stuck on the small ones, I'm not sure', and then it also happened that I couldn't pass through a couple of them that I thought the collision wasn't right on, I might as well avoid them, so then I just went through them. I did the same with the big boxes as well at times, but they were more convenient to jump around on" (Participant 4). "Some of the platforms you attempt to land on were too small sometimes" (Participant 2). "Definitely the big platforms are easier to navigate than the small ones, but that's of course logic. I'm not saying you couldn't have platforming levels in it, but I'd definitely give people a little more space than the small boxes to navigate on" (Participant 2).

Participant 4 explained that he preferred platforming on the big boxes because they obstructed his vision, making it hard to tell if anything dangerous was beneath them, whereas the smaller boxes were easier to see between but harder to land on: "The small boxes were much more tedious, because you have to jump again and again so the bigger boxes were better for platforming because like I pointed out I could not see what was down there, and it was just better if I tried at times to just jump from another one to get a better angle of view what I was getting into. So it was better in terms of platforming if you wanna call it that to use the bigger boxes than the small one because you had to push jump too many times, plus the character speed is not guaranteed to land you on the one that you wanted to go to because at times they were too far and then I would try to jump at the small one and then I would overshoot."

Though Participant 7 avoided the obstacles because he didn't find a reason to land on them most of the time, he would occasionally use the big objects as intermediate stops where he could orient himself and locate any nearby candy: "I tried a couple of times to land on them, but… I think I could make it without. I didn't see the point of just landing. There was a candy to get, so it was just, 'okay it's here I will just take a look and then re-rotate', when there was candy or some other thing to do I would pay more attention." This was also the reason Participant 6 gave for favouring platforming over weaving: "I see them as platforms to use as… platforms. For avoiding getting squashed by the falling cubes, and to stand on them so you can look around and then move to another one and look from there; things like that."

The fact that players would land on the large boxes but avoid the small boxes seems to imply that some of the players chose to deliberately weave around obstacles because they weren't confident that they could consistently land on them. Nothing in the interviews gives a clear reason for why this might be, but a possible explanation is that players wish to set micro-goals for their own movement and then achieve those goals, and if they find that achieving the goal of landing on a certain object is frustrating or annoying, they will choose the alternative goal of consciously avoiding objects rather than surrendering to randomness.

6.3 The boxes and the breakable wall

Some players found that their interactions with the moving boxes were improved by the greater distance that they had to fall. One tester pointed out the greater bounce of the boxes hitting the floor as his reason for enjoying it. Another was nearly crushed by the falling boxes on several occasions, which he found to be particularly exciting. No players thought the increased fall distance did much for the feel of smashing through the breakable wall - the lack of any change in the sound effect was brought up as a reason for this.

The most significant difference between Mod 0 and 1 and Mod 2 was in the players' interactions with the moving boxes. As each cube in Mod 2 was about half as big on a side as the falling boxes, and the cubes were placed very erratically, the boxes would tumble and turn very unpredictably through the obstacles. This caused much more trouble and annoyance for some players than for others, but almost nobody actually enjoyed it - those who observed the obstacle placements and planned a route for the boxes were no more effective than the one tester who consistently (in his own words) "rattled" them by turning the world back and forth between two positions until the boxes were clear of the cubes.

The only really positive thing said about the task of manoeuvring the boxes to the breakable wall in Mod 2 was that it forced you to pay more attention to the boxes, because they might more easily crush you, but at the same time could be used as cover from the falling boxes if you were paying attention. One tester even stated that he felt safer from the boxes in Mod 2 because the small cubes were almost always in the way of him getting crushed. Some testers did acknowledge that the randomness of the movement of the boxes through the cube patterns could appeal to a certain type of player, and one player noticed that the randomness was in fact a benefit in getting rid of the obstructive box in the first level.

General consensus was that the breakable wall puzzle was more involving and rewarding in Mod 3 because the large cubes affected the moving boxes in far more predictable ways than the small ones - as the stationary cubes in Mod 3 are much larger than the moving boxes, they rarely cause the boxes to rotate on impact, and the boxes rarely hit the cubes at odd angles. Furthermore, the obstacles immediately in front of the breakable wall had been carefully arranged to require at least four rotations to get the boxes through to the wall, which most players perceived as a worthwhile extra challenge. This was described by some testers as making you feel more closely attached to the movement of the boxes. A few players did not appreciate this type of challenge, however, and experienced the added complexity as pointless busywork and annoying obstruction of their progression. A couple of players did as expected remark that the very short distance that the boxes can at most fall before hitting the wall made the wall seem quite flimsy and weak, but most players understood that the breaking wall worked by means of a binary trigger, and so did not particularly perceive a difference in how it felt to break the wall.

6.3.1 Threat and unpredictability

In addition to being a tool for the player to complete the second level, the boxes added an element of danger as they could crush the player character when they hit him. This didn't seem to concern most of the players much, but it did come up in a few of the interviews: "there's that little bit of fear of the boxes hitting you" (Participant 10). Participant 9 seemed to enjoy the thrill of it quite a bit, always keeping track of where the boxes were in relation to his avatar, and exclaiming loudly every time they were close to hitting him: "It just slammed in next to me I was like 'OH GOD!' But maybe I'm a very aware player because I was looking around *for* the boxes, and stuff like that, which makes it more fun for me." It was clear that this element of danger was substantially reduced when more obstacles were added to the game world: the participants were crushed much less in Mod 2 and Mod 3 than in the other level types, perhaps partially because the obstacles forced the players to pay more attention to the moving boxes, but also because the obstacles served as "cover" to shield the player character from the moving boxes: "It's safe to get the box out safely because I can take cover behind the cubes" (Participant 4).

6.3.2 Interactivity of indirect control

Just like how the obstacles were perceived to add more interaction to the movement compared to the empty corridors, similar feedback was received in relation to the moving boxes: "I like the one with the big boxes because there's more interaction" (Participant 3). "I felt more interaction with the small boxes" (Participant 7). Whereas the increased interaction in the basic movement was about having to adjust your direction more often, here it manifested as a necessity to rotate the world more times to get the boxes where they needed to be: "the big blocks didn't fit easily between the small ones so you had to spin the world a lot of times in order to get them to the obstacles" (Participant 1). "There was one where I had to twist a lot of times to get it aligned to a small hole to get it past, the big cubes. But that was okay, I knew exactly what I had to do, so that was actually pretty good" (Participant 5).

To Participant 4, this increased interactivity meant he had to exert greater control over the movable boxes, making the otherwise indirect control that he was given over them somewhat more direct: "The third one that I did was more like I was carrying those boxes myself, I was guiding them to their destination by doing many actions because I had to rotate again and again and again. […] The first one, it was more that I would see where I was going, and then it would turn out the boxes were doing the right thing. I didn't even notice them." This goes quite contrary to the expectation that the unpredictable movement of the boxes would make them feel more out of the player's control: "you can say more chaotic. But less control? No. The right way to put it was I was more constrained" (Participant 8).

Participant 1 enjoyed the challenge and even preferred it over the much more predictable obstacle course formed by the larger objects: "In the small one there was more points to block for the obstacles, that made it way more entertaining than the big one because the big ones were like five or six [turns] I guess for the long run, and once you spin 5 times it's fine. You get stuck a couple of times in a physics way, it was not as enjoyable as the small one." Most players, however, found the difficulty and unpredictability of manoeuv-ring the movable boxes through the small obstacles tedious: "the big boxes were definitely an improvement because there was less wiggle space where you had to wiggle the box through. [...] it was less fiddly and less tedious" (Participant 2). The cause of this tedium was the complexity of the environment that made the movement of the boxes difficult to predict, making it seem random.

6.3.3 The effect of randomness

In terms of the basic movement of the boxes, it was expected that the small objects in Mod 2 would make them feel large and clumsy while their movement would be more chaotic and harder to control, whereas the larger obstacles in Mod 3 would make the moving boxes feel smaller by comparison while their movement would be more measured and require more planning to control.

By far the most repeated opinion was that the boxes were indeed very difficult to predict and control in Mod 2: "in the beginning you could see every time that it was really easy because there were no obstacles from the rocks to reach the wall, so I had just to rotate twice to bring them in the right path and it was really easy. But now I had to do it again and again, but it wasn't really easy to see from the beginning okay I had to do this and then this and then this in order to find the right path; so I was kind of improvising" (Participant 8). "These blocks pass through the fixed blocks, I'm not sure if it's good to have them kind of random, if it would be good to have fixed paths to follow" (Participant 7). "I didn't like to carry the blocks through with the small blocks around, it seemed a bit too chaotic kind of because the small blocks were all over the place, and then there were the big blocks trying to get through" (Participant 9). "The small cubes look too random and the big cubes are not placed in intervals that are a whole cube, so that's just pretty random" (Participant 5).

Some of the participants described that they would "rattle" or "shake" the boxes by rotating the world more or less at random until the boxes would move in the right direction: "It was too random, it was like shaking something to free them" (Participant 7). "I'll shake them around to make them lie straight. I need to find a hole" (Participant 5). Participant 5 further specified what he meant by his use of the word "rattle": "I mean like just randomly twist until the stuff fell through. Not like you can use the minimum amount of input and then get exactly what you want." This expression that the participants came up with, to rattle or shake the world, should probably be seen as the opposite of coming up with a plan and executing it with deliberate though indirect control of the movable boxes.

Fig. 37: The movable boxes often get stuck in Mod 2, and it's all you can do to "rattle" them loose.

Participant 4 suggested that it was simply too difficult to see past the obstacles in order to plot a path for the boxes: "It's quite hard to see around these boxes and plan properly." However, a more likely theory was that the changing rotation of the boxes was to blame: "because of the bouncing of the big rock into the small obstacles, it was changing the rotation in all the three axes in the 3D space so that would make it even more complicated" (Participant 8).

Though only one of the players ever managed to get the boxes stuck in a place where he couldn't get them free again, most participants seemed to intuitively believe that it was more likely that the boxes could get irrevocably stuck in Mod 2: "probably it was more random with small blocks, because there were more obstacles where the block could get stuck, where with the big blocks it was a bit less" (Participant 7). "They kind of felt annoying the small boxes, they felt like they could get caught on something small you know? And that was a bit annoying, I like it that the boxes have like big spaces" (Participant 9). Participant 5 even became suspicious that there might not be a way to complete the puzzle, because the placement of the obstacles looked completely random to him: "you might not be able to solve it, it just looks random. So you had to look pretty carefully for the obvious route through this thing if you wanted to have this big cube-shaped rock throughout the level you probably have to rattle it around pretty randomly, there's no elegant solution that you can look at the thing and then see what the solution is."

Most players seemed to experience L2M3 as less frustrating than L2M2, with the larger obstacles simply adding more steps to the puzzle: "It definitely felt better, like big blocks with big [movable] blocks, and then small blocks separately. Like if you mixed the small blocks with the big [movable] blocks then I start to get really confused" (Participant 9). "The one with the smaller boxes were annoying. But the bigger boxes you had to navigate around, it was fun, it was more intuitive. The level was solved quicker" (Participant 2). Participant 2 theorised that one reason for his animosity towards L2M2 was the order in which he'd played the levels: "if I'd started with the big boxes so I'd learned, okay this is solving that kind of puzzle, then maybe the small boxes… I wouldn't hate them as much; because that would just be an increase of difficulty."

Almost all of the feedback about the movable boxes concerned level 2, where at least one of two boxes must be manoeuvred to a breakable wall. The only participant to mention the single movable box blocking the exit in level 1, which must be removed in order to complete that level, was Participant 3: "in the ones that had the cubes, the box didn't fall back down into the exit and block it off again, so it required less rotations. Compared to the ones that had the boxes you had to get down to the wall, you had to rotate much more to get them down there and you had to take care to get the boxes where you needed them." In this case, the randomness that the complexity of Mod 2 added to the movement of the box turned out to be a boon, as it drastically reduced the risk of the box falling back into the exit after being removed once. This shows that the exact same changes to the movement patterns of objects in the game world can either work for or against the player depending on the situation and the player's goals.

6.3.4 The impression of kinetic force

Another important feature of the movable boxes is their role in solving the puzzle in level 2 by smashing through a cracked wall. During the development of *Broken Dimensions*, a large amount of attention was given to the kinetic feel of this impact, with the goal of making it feel *powerful*. The disintegration of the wall, the smoke particles emitted from the moving boxes upon impact, and the noise of the crumbling wall were all designed and implemented with this goal in mind. Most importantly, the context of the impact was equally designed to create a feeling of great momentum: the corridor was made comparatively long in order to increase the fall distance of the boxes prior to impact.

Some of the interviews confirmed the connection between the fall distance and the feel of the impact. Several participants had worried whether the short fall distance enforced by especially the obstacles in Mod 3 would be enough to break through the wall: "Now I hope it will break the wall" (Participant 8). "In terms of the small boxes, that was really difficult, because I didn't see the pattern of how the boxes that were supposed to smash the wall would travel to their destination in that scenario, and how much speed and physics it needed, so if I just bumped them off from this smaller height, would they actually crash through the wall or not?" (Participant 4).

Fig. 38: The obstacles in Mod 3 leave little distance for the boxes to fall to the breakable wall (left).

Judging from the observations in the think-aloud sessions, this difference was only really pronounced with the very short fall in Mod 3. None of the participants seemed to notice any difference between the original Mod 0 fall distance and the four times as long Mod 1 fall: describing the difference between Mod 3 and the other versions, Participant 8 said: "it feels much better when it's a longer distance." When asked about a difference between Mod 0 and Mod 1, his response was different: "even if one of these versions I made the drop really small, and the other one was a really high fall, still I'm not sure, maybe there was a difference, maybe there wasn't. At that point of the small fall I was thinking if that would be enough to break the wall."

Participant 9 suggested that adding more polish effects, specifically making the box bounce differently, might make the impact feel more powerful: "[smashing through the wall] seemed to be always the same, so I didn't notice really. I mean technically you're right but I didn't notice a big difference. It could be funny if the rock reacted differently, like it maybe bounces more but then that's very dangerous." Participant 5 suggested that a small change to the rules governing the damage to the wall would do the trick: "Maybe if it took like three impacts that would be better, so you had to like 'knock knock knock' and then it would go through? That would feel more… especially if it had like either three impacts or if it had to fall a long distance, like a certain amount of damage or something, that would be more satisfying." Participant 5 described the wall as "flimsy" when the moving boxes made it crumble after the short fall in Mod 3 – by making a short fall effective only after three attempts, the wall would appear stronger and its inevitable collapse would be more impressive.

6.4 Tangential issues

The few players who had figured out how the spiked wall works (it can never accelerate to a higher fall speed than the player, but may crush the avatar if the player rotates the world too close to it due to the delay before the player starts falling) perceived no change in their interactions with it, but simply rotated immediately and fell to the exit. Players who had not grokked the movement of the spiked wall would always run all the way down the corridor and only rotate right in front of the exit.

In terms of navigation, most players said that they found it slightly more difficult to navigate in Mod 3 than in any other version, and one player analysed that this was probably because while the small cubes obscure your movement paths more than the large ones, the large ones obscure your vision much more thoroughly - the exits can typically be glimpsed between the arrangements of small cubes in Mod 2, but the large solid obstacles in Mod 3 allow no such glimpsing. Several players were observed to get thoroughly lost in the Mod 2 levels, however, which is likely because the sheer visual complexity added by all the small objects obfuscate the overall layout of the levels.

6.4.1 Spiked wall

The inclusion of the spiked wall in the test was an attempt to see how an element that was included purely to pose a threat would be perceived to change depending on the medium-level context, and how it might in turn change the perception of the movement in the game. Unfortunately the spiked wall was not compatible with obstacles (they would simply stop it), and so it was only altered in Mod 1 where the tunnel was longer, giving it more time to chase the player. Most players didn't realise that the spiked wall falls with the same maximum speed as the player character. This caused them to run all the way to the end of the corridor before rotating, which they believed would give them more time to get to safety in the exit before the spiked wall would catch up to them: “[I’ll] wait until I’m close so I don’t die” (Participant 3). “Ooooh this is a very long corridor and I can’t rotate!” (Participant 4). “I didn’t really trust that the falling speed of the spikes wasn’t a little bit faster than the main guy. So I would rather totally control it than just trust that it would fall at the right speed” (Participant 5). “Besides the long one? That I need to get closer to the hole in order to get through, because otherwise I would die. The other ones weren’t much different” (Participant 1).

Some of these players stated in their interview that they perceived the longer version of the corridor (Mod 1) to be more dangerous than the shorter versions: “Yeah of course because you had to get closer to the hole to rotate” (Participant 1). “When I saw the spikes I almost thought that I should not rotate because I thought that the spikes will kill me before I get to the hole. That was why I thought it was harder to solve the puzzle” (Participant 4). Participant 5, however, did not believe it had a difference to how dangerous the area seemed, despite thinking that the spiked wall would fall faster than his avatar: “I knew it was pretty binary, either it was at one end or the other end, or horizontal, so I didn’t worry about the length because it was just a no-go zone that I would need to totally control.” Participant 5 pointed to missing polish (specifically a sound effect) as the reason why it was difficult to tell how fast the wall was moving: “you couldn’t really trust that it was gonna behave like you think it would, it was falling too fast; and it didn’t have a sliding sound.”

Participant 10 initially suspected that the wall could not catch up to him, but the first time he reached the corridor, he rotated too close to the spiked wall: while the maximum fall speed of the avatar is the same as the wall, the wall accelerates faster, and it caught up to his avatar: “The long version, yeah, the first time I thought ’okay it might be better to just fall down and try it again’, because it was kind of annoying to reach the end by running. But since it didn’t work the first time, I thought ’okay let’s just run’” (Participant 10). This confusion is certainly down to the inconsistent behaviour of the wall compared to the only other movable objects in the world, the boxes. The boxes fall faster than the player character and may kill him if they hit him in mid-air. It is reasonable for players to expect that the wall would behave in the same way, especially when no aural or visual cues exist to tell them otherwise – in other words, better polish would have solved this problem.

Fig. 39: Being chased farther by these spikes is no more scary when you know they can't catch up.

To these players who understood that the spiked wall posed no real threat as long as they gave their avatar space to accelerate before it hit him, perhaps obviously, the length of the corridor made no difference: “it was the same sort of thing, but it was a longer distance” (Participant 9). “The spikes were, I guess they had the same speed or smaller speed than me so when I was dropping and the spikes were falling I kinda knew that they weren’t hit me, I just had to find the gap in the ground” (Participant 8). “I assumed that I had a higher fall speed than the wall, simply because there was no way of… it was clear when you solved the level the first time … okay I can’t do anything about it, I’m just going to try and fall” (Participant 2). It seems that when real threat is involved, once the rules are understood, context itself makes no difference unless the rules themselves are changed by it – even though the spiked wall was chasing players for a longer time in Mod 1 before they reached safety, this only made it seem more threatening as long as the players thought it would genuinely behave differently.

6.4.2 Camera

One worry was that the dynamic movement of the camera (zooming in and out to avoid colliding with or being obstructed by obstacles) would be confusing or annoying when the object density of the game world was increased, which could interfere with the game feel. Only Participant 4 brought this up during the think-aloud session: "The camera is slightly annoying when it zooms all the way in." When asked about it in the interview, he elaborated: "Because of the arrangement of the small boxes, in haphazard, or kind of random, jagged… so if you rotate around you're not sure which boxes you will hit and then it'll try to just cull it, so it would move around a lot as compared to a bigger box where in an area you would have one box maybe." The primary problem this caused for him was that it made it difficult for him to judge his avatar's position in the three-dimensional space: "The camera changes so much you can't judge how close you are to ledges, so you fall down."

Participant 4 wasn't the only player who reported issues with the camera when asked about it: "something that I noticed with the small cubes that just if I moved then it would move funny" (Participant 6). "The small blocks were kind of weird. I felt a bit claustrophobic cause even when the camera kind of got stuck in the guy's face" (Participant 9). "Sometimes you're a little confused of where you are if you press the right button at a place that's too narrow" (Participant 10). "When he jumps, the camera zooms in on him so you can't actually see anything" (Participant 2).

The distinct impression was that these were small gripes that hadn't significantly affected the participants' perception of movement within the game world, however. Indeed, Participant 1 even praised the camera for fulfilling the only purpose he would ascribe to it – ensuring that the player character was always visible: "I think it behaves pretty good, because I always had the ability to see where my character was, it never got occluded by objects. You know, it was a third person game, sometimes in third-person games there's like objects that cover the player so that's annoying, but in this sense I never had those kind of problems." Based on these limited comments, the camera can't be said to have interfered with the rest of the results, but it's clear – though at best tangential to this project – that the implementation of the camera in a third-person game can be very important in creating or preventing feelings of claustrophobia, confusion, etc. in relation to the medium-level and high-level context of the game (particularly object density).

6.4.3 Navigation

As previously mentioned, this project is all about movement as kinesthetic sensation, rather than movement as navigation. However, navigation is an important aspect of movement as well, and it was considered highly likely that altering the game environment in order to change the feel of movement would also change the players' navigation through the game world. Furthermore, it was expected that changes to the navigation might feed back into the feel of movement, necessitating that such changes be accounted for as well in the think-aloud sessions and the interviews.

As expected, game feel and navigation seemed closely connected in the minds of the participants, and it was difficult to separate the two during the interviews. Despite the fact that the overall level layouts remained the same, many of the players apparently considered the obstacles added in Mod 2 and Mod 3 to be changes in the basic layout, which prevented them from calling upon their mental maps from playing the baseline versions. Interestingly, not all players agreed which type of obstacle pattern made it more difficult to navigate: many players had a harder time finding their way through the many small obstacles because of the visual confusion they added to the levels, but a few players found the larger obstacles to pose a greater problem because they obscure the player's vision more fully.

L2M2 was the level that caused players to get lost the most: "Holy shit I don't even know where to take the first step" (Participant 4). "I immediately think 'where is everything?' I enter puzzle mode" (Participant 5). "Really complicated structure: harder to tell where I came from" "it's also harder to navigate with these cubes around" (Participant 6). Some players fell back on the murals on the walls that were always aligned to show the way forward: "Guess I have to follow the green arrows" (Participant 3). "I like that you have paintings on the wall to tell you what way is up or down" (Participant 8).

Participant 4 was one of the few players who seemed to have problems navigating both with the small and the large obstacles, but he suggested a very interesting explanation for why the small blocks may be worse for most people in terms of navigation: "frustration with the small boxes because of view and with the big boxes and level in general because I couldn't see what lies beneath it was mostly leap of faith; and really stupefied by the small boxes because they didn't really provide a direction that I should move in." This lack of direction was further extrapolated upon: "I couldn't see where I should be going because they block off almost all the peripheral vision so you don't know what is the depth thing, you can't tell where you should be going."

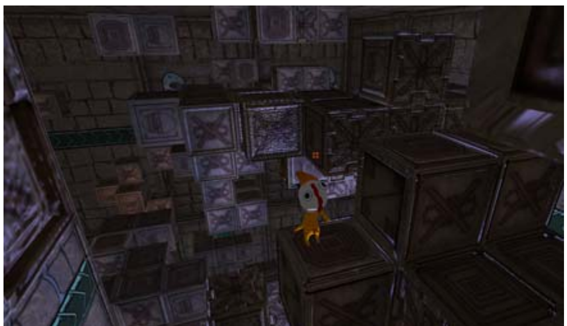
Fig. 40: Where the bloody blazes is the way forward?

As the small obstacles (in a manner of speaking) dissolve the edges of the game world, breaking up the lines of the walls, they obfuscate the linearity of the world, turning corridors into something resembling multicursal labyrinths. Though Participant 4 was the only player who picked apart his navigation trouble to this extent, feedback from the other players who found the Mod 2 levels harder to navigate similarly focused on the visibility of the level: "I like the first versions more, they're simpler. You can't see the exit" (Participant 2). "For the small blocks, because there were so many of them, it often obscured a lot of the levels, like I couldn't see a lot of the levels, I was almost kind of guessing" (Participant 6). "It added a lot of confusion and fuzziness to the level so you didn't see where you had to go" (Participant 1). "It obscures your vision so much that you can't see anything; it becomes more a labyrinth puzzle than it becomes a rotation puzzle" (Participant 2). "It's more clear, the one with the big boxes; you see the way through clearly" (Participant 3).

Two of the participants explicitly stated that they found it easier to navigate with the many small objects than the fewer large objects because they could see between smaller objects, whereas the larger objects blocked their line of sight entirely: "the big blocks made it harder to look past them so you had to walk around more and see what was behind them, where the small boxes you could just look through the holes and see everything" (Participant 5). "It was kind of confusing at the beginning because you don't know where to go and in some ways you can see through the boxes compared to the big box where you don't have the complete line of sight, so you still have to get through all the cubes" (Participant 1).

Finally, one player even expressed difficulty with keeping their bearings through the long corridors of Mod 1: "With the cubes you don't see where you're going, so you need to move around to see okay, this is my direction. With the empty corridors it's more straight-forward because you know where to go, there's nothing occluding your visuals, but you get lost because you get bored and you forget where you were going" (Participant 1). Indeed Participant 1 did get turned around in one of the long corridors and ended up running all the way back to the start, which can be attributed to the lack of clear distinguishing features in the large empty spaces of Mod 1. However, this can be considered an outlier in the test as nobody else experienced the problem.

7. Conclusion

This project has explored game feel and particularly kinesthesia in relation to game worlds. More and more games are released that allow players to interact with the game world in more direct and interesting ways, often by using the level architecture for climbing, taking cover, or being stealthy. Chiefly inspired by a relatively recent trickle of games that use climbing as a major game mechanic, this thesis set out to define the role of kinesthesia in computer games, and to test how certain aspects of level design shape players' perception of movement in avatar-based third-person games.

7.1 Contributions and takeaways

The thesis' primary contribution to game studies is the expansion and concretisation of context in relation to the player's perception of the movement of the avatar. The thesis found that the design of the game world has a clear and observable impact on the player's movement patterns in games that use context-sensitive controls, ie. control schemes that either change their response to certain inputs or enable or disable inputs depending on the state of the game. The distance between structures and the number and density of objects within the game world are the most significant factors in shaping movement patterns. One interesting conclusion was that the number of objects changes the significance of the object layout: in the analysed games, objects enabled movement, and reducing the number of objects therefore reduced players' options, instead channelling them along certain routes. This was reflected in the tests, although the other way around: in areas with more obstacles, the players were forced to understand the placement of the obstacles in order to effectively circumnavigate them.

In games with context-insensitive movement controls – ie. games where all the movement-related inputs cause the same response in the game regardless of the game state – the effects of the game world on the player's perception of movement are more subtle and less predictable. Traversing empty space is typically perceived as a lack of interactivity. This is universally considered boring, and only more so when the player has to hold down a button to move, but when movement is automated to some degree, the kinesthetic pleasure of motion may compensate for the lack of interaction. Adding obstacles is one way to make movement more interactive, but alternatively players can be given something to aim for while moving. Some players were compelled to create their own spatial goals to imbue their movement with challenge (picking out more difficult ways to move through the game space or aiming for something while falling), and such challenges could be encouraged and rewarded by the game rules in order to make basic movement more interactive and engaging for more players.

It was found that indirect control was affected in slightly different ways than direct control by the same changes. It's difficult to draw broad conclusions from a test with just one particular implementation of an indirect control scheme (changing the direction of gravity to move physics-governed objects), but the test should serve as an interesting case-study. The results showed that adding more obstacles to the world caused players to feel more closely connected to the objects they were indirectly controlling, but when the obstacles were small enough to throw the movable objects off-course, they added an unpredictability to the objects which made the challenge frustrating to most players and in some cases created an intuitive uncertainty about whether the objective could always be completed.

The thesis found efficiency, difficulty, and danger to be three major factors in what movement patterns players prefer. Some players will adopt the fastest means of travel no matter the difficulty or perceived danger of it, while other players will prefer slow and laborious but safe movement over quick and simple but potentially dangerous movement. Depending on the desired aesthetic, this can be exploited as a risk/reward dynamic by making the most effective movement patterns the most dangerous, or it can encourage players to always use the most effective means of movement by making the slow options dangerous.

The thesis further contributes empirical observations about the relationship between the game world and player input, the game's response to player input, and the rules governing the game world; the thesis gives concrete examples of how these relationships influence movement patterns and the feel of movement. It was seen that *Assassin's Creed: Brotherhood* had different areas specially tailored for different control schemes, for example matching fast and poorly manoeuvrable vehicles with large, empty spaces. During the test, participants were particularly critical of the basic controls when small obstacles were introduced that the controls were clearly not calibrated for: the long jump and the slow fall made it difficult to accurately jump onto small obstacles, making the player character feel clumsy and "floaty", whereas none of these problems were raised in relation to the empty levels. This had observable effects on the players' movement patterns as well, with some players falling from platform to platform when the obstacles were large enough to hit on purpose, but weaving around the small obstacles.

Mirror's Edge demonstrated that combining certain types of challenge with certain movement patterns can have great effects on difficulty and aesthetics depending on whether the context supports the rules or works against the rules. Being chased by enemies through an area that facilitates fast movement patterns gives a sense that the situation is in the player's favour, whereas the contrast of being chased through a cramped and complicated area designed for slow movement patterns creates a more desperate aesthetic. A similar dynamic was seen in the frustration players expressed when tasked with shepherding two large movable boxes through a maze of small obstacles that seemed not to have been designed to accommodate such large objects. Some players felt the environment working against them to such an extent that they wondered whether the task was solvable at all.

Another part of the test showed that the rules may take precedence over any perceptions created by the context: players felt no more threatened when being chased by a deadly spiked wall over a long distance than they did when the distance were shorter, as long as they understood that the wall moved at the same speed as their avatar and would thus never be able to catch up with them. Threat or danger is created by the rules, and the context can be used to modify it, but cannot in and of itself create it. As shown above, however, potential danger or the illusion of threat may be enough to change players' movement patterns in some cases.

7.2 Reservations and potential for further study

The scope of the project limits the general applicability of these results. Though 10 participants is an appropriate sample size for the scope of the thesis, data gathered from such a relatively small group is difficult to draw general conclusions from. Compounding the problem is the lack of consensus among the participants – if most of the group had been able to agree most of the time, it might be easier to draw sweeping conclusions based on the results, but the participants were split more or less 50-50 on many points, further reducing the usefulness of the data.

Another factor that conspired to reduce the amount of useful data gathered by the project was the lack of a common understanding of what constitutes "feel" in games. Despite the fact that the participants were selected primarily based on their advanced game literacy, because game feel is such an under-researched area, it was extremely difficult to get the participants to talk about the relevant parts of their play experience. Instead, participants focused on tangential subjects such as navigation, difficulty, puzzle solving, or aesthetics. When the participants did talk about movement and the feel of interacting with the game, they would typically focus entirely on what form of movement they preferred, rather than how they experienced the different movement patterns as different from each other. This was a failure on the part of the interviewer to clearly and thoroughly communicate to the participants what the purpose of the test was and what kind of data was needed. On the other hand, such a briefing might have had the undesirable effect of participants censoring themselves too much, erroneously omitting relevant data.

The main weakness of this project is that its empirical research is limited to one game with context-insensitive movement. It was important to study how pronounced the effects of context on the feel of movement were in a context-insensitive game, but the thesis sees the greatest potential for shaping player movement in games where inputs can be outright enabled or disabled based on the spatial context. Such results might be less subjective, as they are expected to have greater effects on the actual movement patterns of the player rather than simply changing the way the movement is experienced. Though some alterations in the participants' movement patterns were found in this thesis, such differences would undoubtedly be much more pronounced and more consistent in a context-sensitive game, which means it would lend itself better to a prescriptive research project.

The project tested how different contexts for the same set of movement mechanics change the player's perception of the avatar's movement. It would be interesting to conduct a similar experiment where different movement mechanics are tested in the same context to examine how this changes the player's perception of the game world. Another possible avenue for further research is how changing the rules governing the player's interaction with the game world would change the player's perception of movement – how would the player experience the superhumanly adroit movement of *Assassin's Creed: Brotherhood* if the fall damage was multiplied by 10? The thesis has shown that time pressure has profound effects on the player's kinesthetic perception in *Mirror's Edge*, but it would be interesting to delve into this relationship between rules and context with empirical research.

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8.2 Games

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9. Appendices

Appendix A. Interview questions

Note: Questions are bold, interviewer's notes are regular.

1. **Would you please briefly summarise your play experience?**

2. **What differences did you observe between each version of the levels?**
   Probe for differences not pertaining to feel, such as difficulty or aesthetics.

3. **How would you describe the movement of your avatar?**
   Keywords: control, animations, camera, falling, rotating, speed.

4. **Was the process of finding the way forward through each level altered?**
   It may be harder to navigate when the sight lines are obstructed by boxes.

5. **Did the level variations change your interactions with the green glowing boxes?**

6. **Did the variations change your interactions with the wall of spikes?**
   It chases you for longer in the extended version of the level. How is this perceived?

7. **Which version of the levels do you prefer, and in what way? Why do you think that is?**

Appendix B. Think-aloud notes

Please find on the attached DVD:

- *Appendix B - Think-aloud notes.pdf*

Appendix C. Interview transcriptions

Please find on the attached DVD:

- *Appendix C - Interview Participant 1.pdf*
- *Appendix C - Interview Participant 2.pdf*
- *Appendix C - Interview Participant 3.pdf*
- *Appendix C - Interview Participant 4.pdf*
- *Appendix C - Interview Participant 5.pdf*
- *Appendix C - Interview Participant 6.pdf*
- *Appendix C - Interview Participant 7.pdf*
- *Appendix C - Interview Participant 8.pdf*
- *Appendix C - Interview Participant 9.pdf*
- *Appendix C - Interview Participant 10.pdf*

Also on the DVD

- *Broken Dimensions PC Build*
- *BrokenDimensions* (thesis test files for Unity)