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The embodied and situated nature of computer game play

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Contents

1 Introduction

People spend hours on playing computer games without getting bored and often without even realising the time spent. The fact that people can get emotionally deeply involved in such an activity raises questions regarding the nature and potentials of games. What makes computer games so incredibly engaging? What is happening in the minds of gamers? Based on the huge interest in computer games and the fact that they are reshaping business[1] and education, game research has become an area of growing importance and interest. In contrast to more well-established research areas such as psychology, computer science or engineering, game research, however, is quite a newcomer in the academic world and researchers interested in games are currently discussing the future and possibilities in this area (e.g. Aarseth, 2001; Svedjedal, 2003). In previous years, a large amount of researchers has been interested in how people, and children in particular, are affected by computer games (e.g. Gentile, Lynch, Linder, & Walsh, 2004). The focus so far has mainly been on *shooter games*, a game genre where the player's task is to fight and shoot as many of (virtual) enemies as possible (Figure 1). However, potential negative influences of computer games have not been the only concern of researchers in the past (e.g. Spence, 1988; Subrahmanyam & Greenfield, 1994). In recent years, even the HCI–community has picked up on the increasing interest in games (e.g. Pagulayan, Keeker, Wixon, Romero, & Fuller, 2003). This is especially interesting as the activities of using computer applications and playing computer games have something in common as both require humans to interact with a computer based interface.

Figure 1: Screenshot from Half-Life2, a First Person Shooter game (FPS game)

1.1 Human-computer game interaction

Most research in the field of human-computer interaction (HCI) focuses on aspects such as interface design, evaluation of computer systems and computer–mediated human to human communication (Sharples, 1996; Dourish, 2004). Computer games, as the object of interest here, have not received equally much attention in this area. This might be explained by the fact that games still are not taken very seriously by many researchers and funding agencies; computer games are games – they work without much effort and are designed for fun and are thus for many researchers of limited interest. *Usability* subsequently is mainly associated with advanced information systems designed to perform work-related tasks and not with human use of and interaction with computer games. At first glance this might not look quite as a problem since accepted usability standards within HCI likely will not apply to computer games, but this does not mean that usability-related questions are of limited relevance to computer game research. On the contrary, we know by far too little about how people interact with computer games and which (cognitive) impact it has on them to ignore this research direction. This is also in line with Goldstein (2003) who argued that

> [i]f we are better to understand the cognitive and social effects and uses of electronic games, researchers will profit from longitudinal, prospective studies, with a broader range of outcome measures than is currently the case (p. 41).

[1] According to Spelplan (2004) about 248 million computer games have been sold year-to-date 2004.

The increasing interest in games that has been shown in HCI in recent years can thus be considered an important step towards a better understanding of the human interaction with computer games since games are being approached from many different research directions in this area (Mallone, 1982; Fabricatore, Nussbaum, & Rosas, 2002; Pagulayan et al., 2003; Desurvire, Caplan, & Toth, 2004). Moreover, there is a lot of research going on in this area which is directly or indirectly connected and highly relevant to computer game research. In many sub-areas new technology is being tested and developed and behind this technology is the conviction of researchers that bodily experience is a factor not to be underestimated. The underlying intention in areas such as *haptic interaction* (e.g. Ruspini, Kolarov, & Khatib, 1997) and *pervasive/ubiquitous computing* (e.g. Weiser, 1993; Headon & Curwen, 2002) is to develop technology that makes it possible for users to interact with a computer based interface in a way that feels more natural to them – a development that recently also has reached the computer game society. EyeToy: Play, for instance, is a collection of computer games where the user's motions are captured by a color- and motion sensitive digital camera device.

The *embodied interaction* approach put forward by Dourish (2004) can be considered a theoretical foundation for such ideas as it emphasises the embodied nature of human cognition and its impact on people's interaction with software systems. Dourish has very much drawn his inspiration from research in the area of cognitive science. Within the frameworks of *embodied cognition (EC)* and *situated cognition (SC)* researchers strongly emphasise the role of bodily activity and environmental resources in human cognition. As Port and van Gelder (1995) put it:

> Cognitive processes span the brain, the body, and the environment; to understand cognition is to understand the interplay of all three. Inner reasoning processes are no more essential cognitive than the skillful execution of coordinated movement or the nature of the environment in which cognition takes place (p. viii-ix).

Traditionally, human-computer game interaction is mostly limited to pushing selected buttons on a keyboard or a console in order to control a virtual agent's movements. From a pure cognitive point of view, this is a rather unnatural way to move in and through an environment. It takes some time for people to learn, for instance, the mapping between "pressing the left arrow key" and "turning left". It is thus tempting to argue that people who are given the opportunity to actually walk through the game environment might find it a more intuitive way to interact with computer games. We cannot ignore one important fact, though. Computer games have been spectacularly successful for around three decades now, despite apparently limited interaction opportunities for the users. Successful interactions between player and game thus can be said to take place whenever people get caught up in their gaming activities, regardless of the interaction mode. This raises important questions about the nature and development of skilled human-computer game interaction.

1.2 Aim

The primary aim of my research is, preliminarily speaking, to refine the current understanding of human use of and interaction with computer games from a situated and embodied cognition perspective. Embodied and situated cognition appear at this moment to be one of the most promising theoretical frameworks for an adequate understanding of human-computer game interaction since the activity of playing a computer game in many respects is a very social activity, spanning the brain, the body and the (game) environment. The term *use of and interaction with computer games* refers accordingly to the way people, when playing a computer game, make use of their game environment which includes both the game interface, e.g. input/output devices, and the surrounding environment, e.g. objects and other people. My research is centrally driven by the goal of furthering the understanding of the underlying mechanisms involved in peoples's interaction with computer games and their impact on the game outcome in terms of player performance and gaming experience.

As a first step towards the PhD degree, an introduction to the object of interest is provided in this paper, showing its relevance to the areas of HCI, cognitive science and game studies. Research on human-computer game interaction from a SC/EC viewpoint would be a *valuable contribution to the area of HCI* since interaction studies largely have focused on standard computer applications, which most decisively also has shaped the understanding of games in this area and the ways in which they are approached. Scientists active in the different fields of HCI consider computer games mostly to be somewhat different computer applications without paying adequate attention to the various levels and dimensions of computer games and the activity of playing them. The field seems not to have noticed yet that computer games provide a unique opportunity for studying leisure-oriented, non-instrumental uses of virtual environments. As a result, the common understanding of computer games and game play in HCI is fairly limited and superficial (cf. Rambusch, Jakobsson, Pargman, & Ziemke, submitted). Due to the complexly socially situated, and increasingly body focused nature of computer games, computer games offer also *an interesting field of application for SC and EC research*, making it possible for scientists to gain a deeper understanding of the situated and embodied nature of human cognition in general. Last but not least, research on games from the a SC and EC perspective can also be expected to make a *valuable, qualitative contribution to the field of game studies*; computer games are being approached from many different research directions, but the situated and embodied nature of computer game activity with the player in focus is still a largely unexplored issue.

1.3 Outline

The report is structured as follows: firstly, an overview of computer games is provided (section 2), which is followed by a discussion of to what extent research in the area of HCI needs to be taken into consideration when studying human interaction with computer games (section 3). In chapter 4 the theoretical frameworks of embodied and situated cognition are discussed more in detail with regard to the research object. In the final chapter (5), two guiding research questions are identified and future steps of theoretical and empirical research are outlined.

2 Computer games - an overview

Games are an indispensable component of human behaviour and have, as Crawford (1982) put it, a "vital educational function for any creature capable of learning" (p. 16).[2] From this perspective, the huge interest in computer games is not so surprising after all. The excessive and widespread use of electronic games in recent years, however, has been rather controversial among politicians, educators and the public, raising questions regarding the nature and potential dangers of video games. In the early years, mostly male teenagers used to play computer games, but in recent years, this situation has fundamentally changed. Instead, computer games seem to have become a generation and gender overlapping phenomenon (cf. ESA, 2005). Exactly who and how many people actually play computer games on a regular basis is difficult to pin down as the computer game market is in constant and rapid change. Despite this, there has been a number of studies carried out in an attempt to find and document trends in the use of computer games (e.g. Livingstone, 2002; Spelplan, 2004; ESA, 2005).

The tremendous interest in computer games and their widespread, expanding use has in recent years also given rise to a strong interdisciplinary research interest. Research on games falls to a large extent under the heading of game studies, even though the status of the field is still uncertain since games are approached from a bewildering range of perspectives and no consensus exists on which areas actually fall within this field (cf. Wolf & Perron, 2005; Raessens & Goldstein, 2005). On a general level, computer games are usually approached from two research directions: researchers are either interested in the *effects of computer games on people* or they seek to understand *what computer games are*. The latter is usually a topic in areas such as literature, media science, or cinematography (e.g. Atkins, 2003). As far as the former is concerned, much research has focused on people's motivations to play games (e.g. Crawford, 1982; Douglas & Hargadon, 2000), the potential, negative influence of games on people (e.g. Gentile et al., 2004), and the impact of games on people's learning performances and social behaviour (e.g. Holmes & Pellegrini, 2005). It is of course difficult to distinguish rigidly between these two approaches, which also is in line with Aarseth (2003) who argues that there are three, interdependent dimensions that characterise every computer game:

(1) Game play (the player's actions, knowledge and strategies; the identification with game characters; motives; learning processes; social relations)

(2) Game structure (the rules of the game, including the simulation rules)

(3) Game world (fictional content, topology/level design, textures etc.)

Given my research interest, the focus will primarily be on game play since human interaction with games as defined in 1.2 mostly is concerned with the player's actions, knowledge, motives and social relations. The interdependency of the three dimensions will make it, however, necessary to discuss also the other two dimensions to some extent in certain contexts.

[2]Due to time and space constraints, a general definition of what a game is cannot be provided in this paper. However, this issue will be discussed more in detail in a later research phase. Until then, the interested reader might like to look into some of the following books: e.g. Huizinga (1938); Caillois (2001); Juul (2003).

2.1 Motivations for game play

Ever since video games were introduced there has also been a public interest in understanding the impact of games on people's social behaviour, and one of the leading questions has been *"Why do people play computer games?"*. Computer games have existed for more than 30 years and the main (play) motives are believed to be the search for *power* and *success* and an *escape from real-life burdens and problems* (Fritz, 2005). Crawford (1982), presenting a more differentiated analysis of people's motivation for playing video games, argued on the other hand that "the fundamental motivation for all game play is to learn" (p. 17), even though people do not necessarily have to be aware of it. Other motivations, according to Crawford (1982), are *fantasy/exploration, nose-thumbing* (the overcoming of social restrictions), *proving oneself, social lubrication, exercise*, and *need for acknowledgement.* Goldstein (2003), in addition, points out that we cannot generalise as different people play games "for different reasons with different patterns of play" (p. 27). People can play a game for analytical or practicing purposes, some people do it to experience excitement, others to impress their friends and/or family, to initiate and keep up social relations with others, or because they find computer games challenging and/or educational. Gender and national identy have also an impact on the motivations for playing as well as the location where the playing activity takes place, e.g. at a public place or at home (Flynn, 2003; Bryce & Rutter, 2005; Joyner & TerKeurst, 2005).

Clearly, motivations for playing computer games are considerably more complex than the common public perception or what is found in magazine and newspaper articles. Most people who do not play computer games themselves have surprisingly often a quite negative attitude towards games and those who play them. One of the reasons is probably that the presence of games in the media largely is reduced to so-called shooter games and computer game play is viewed as a very lonely activity which keeps people from socialising with their peers. However, this a very limited and superficial understanding of computer games and game play, which hopefully will become apparent in the sections to follow.

2.2 Defining computer games

Computer games require people to interact with a *computer-based interface* which means that the input usually is taken through input devices such as mouse, keyboard, console buttons or joystick while the output is given through a computer screen and mobile speakers. More advanced input/output devices such as VR gloves and (improved) steering wheels can also provide the user with tactile feedback. It is also worth mentioning that computer games and their increasing popularity are tightly linked to the development and refinement of computer technology in general, that is, the faster and more complex the computers the more advanced and skill demanding the games become. Games, nonetheless, also play a key role in pushing computer technology forward. The development of graphic cards, processors and sound cards, for instance, is indeed closely related to the increasing public demand for highly graphic and sound intensive computer games (Pagulayan et al., 2003).

Computer games are usually developed for specific platforms or applications, e.g. consoles, handheld systems, or common personal computers, and include an expanding collection of multimedia features (cf. Forster, 2005). In recent years, there has also been a development towards *gaming in virtual reality environments*. Being connected to equipment such as VR helmets and gloves, the user experiences a sense of presence in the virtual game world (cf. Carassa, Morganti, & Tirassa, 2004). This technology, however, is still out of reach for most people because of its highly complex and expensive technical requirements. *Pervasive gaming*, on the other hand, takes a completely opposite approach than virtual reality by integrating game technology into the physical world (e.g. Schrader, Jung, & Carlson, 2005). Games such as BotFighters are based on location technology implemented in mobile phones and PDAs (Personal Digital Assistant) and mirror the players' movements, that is, the player's location is a central theme in these kinds of games. A quite popular and increasingly widespread form of game technology is also *online gaming* which first and foremost requires a fast, reliable Internet connection and a fairly powerful computer. One of the most popular online games currently around is World of Warcraft, a Massively Multiplayer Online Role Playing Game (MMORPG) that allows thousands of players to interact within the same world.

2.2.1 Taxonomy

A precise taxonomy of computer games is nearly impossible given their constantly changing 'nature' and number. However, computer games can usually be devided into different *catogeries* or *genres*, according to their atmosphere and/or setting (e.g. cartoon, science fiction). In Table 1 examples of different kinds of game genres are listed, but it should be noted that no warranty of completeness or accuracy can be made for the content of this list as the different genres often are overlapping and also frequently occur with different names. Wolf (2001), for instance, distinguished between 42 different kinds of games, while Jonas Heide-Smith and Simon Egenfeldt-Nielsen simply make a distinction between *action*, *adventure*, *simulation*, and *strategy games* on their website `www.game-research.com`.

Table 1: Game genres

Adventure games	Music & dance games
Beat'em up games	Shooter games
Skill games	Sports games
Jump'n run games	Strategy games
Learning games	Simulations
Role-playing games	Driving games

Among these genres, especially the so-called *shooter games* have generated a widespread interest in the media as games such as Counter-strike and the like often are held responsible for an increasing violence among children and adolescents. This stereotypical view is increasingly being challenged from different research directions. Goldstein (2003), for instance, criticises that it is rarely distinguished between real violence and fantasy violence, and that scientists too often fail to "distinguish *aggressive play* from *aggressive behaviour*" (p. 32). Looking at the above listed genres it should also become clear to the reader that computer games are not just about shooting and killing, but that there is a whole range of games out there that also address other issues that are important and interesting for children and adults. This fact is also reflected in statistics released by e.g. ESA (2005). More importantly, the increasing use and refinement of games has also led to a point where playing computer games is not just about *playing* anymore since computer games increasingly are used in education (Dumbleton & Kirriemuir, 2006) and psychotherapy (Shapiro & Shore, 1993).

2.2.2 Computer games vs. common computer applications

The increased use of computer games for educational and therapeutic purposes raises the question regarding the nature of computer games. What makes a computer game a game? Are computer games used in a class room still games or have they turned into a common computer application? How can we tell the difference? According to Pagulayan et al. (2003), there are some methods and principles that can be applied to both games and productivity applications. Confusing screen layouts and misleading feedback, for instance, can cause problems in both cases. However, Pagulayan et al. (2003) also points out that there are fundamental differences between computer games and other computer applications, even though the differences at times can be quite subtle.

The fun factor The most important difference between games and other applications is, according to Pagulayan et al. (2003), the fact that games have been designed for fun, intended to stimulate thinking and feeling. Common applications, on the other hand, are tools with the overall intention to make a certain task easier, to decrease the amount of errors and (or) to make work more precise and faster.

The concept of 'fun' as used by most researchers in HCI, however, gives a misleading impression of its meaning and the ways in which computer games are played. The traditional conception of fun ("having a god time") does not by a long way capture the various dimensions of computer games and game play. The fun of playing games has, for instance, been described as immersion (Ermi & Mäyrä, 2005) or flow (Douglas & Hargadon, 2000) and these terms reflect a more differentiated view on fun than presented by Pagulayan et al. (2003). Moreover, fun is not necessarily the primary motivation for playing games; for many people the activity of playing has become an activity like going to work – they do what they are good at and make money with it, in some cases thousands of (virtual) dollars in prize money (cf. Castranova, 2001). People meet also online to practice, to learn from each other, to develop winning strategies with their clans, and none of these activities is related to fun in the traditional sense either.

Goals Another difference is, according to Pagulayan et al. (2003), that games define their own goals while "the goals of productivity applications are defined by the external environment, independent of the application itself." (ibid., p. 885). For instance, writing a letter is not a goal within the application, but comes from the outside. In a computer game, on the other hand, the goal lies within the game and needs to be clear to the user right from the beginning. Take the example of COUNTER-STRIKE. The user needs to know that she has to shoot as many (virtual) enemies as possible in order to make it to the next level.

The question, however, is how games which are played in ways that go beyond the intended object of the games fit with the assumption that games define their own goal. COUNTER-STRIKE is a good example of how people play a game in a different way than what was intended by game developers. Instead of shooting their (virtual) enemies, players use their weapons for jumping; the goal is not to win the game, but to jump higher than other players. In this case, the intended object of the game does not lie within the game as designed by the game developers (cf. Wright, Boria, & Breidenbach, 2002).

Constraints In contrast to productivity applications, games "must provide a variety of experience" (Pagulayan et al., 2003, p. 886), that is, every game has to be different from other games as users easily get bored. In productivity applications, on the other hand, it is a *must* for designers to provide consistent products which users easily can recognise and use. In those applications designers also try to remove or at least structure constraints for the user, making it easier for them to use the application in a proper way. Games, on the other hand, often and deliberately impose constraints because they make the use of a game much more fun. As pointed out by Pagulayan et al. (2003), having simply a button that lets the user win the game every time the button is pushed would presumably not cause any usability-related problems, but it would not be much fun for the user either.

Use of sound and graphics In computer games, an extending collection of multimedia features is usually used to increase the game experience. A spooky atmosphere in a game, for instance, is achieved through the use of bones, dead bodies, skeletons, spider webs and the sound of pouring rain and thunder. In productivity applications, in contrast, sound and graphics are used only rarely (e.g. a "click" sound providing feedback that the button has been pushed).

Perspectives According to Pagulayan et al. (2003), productivity applications seldom have a point of view or perspective as can be found in computer games (e.g. in HALF-LIFE2, the person who plays the game takes the perspective of research scientist Gordon Freeman, the main character of the game). Productivity applications such as WORD™ and POWERPOINT™, on the other hand, simply provide the user with different views (e.g. print view, web view). The increasing use of three-dimensional environments also has resulted in game environments that often are very similar to virtual reality environments - which, of course, also has an impact on the user's perspective on the game. However, Pagulayan et al. (2003) also pointed out that "game designers must appreciate the difference [...] between trying to simulate reality and creating an environment that user's perceive as reality" (p. 887).

Innovations People who regularly play computer games are generally very open-minded about innovations in game design as they expect new, exciting game features. Users of productivity applications tend to be more cautious about innovations as they often require a longer learning period. However, even though experienced players usually have a positive attitude towards innovations it does not mean they cannot cause any usability problems.

User interaction Not surprisingly, a greater variation of input/output devices can be found in computer games. In the game DANCE DANCE REVOLUTION, for instance, the input device is a dance pad. In productivity applications, on the other hand, the most common input devices are standard applications such as keyboard and mouse. Even here things are changing, though, as in areas such as ubiquitous computing increasingly new interaction technologies are being studied.

The above described list of differences between computer games and productivity applications is, of course, far from complete. The intention here, however, has not been to describe *all* the differences in detail, but to give the reader a general picture of the relation between computer games and standard productivity applications. Later on, we will return to this issue by discussing it especially from a usability perspective; the reason for this will become more apparent below.

2.3 Interaction with computer games

The overall purpose of my research is to refine the current understanding of the mechanisms involved in people's interaction with computer games (cf. section 1.2). Games, as we have seen, are being approached from many different research directions, but there are various aspects in game play that so far have been of little concern to scientists. These include, among other things, the act of playing a game (Ermi & Mäyrä, 2005). As pointed out by Aarseth (2003), the game play dimension includes also the player's actions and these are to a considerable extent shaped by the game interface.

The human use of and interaction with (in) computer-based interfaces has been a continuous issue in various fields of HCI, but computer games have only in recent years become an issue on the agenda of scientists in HCI. There is, for instance, an increasing awareness in the area of HCI that features from games can be useful in the design of user interfaces for different standard computer applications as they can provide a significant usability improvement (e.g. Mallone, 1982; Thomas & Macredie, 1994). Recently, scientists in sub-areas of HCI such as pervasive and ubiquitous computing have discovered computer games also as a potential test bed and application area for novel interaction technology (e.g. Björk, Holopainen, Ljungstrand, & Åkesson, 2002; Headon & Curwen, 2002). The primary focus in HCI, however, has been on productivity applications, usability aspects and user-centred design, which quite naturally has shaped the ways in which computer games and game play are being approached in this area. Games are, for instance, almost exclusively viewed in terms of product development, that is, the design, the functionality and the development of games are in focus, not how they are actually used on a daily basis (e.g. Pagulayan et al., 2003). Moreover, only games with 'noble' and/or instrumental purposes seem to be of interest for researchers in this field, that is, games which are educational, can be used for training purposes, and/or engage people on a more active level (e.g. Stolk, Alexandrian, Gros, & Paggio, 2001). Large parts of the broad spectrum of computer games are subsequently generelly ignored within HCI.

It seems that research on games in the field of HCI so far lacks sufficient understanding of the various dimensions of computer games and game play; scientists have incorporated games into their areas of interest without being genuinely interested in games as such and without ever seriously questioning their methods and tools used in the past. A HCI perspective on games is necessary, though, as it can address questions concerning the interface of games and user's interaction with them. The following chapter explores in more detail to what extent ongoing research in the field of HCI has to be considered in the study of the human interaction with computer games as defined in section 1.2.

3 Human-computer (game) interaction

Human-computer interaction (HCI), generally speaking, is the study of how people interact with computer based interfaces, and one of the main issues in this area has been to provide people with interfaces that are easy-to-use (Sharples, 1996). In recent years, the range of domains in the field has dramatically increased, thereby including domains such as computer-mediated human to human communication, computer supported cooperative work, haptic interaction, ubiquitous computing, and virtual reality. The impressive diversity of research domains that now characterises the field of HCI has its roots in the sudden, explosive arrival of new technologies in the last few years, which has provided many new opportunities for augmenting and designing more flexible and intuitive user experiences (Rogers, 2004). Unfortunately, this apparently positive development has had some undesirable consequences as now HCI is "bursting at the seams" (ibid., p. 87). More precisely,

> [w]hat was originally a confined problem space with a clear focus that adopted a small set of methods to tackle it – that of designing computer systems to make them more easy and efficient to use by a single user – is now turning into a more diffuse problem space with a less clear purpose as to what to study, what to design for and which methods to use (Rogers, 2004, p. 87).

The recent developments in the field of HCI have, of course, also a profound impact on computer game research in as much as all research involving computer-game technology has to deal with the same variety and complexity of appoaches and methods. Moreover, the fact that large parts of the HCI community are not particularly interested in game research as such makes things even more difficult as there are not many scientists who are intrested in finding and developing a framework for the study of human interaction with computer games. Computer games are most of the time simply seen as a 'somewhat' different type of computer application whose features partly can be applied to productivity applications. This conviction is justified in so far as computer games and other computer applications have a lot in common, however, there excist also significant differences. Usability, thus, being one of the cornerstones within HCI, has probably a quite limited applicability to video games.

3.1 Usability – definition(s)

A common, and most widely accepted understanding in the HCI community is that computers need to be "easy to use" (Macaulay, 1995). As a result the usability of a system is mainly associated with *ease of use*. This, however, is somewhat problematic as no one exactly knows the actual meaning and range of the concept, e.g. does the system have to be easy to use by anyone or do we refer here to a particular group of users? According to Macaulay (1995), ease of use is just *one part* of the usability definition, along with ease of learning, flexibility of use, effectiveness of use, and user satisfaction:

> *Usability* is the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments. *Effectiveness* is the accuracy and completeness with which users achieve specific goals. *Efficiency* is the accuracy and completeness of goals achieved in relation to resources expended. *Satisfaction* is the comfort and acceptability of using the system (Macaulay, 1995, p. 174, in accordance with ISO CD 9241 – 11).

Considering the terminology used, this definition is clearly largely based on how designers look at usability as the end users of a system usually have a different, more ambiguous and unclear perspective on the system's functionality and usability. This, however, does not mean that designers are not able to meet the needs of the end users. It should also be noted that there are often more than just two different viewpoints. Macaulay (1995), for instance, makes a distinction between user, designer, and customer and each of them has certain expectations towards a system. The customer (e.g. a company) might be more interested in keeping the installation costs of the system at a minimum while the end user is possibly more interested in doing his job well. The designers, moreover, are usually more concerned with technical issues, thereby paying less attention to the needs and requirements of the end users. Macaulay also pointed out that all stakeholders have different requirements with respect to the usability of a system, depending on the stage within the *usage cycle*. At the 'installation stage', for instance, it is important that a system is installed in the shortest time possible. At the 'introduction and training stage', on the other hand, it is important that the system is easy to learn and that supporting material is provided.

Usability definitions derive from differing views of what usability means, and many of these views are related to how it should be measured (Bevan, Kirakowski, & Maissel, 1991). 'Measurement guidelines', as one could call them, provide a concrete basis for system engineers, ergonomists, and users to cooperate more closely to improve a system's usability. Definitions providing such guidelines emphasise, according to Bevan et al. (1991), usually at least one of the following viewpoints:

(1) A *product-oriented* view where ergonomic attributes of the product are in focus
(2) A *user-oriented* view where researchers especially look at the mental effort and attitude of the user
(3) A *user-performance* view where researchers mainly are interested in how easy the system is to use and whether or not the system will actually be used
(4) The above-listed viewpoints usually are complemented by a *contextually-oriented* view, which provides a more complete view of the user or class of users, the task to be performed, and the task environment

To summarise the findings in this section, the concept of usability is almost exclusively related to productivity applications whose purpose is to provide users with an appropriate tool to get work done fast and efficiently. This rises the question to what extent usability standards actually apply to computer games. That is, how 'usable' is the usability concept for the study of people's interaction with games?

3.2 The concept of usability and computer games

A short answer to the above question is that usability standards likely will not (completely) apply to computer games as the differences between games and standard applications far outweigh the similarities between them, even though the differences are not always obvious or quickly determined (cf. section 2.2.2). However, a more detailed answer is needed here as things are not always as simple as they seem. Despite significant differences, there excist *important* similarities, a computer-based interface being one of them. This means that also in the case of video games different usability perspectives need to be taken into account.

A *product-oriented* product-oriented view deals, as we have seen earlier, with ergonomic attributes of a product. Ergonomics in a nutshell concerns the human body's response to physical and physiological stimuli (e.g. awkward body postures, vibrations, force) and organisational factors (e.g. policies, organisational structure). Clearly, ergonomics is also of relevance for the design of video games as input devices such as keyboard and game pad affect the user presumably in a different way than do input devices that involve the whole body and/or provide force feedback. Applying a *user-oriented* perspective, especially cognitive aspects such as mental effort and attitude of the user are in focus. No question, in order to understand what (cognitive) impact the interaction with computer games has on people researchers need to take a user-oriented perspective on games. However, what seems to be appropriate for productivity applications can be quite different for computer games. "No surprises" – applying this guideline to video games and we do not have fully-functioning games anymore. Taking a *user-performance* perspective, the emphasis is on ease of use, but what does this mean in relation to video games? How easy to use does a game have to be? One of the characteristics of games is that they often contain lots of constrains just to make the use of them more fun or challenging. This goes directly against a common view in HCI according to which constraints should be removed as far as possible. It seems that a new 'ease-of-use definition' is needed for computer games. Or can we do without one? Probably not, as video games are used by people and people have different types of skills and are constrained by limited cognitive capacities. The necessity of usability evaluation and testing of computer games is also increasingly being acknowledged by game developers (e.g. Laitinen, 2005). By adopting a *contextually-oriented* perspective, the user (class of users) is taken into consideration, the task to be performed and the task environment. Of course, there is not such a thing as 'the game user' since games are played by different people for different reasons. In order to understand why a certain game is successful compared to other games, researchers have to take a closer look at who actually is using the game (e.g. Bartle, 1996). Also, games are mostly designed for fun and enjoyment and not for the purpose of getting work done. The 'task of a game', thus, is difficult to identify, especially when people play a game in a way that goes beyond the intended object of the game. Given the diversity of game technology and players it is also difficult to specify a 'task environment' as it is closely related to where a game is played (e.g. online, at home, public places) and what kind of technology is used (the quality and quantity of input and output devices).

Existing usability standards clearly do not apply to computer games very well but, on a general level, they can serve as a source of inspiration and guide in our attempts to further the understanding of the human use of and interaction with computer games. Given the research object here, especially a product-oriented and user-oriented view should be followed up as they particularly address questions concerning the *interface* of computer-based systems and user's *interaction* with them.

3.3 User-interface interaction in games

During the last couple of years a broad range of interaction technologies has been studied in the area of HCI, but the focus has mainly been on different kinds of productivity applications (e.g. Sharples, 1996; Shneiderman, 1998; Preece, Rogers, & Sharp, 2002). Much of this research is nonetheless definitely also of great importance for computer game research (cf. section 2). What makes areas such as haptic interaction, ubiquitous computing, and virtual reality so interesting and useful for game research is their underlying idea of people taking a more *active* role in their interactions with computer based interfaces. In the field of haptic interaction, for instance, technologies are being tested that provide the user with information about the location, the structure and other material properties of an object. Using this technology in computer based games would probably greatly increase the game experience of people. Ubiquitous computing, on the other hand, is a field in which researchers are trying to make technology disappear, that is, invisible to the user (e.g. a dance pad that functions as an input device by sensing the location, motions and actions of the user), which would allow people to interact with a (game) interface in a way that feels more natural to them (cf. Weiser, 1994; Headon & Curwen, 2002). As Weiser (1988) pointed out,

> people live through their practices and tacit knowledge so that the most powerful things are those that are effectively in use [...] so embedded, so fitting, so natural, that we use [them] without even thinking about it.

This way of thinking has apparently already extended to the computer game society. Games such as DANCE DANCE REVOLUTION or EYETOY: PLAY, for instance, are very good examples of how people can interact with a computer-based interface in a more natural manner since the user interfaces are rather intuitive and do not require extensive learning or technical skills to be used successfully. It appears, though, that games with input devices such as dance pads mainly are directed at 'casual players' with little or no game experience at all; the games are kept very simple, can be played repeatedly within a short period of time, involve even those not being active (whatching others making strange movements is an essential part of these kinds of games) and are thus perfect for birthday parties and the like. The development of these kinds of games, in other words, has been more a matter of reaching a new audience of users and not so much a matter of applying the latest discoveries and theories in science. A quick Internet search has also revealed critical voices about the potentials of these games, "rigid and bearing little resemblance to actual dancing" was one of the comments at `www.wikipedia.org`.

This rises a number of questions about the potentials of those kinds of input devices and the quality of interaction that is provided by them. That is, how natural is the interaction with a game interface through input devices such as dance pad and movement-sensitive cameras, and to what extent can the technology be implemented in other game genres? There is only a small number of games with more 'natural' input devices on the market, and all of these games are quite similar in their design and their target audience. Moreover, there seems to excist very little empirical material providing new insights into how people's play of computer games is affected by different kinds of interaction technology. Noticeable exceptions can be found in the fields of ubiquitous and wearable computing (e.g. Cheok, Yang, Ying, Billinghurst, & Kato, 2002), and in an area which very much has drawn its inspiration from these fields, pervasive gaming (e.g. Warn et al., 2004; Schrader et al., 2005).

Large parts of the technology developed in areas such as VR, ubiquitous computing and haptic interaction, however, has so far mostly been tested in specific sectors such as health care or the military since funding agencies often are more willing to provide significant financial support for this kind of research. This has resulted in that novel technologies to a large extent only are accessible to a small number of users. It also seems that the excitement about being involved in the development of new interface control systems largely outshines the need for a strong, coherent theoretical foundation for research in some of these fields. This is somewhat surprising considering that researchers within HCI can rely on a strong body of methods and theories that goes beyond the traditional usability thinking and that particularly addresses issues discussed in fields such as ubiquitous computing and pervasive gaming (e.g. Suchman, 1987; Hollan, Hutchins, & Kirsh, 2000; Dourish, 2004)

The research going on in areas such as ubiquitous computing is, for instance, a substantial part of the approach set out by Dourish (2004). Bringing together two areas of interactive system research, i.e. tangible computing and social computing, Dourish explores in his approach the active, embodied nature of people's interaction with computer-based systems.[3] Fundamental to his approach is the notion of *embodiment* which, in a nutshell, is described as "the common way in which we encounter physical and social reality in the everyday world." (Dourish, 2004, p. 100). The 'real-world' is already reflected in interactive systems in many differen ways, for instance, people playing a computer game understand that objects can be hidden from view by other objects and/or people. However, as pointed out by Dourish (2004) there is a substantial difference between using the real world as a metaphor and using it as a medium for interaction.

> [R]eal-world metaphors can be used to suggest and guide action, and to help us understand information systems and how to use them. Even in an immersive virtual-reality environment, users are disconnected observers of a world they do not inhabit directly. They peer out at it, figure out what's going on, decide on some course of action, and enact it through the narrow interface of the keyboard or the dataglove, carefully monitoring the result to see if it turns out the way they expected. Our experience in the everyday world is not of that sort. There is no homunculus sitting inside our heads, staring out at the world through our eyes, enacting some plan of action by manipulating our hands, and checking carefully to make sure we don't overshoot when reaching for the coffee cup. We inhabit our bodies and they in turn inhabit the world, with seamless connections back and forth (Dourish, 2004, p. 101–102).

The distinction between interaction in the real world and virtual environments, however, suggests that people's interaction within a virtual world is only to a limited extent embodied and thus interfaces are necessary that support a seamless connection between body and virtual world. Yet, looking at computer game players it seems that, in many cases, a seamless connection between body and virtual world already exists. The interaction might be limited in the beginning, that people try to figure out what is going on, but after a while the virtual world becomes part of the real world, which makes it impossible for an observer to draw a line between the real world and the virtual world. Take the example of an expert player performing an average of 200 actions per minute.[4] It almost seems that mouse and keyboard become an extension of the player's body through which the virtual world is perceived directly. This example is very similar to a blind man and his stick where the stick is no longer sensed for itself as the user gets accustomed to using it. This process is defined by Hirose (2001) as an *act of embodying*, a process where objects cease to be objects and, instead, become part of the body. A person's actions in a computer game thus reflect in many respects processes of embodied interaction which are more related to the act of embodying, and less to the state of being embodied, something Dourish mainly seeks to emphasise. So far, research on computer games from this perspective is quite rare, not to say almost non-existing. Thus, it definitely needs further elaboration in order to better understand what game interfaces afford a person in terms of action opportunities

[3] Tangible computing is described by Dourish (2004) "as an attempt to move computation out of the 'box on the desk' and into the environment" (p. 189), which also includes research in areas such as ubiquitous and wearable computing. Social computing, on the other hand, "refers to the application of sociological understanding to the design of interactive systems" (p. 55).

[4] The example is based on a log from a StarCraft game where one expert player took on three other players. One measure of expertise in this kind of game is manual dexterity. Different kinds of tools are used in game communities to log, for instance, keyboard activity and events during a game, and this information is often displayed in EEG-like curves. The expert player in question performed an average of 200 Actions per minute (200 APM) in a 25 minutes long game. The maximum APM was even higher and reached over 500 APM. The accuracy and precision of the data is of course debatable, however, it is probably safe to say that 200 APMs display *a lot* of keyboard actvity which can be considered a good indicator for skilled human computer-game interaction.

and how this affects the player's thinking processes and, subsequently, the outcome of the game. As Hirose (2001, p. 292) pointed out, "the body may change with tools [and these] changes in the body may alter the observer's action capabilities, and thus the observer must adjust perception of affordances to these changes in order to fit the environment"– be it the real or the virtual one.

Research on the state of being embodied is, of course, also necessary to understand human interaction with computer games. Dourish' (2004) approach is of utmost importance in this context as it successfully captures the socially embodied nature of people's interaction with computer-based interfaces. Drawing on embodied and situated cognition theories, Dourish views the human interaction with computers as an activity that is socially distributed, embodied and inseparable from the complex cultural environments people live in (cf. also Hutchins, 1995b; Hollan et al., 2000). This perspective can help us understand the human interaction with computer games since game play in many different ways is an embodied activity that is socially distributed across player(s), game world and input/output devices. The identification with a game character seems, for example, to be fundamentally related to the physicality of having a body, which manifests itself in a player's *Game Ego* (Wilhelmsson, 2006). The Game Ego shares some similarities with the concept of *presence* as discussed in the field of virtual reality since both the identification with a game character and the experience of presence are believed to be rooted in people's bodily interactions with the world (e.g. Biocca, 1997; Carassa et al., 2004). The embodied and distributed nature of the human mind also becomes visible in how people make use of their surrounding environment. Kirsh and Maglio (1994) showed, for instance, that people playing TETRIS use the video game's screen to decide whether or not an L-shaped brick fits in between other bricks by rotating the brick directly on the screen; they argued that the physical rotation considerably reduces the cognitive workload than if the rotation would have to be performed mentally. The social dimension of the embodied mind, in addition, becomes particularly apparent when people go online to practice their skills and to learn from others and develop advanced divisions of labour.

However, these examples cannot hide the fact that research on game play from this perspective is not very advanced yet. The field of HCI is still mostly concerned with the instrumental use of computer applications and the field of game studies has not yet paid much attention to the player and his/her interactions with the game (Ermi & Mäyrä, 2005). Also, researchers from the social and psychology sciences are generally more concerned with human behaviour and the human mind in general and not with computer game play as such.

3.4 HCI and computer game play

The human interaction with computer-based interfaces has become a greatly increased research area in recent years with computer games adding just another complex dimension to it. Research on computer games, however, requires more than the mere application of existing methods and theories to the computer game domain. This became quite apparent throughout the discussion of the usability concept (cf. section 3.2). Research on games in HCI also suffers from a quite limited understanding of computer games and game play since computer games often simply are viewed as somewhat different software applications that are designed for fun while many dimensions of computer games and game play are being ignored (cf. 2.2.2 and 2.3). A HCI perspective on games is nontheless necessary as it addresses questions concerning the game interface and people's interaction with it. As we have seen, there is ongoing research in this area which has the undeniable potential to contribute to a more thourough and balanced understanding of human use of and interaction with computer games (cf. section 3.3).

Given my research interest particularly Dourish' (2004) embodied interaction approach requires further elaboration since in his approach the human interaction with computer-based interfaces is grounded in philosophical and sociological claims about the embodied and situated nature of the human mind. Theories of embodied and situated cognition are intended to provide the theoretical foundation for my future research on human interaction with games, which makes it necessary to explore and describe in more depth these two current lines of theoretical thinking in the area of cognitive science.

4 Embodied and situated cognition

For quite a long time, cognition has been believed to be the product of internal (individual) processes, comparable to the symbol-manipulating processes of a computer (e.g. Pylyshyn, 1990). Accordingly, the focus in cognitive science has largely been on information and its mental representation and processing, thereby often reducing an agent's interaction with the surrounding environment to nothing but a set of interactions between external stimuli, mediating internal (symbolic) knowledge, and behavioural responses. In recent years, however, there has been a shift within parts of the cognitive science community, leading to approaches and perspectives where in particular the interaction between agents and their environment is in focus (Hutchins, 1995a; Clark, 1997). Drawing attention from the individual to individuals acting in a sociocultural context, much research indicates that the cognitive processes of human beings cannot be understood without taking into consideration the social and situated nature of human cognition. But not only the individualistic perspective has been questioned; many researchers are also opposed to dualistic and functionalist viewpoints, which in different ways presuppose the separation (non-relatedness) of mind and body. Going beyond this perspective, it has been argued that body and mind cannot be separated, since they strongly affect and depend on each other (e.g. Varela, Thompson, & Rosch, 1991; Clark, 1997).

Today, there is an increasing awareness of the cultural, embodied and situated nature of human cognition in different scientific fields of cognitive science. Theories of embodied and situated cognition, in a nutshell, are largely based on the idea that human thought and action are situated, in the sense that "what people *perceive*, how they *conceive of their activity*, and what they *physically do*, develop together" (Clancey, 1997, p. 1). The sharp distinction between different kinds of knowledge (explicit vs. tacit) is being questioned and the boundaries between 'in here' and 'out there' have become blurred. As Thelen, Schöner, Scheier, and Smith (2001, p. 1) put it, cognition

> arises from bodily interactions with the world. From this point of view, cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capabilities that are inseparably linked and that together form the matrix within which reasoning, memory, emotion, language and all other aspects of mental life are meshed.

4.1 Definition(s) and trends

The relation between embodied and situated cognition, though, is far from being clear or well-defined. Embodiment approaches bear many similarities to situated approaches to cognition and activity as many of the underlying assumptions in situated cognition and embodied cognition are closely related and to a considerable extent also have the same historical roots (e.g. von Uexküll, 1928; Vygotsky, 1932; Dewey, 1938; Mills, 1940; Piaget, 1969).The notions of situated cognition and embodied cognition are often used in an interchangeable way while at other times they are used to express different ideas and views. Anderson (2003), for instance, considers sociocultural situatedness to be one of the most complex aspects of embodied cognition, which according to him has led to a point at which the division between *embodied* and *situated* cognition does not really make sense anymore. Clancey (1997), for his part, does not distinguish at all between situated and embodied cognition. In his concept of *situated cognition*, Clancey has acknowledged and taken into consideration *both* the embodied *and* sociocultural nature of human cognition:

> [C]ognition is situated, on the one hand, by the way conceptualizing relates to sensorimotor coordination and, on the other hand, by the way conceptualization, in conscious beings, is about the agent's role, place, and values in society. Thus, situated cognition is both a theory about mechanism (intellectual skills are also perceptual-motor skills) and a theory about content (human activity is, first and foremost, organized by conceptualizing the self as a participant-actor, and this is always with respect to communities of practice) (pp. 27–28).

Mataric (2002), on the other hand, described *situatedness* as "existing in, and having one's behavior strongly affected by [. . .] an environment" and *embodiment*, in contrast, as "a type of situatedness". Embodiment, she argued, "refers to having a physical body and thus interacting with the environment through the constraints of that body" (p. 82). At first glance Mataric's approach seems to have some similarities to Clancey's idea of situated cognition as both have integrated embodiment cognition in the concept of situatedness, but it is nonetheless very obvious that Mataric and Clancey have a different perspective on situated cognition. For Mataric (2002), there is still a clear distinction between agent and world; here, we have the agent being affected by the environment, there, we have the objective and independent world outside. Clancey (1997), on the other hand, questions this well-defined distinction by making the agent an active part of its social, cultural and physical environment.

Despite differing ways of attending the issues of embodied and situated cognition, however, there exist a number of features that generally are associated with both perspectives. Wilson (2003), in an attempt to distinguish and evaluate central views on embodied cognition, identified *six different claims* that in one way or another run through the literature on embodied and situated cognition: (1) Cognition is situated, (2) Cognition is time-pressured, (3) We off-load cognitive work onto the environment, (4) The environment is part of the cognitive system, (5) Cognition is for action, and (6) Off-line cognition is body-based.

4.1.1 Cognition is situated

The first claim is one of the cornerstones in the theoretical frameworks of embodied and situated cognition (e.g. Clancey, 1997; Clark, 1997; Kirshner & Whitson, 1997; Ziemke, 2002). Cognitive activity is situated as it takes place "in the context of a real-world environment", "in the context of task-relevant inputs and outputs", thereby inherently involving perception and action Wilson (2003, p. 626). Wilson (ibid.), nonetheless, criticised that some authors have gone so far as to claim that there is no activity that is not situated (cf., e.g. Lave & Wenger, 1991). By viewing cognition as being situation bound, she argued, a "large portions of human cognitive processing are excluded" (p. 626). According to her, cognitive activity is sometimes unaffected by the ongoing interaction with the environment (e.g. day-dreaming, remembering) and, hence, is not situated but takes place 'off-line'.

Wilson's interpretation of the term 'situated' illustrates a fundamental dilemma in the field of cognitive science. Situated is often interpreted in the sense that an action is grounded in the concrete situation (context) in which it occurs, which evidently is an oversimplification of the concept. Rather than viewing a person as being *in* an environment ("like a cherry in a bowl", as once Dewey put it), situated cognition views the activities of person and environment as "parts of a mutually-constructed whole" (Bredo, 1994). In order to understand human cognition we cannot just look at separated, isolated parts such as the individual brain, but we have to view cognition as a dynamic process that emerges over time and in interaction with people and artefacts (Hutchins, 1995a; Clark, 1997). Broadly speaking then, individual actions cannot be explained without taking into consideration what other people are doing and their shared, over generations developed knowledge and understanding of the world. For instance, when a person leaves a message on the desk for her co-workers the information becomes part of a social activity and individual knowledge becomes shared knowledge. The concept of situated cognition consists, in other words, also of a strong social dimension, which can be the social interaction with others, the cultural and social knowledge incorporated in artefacts and tools (Preston, 1998), but also the individual's 'membership' in various communities of practices (Lave & Wenger, 1991).

4.1.2 Cognition is time-pressured

According to Clark (1997), the human mind needs to be understood in terms of how it works under the pressure of real-time interaction with the environment. All of us usually have to deal with many different things at the same time which seldom gives us the time to come up with a smart plan or action. It is now argued that humans, instead of relying on some mental (objective) representations of the world, simply use the "world as its own best model" (Brooks, 1991, p. 139). This way of argumentation is rooted in the research field of artificial intelligence where traditionally artificial intelligence models are given the opportunity to build and manipulate complex internal representations. In the real world, it is argued now, is no time for such a time-consuming behaviour; instead, an agent has to cope with the environment constantly and as fast as it perceives its surroundings. For example, a person playing TETRIS mostly rotates the bricks directly on the screen instead of doing it mentally (Kirsh & Maglio, 1994).

Wilson (2003) is somewhat opposed to the second claim as there are sometimes situations in which we are not at all under time-pressure, for instance, when we make us a sandwich. The concept of time-pressure, however, is here closely related to how an observer perceives this particular sandwich-making situation, which also has been recognised by Wilson to a certain degree. The person who in fact makes herself a sandwich is still under (indirect) time-pressure, because as soon as she would start thinking about how to make this sandwich she would "fall apart" – and would presumably still be hungry. Perceptuomotor coordination of any kind is always and in every situation an activity under time-pressure.[5]

4.1.3 We off-load cognitive work onto the environment

The idea of using the world as its own model is closely related to the third claim according to which people off-load cognitive work onto the environment. People constantly off-load cognitive work onto the environment as a consequence of limited cognitive capacities, and by taking advantage of the environment people relieve their cognitive workload by letting the environment hold information for them (e.g. Clark, 1997; Kirsh, 1995, 1996). People use, for instance, to write down telephone numbers simply because they have a hard time remembering them. As Clark (1997) pointed out, we can allow ourselves to be 'stupid' because we know how to arrange and use the surrounding world to our advantage. That is, "mind is a leaky organ, forever escaping its 'natural' confines and mingling shamelessly with body and with world" (p. 53). Norman (1993) defined those tools storing and manipulating information as 'cognitive artefacts'[6], and in the following years there has been a growing interest in how artefacts (tools) affect human cognition (cf. Clark, 1997, 1999; Hutchins,

[5] The increasing awareness that cognition most of the time is time-pressured has also led to a heated debate in which the existence of mental representations is being seriously questioned (e.g. Brooks, 1991).

[6] Neither the term artefact nor tool or tool use are particularly well defined, despite numerous definitions in different research areas, which mainly is the result of differing interests and focuses (e.g. Preston, 1998; Neuman & Bekerman, 2000)

1995a; Preston, 1998). Artefacts play, for instance, an important role as organisers as they make information available and visible, e.g. a post-it on the desk, but they also contribute to coordination, cooperation and structure on a social level (Rambusch, Susi, & Ziemke, 2004).

Wilson's perspective (2003) on this aspect of human cognition is somewhat controversial. Offloading parts of the task onto the environment is, according to Wilson, a process that only occurs when the stimuli and the task are new, that is, when we are forced to function on-line and cannot rely on our previous experiences and memories. When functioning on-line, Wilson (ibid.) argues, we off-load parts of the new task onto the environment to minimise the cognitive workload in our short-term memory. The use of storing devices such as diskettes or books, on the other hand, has also been acknowledged by her as some kind of off-loading, but it is according to Wilson (ibid.) not involved in the process of on-line thinking. Doing math with pencil and paper, accordingly, is also considered to be mainly an off-line process as the physical activities involved in the process of calculating are not situated in terms of Wilson's interpretation of a situated (on-line) process. These activities are according to Wilson (2003) performed "in the service of cognitive activity about something else, something not present in the immediate environment" (p. 629). This is also the case when someone is gesturing while speaking to others as it helps the speaker, according to Wilson (2003), "to grease the wheels of the thought process that the speaker is trying to express" (p. 629).

Yet, the manipulation of objects (e.g. the use of pencil and paper) is also a situated process because it involves "the manipulation of spatial relationships among elements in the environment" (p. 629). With other words, doing math with pencil and paper is an off-line process (not situated) because it is about something not present in the environment and it is an on-line process (situated) because it involves the manipulation of objects in the environment. Clearly, the distinction between off-line and on-line cognition is somewhat problematic because neither we nor Wilson can really tell where exactly the line goes between on-line and off-line cognition. Instead of trying to find a line that might not even exist as cognition appears to be a process with changing boundaries, an increasing number of researchers has begun to study and analyse how the use of artefacts and other external structures in the environment is involved in cognitive activity. It is also questionable whether the terms 'off-line' and 'on-line' cognition in themselves really provide much help in our understanding of human cognition as the underlying implication, once again, is the dualism of body and mind. The human mind is not a computer that can be turned off and on and that functions independently and unaffected from its environment.

4.1.4 The environment is part of the cognitive system

The observation that both the body and the environment have an assisting role in cognitive activity has led some researchers to claim that cognition is not the activity of the mind alone, but is instead distributed across mind, body and environment (e.g. Hutchins, 1995a; Clark & Chalmers, 1998). Accordingly, it has been argued that in order to understand cognition scientists must study the situation and the situated cognizer together as a unified system. This way of thinking has, for instance, found its way into the field of HCI (cf. section 3.3). The idea of individual and environment together being the main unit of analysis, however, has been heavily under attack ever since this idea was formulated (e.g. Adams & Aizawa, 2001; Neuman & Bekerman, 2000). Although most researchers do agree on the first part of the claim, that is, that external structures such as artefacts have a considerable effect on a person's cognitive processes, it seems clear to Wilson (2003) "that a strong view of distributed cognition – that a cognitive system cannot in principle be taken to comprise only an individual mind – will not hold up" (p. 631). Susi, Lindblom, and Ziemke (2003), in contrast, argued that the main issue is not where to draw the boundary of cognition, but that it is more important to attend the role of artefacts themselves in cognition as they play a considerable role in human thinking.

4.1.5 Cognition is for action

Both embodied and (most) situated approaches to cognition and activity consider cognitive mechanisms in terms of their function which is "to produce the next action" (Franklin, 1995, p. 412). The mind, accordingly, is the control structure of individuals, and all cognitive processes and senses "must be understood in terms of their ultimate contribution to situation-appropriate behaviour" (Wilson, 2003, p. 626). Unlike the information-processing mind in traditional paradigms which takes in and processes ready-made pieces of information (knowledge) from the objective world, the embodied mind "operates on sensations to *create* information for its own use" (Franklin, 1995, p. 413, original emphasis). Information (knowledge), thus, is not the result of mere symbolic thinking but structurally coupled sensorimotor activity, or to say it with the words of Maturana and Varela (1987), "all doing is knowing and all knowing is doing" (p. 26). Action and manipulation seem, for example, to be fundamental for acquiring knowledge about and the use of objects as the identification (naming) of objects activates premotor areas typically associated with visuomotor transformations for grasping and manipulating objects (Grafton, Fadiga, Arbib, & Rizzolatti, 1997), which clearly shows the mutual, close relation of action and thought.

This perspective is closely related to ecological viewpoints on cognition and object manipulation (Gibson, 1979). From an ecological point of view, *perception is an active process* and all information necessary can be found in the environment, that is, one knows how to use a chair because the chair affords a particular behaviour, not because s/he makes use of a mental categorisation that tells her what a chair is and how it can be used. In other words, there is no perception without an action, and there is no action without perception, only through perceiving and acting knowledge evolves. Scientists use the term affordances often in different ways. Some scientists, for instance, claim that the affordances of an object depend on the context, that is, if we need to change light bulbs the chair does not only afford sitting but also standing (Rookes & Willson, 2000). In other cases, e.g. in Gibson's original theory of affordances, affordances appear to be independent of contextual aspects as only the physical appearance of objects seems to matter, in the sense that a flat surface affords standing and walking while a graspable object affords throwing (Hirose, 2001). Hirose, for his part, described affordances in terms of "opportunities for action that objects, events, or places provide for an animal" (ibid., p. 290) to clearly show the close and mutual relation of agent and environment, that is, affordance is even from this point of view context-dependent as the actions taken by the agent determine how a certain object is perceived. Hirose's concept of affordance differs from other perspectives on affordance in that it also accounts for properties of the agent, called *effectivities*. Effectivities are defined by Hirose (ibid.) as "means for acting that an animal can use to realise a specific affordance" (p. 290), i.e. a graspable object only affords throwing if the agent has the arm to throw with.

4.1.6 Off-line cognition is body-based

The claim that cognition is for action is, along with the third claim, also directly related to the claim according to which all off-line cognition is body-based. The last claim is largely based on the idea that all kinds of cognitive activity, even activity that might be decoupled from the environment, is grounded in bodily activity that has evolved in interactions with the environment. Counting on one's own fingers, for instance, is an activity in which parts of the environment and the body are used to solve a certain problem. This activity can also be done in a more subtle manner, that is, in a way in that only the one who is counting can keep track of the fingers. It seems, however, that this kind of activity also can be performed successfully without really moving the fingers. According to Wilson (2003), many cognitive activities make use of this kind of strategy, i.e. the priming of motor programs without triggering any overt bodily activity. With other words, it appears that mental structures that originally evolved in perception-action-loops at times also run "off-line" and decoupled from the environmental inputs and outputs. Generally spoken, "the function of these sensorimotor resources is to run a simulation of some aspect of the physical world, as a means of representing information or drawing inferences" (Wilson, 2003, p. 633). However, in contrast to Wilson (ibid.) who views sensorimotor simulation merely as *one form* of cognitive ('off-line') activity (e.g. mental imagery, episodic memory), there are other scientists according to whom *cognition in general* is the result of internal simulations of perception and action (e.g. Hesslow, 2002). In terms of this point of view, there is no difference between cognition on the one hand and perception and action on the other since cognition is viewed as being "inherently perceptual, sharing systems with perception at both the cognitive and the neural levels" (Barsalou, 1999). This is also in line with Glenberg (1997) who argued that the traditional view of memory as a storage device for abstract representations needs to be replaced by a view of memory "as the encoding of patterns of possible physical interaction with a three-dimensial world" (p. 1).

Even though no consensus exists as to what extent human thinking is the result of perception-action simulations, there is a growing number of studies providing solid evidence that human cognition is inextricably intertwined with perception and action. A number of studies indicates, for instance, that our language is deeply affected by and rooted in everyday bodily experience (e.g. Lakoff & Johnson, 1980; Rizzolatti & Arbib, 1998; Roth, 2005). Recent findings in neuroscience also suggest that a shared understanding between individuals is grounded in the human ability to recognise and simulate the actions of conspecifics (Rizzolatti, Fadiga, Fogassi, & Gallese, 2002). The body is also frequently used in human communication and social interactions (Goldin-Meadow, 2003) and serves as an important tool in developing and understanding abstract concepts and knowledge (Lakoff & Johnson, 1980; Roth, 2002).

4.2 A cognitive perspective on game play

Cognition is a continuous process with changing boundaries and is consequently much more than what takes place within the individual mind. Cognition, thus, cannot be understood without taking contextual aspects such as the use of environmental resources into consideration. There is also increasing evidence to suggest that cognition is deeply rooted in and inextricably intertwined with bodily activity.

The embodied and situated nature of human thinking needs, of course, to be taken into consideration when studying game play in terms of actions and cognitions. Gameplay is by no means an activity which takes place inside a virtual cyber-vacuum, but it is largely shaped by the player's bodily experience and his/her interactions with the surrounding environment. As we have seen in section 4.1.1, EC and SC view the activities of person and environment as parts of a mutually-constructed whole, which means that is not enough to study the player and the game (interface) separately since neither can be fully understood without the other. The interface alone, even though it plays an important part in the game, would not tell us much about the ongoing gaming activity, because without a human being or a device that can provide feedback there would not be any interaction at all. The player's actions, on the other hand, must also be studied with regard to the interface; it affords not only certain actions (cf. section 4.1.5), but also holds and distributes information (cf. section 4.1.3 and 4.1.4). In the following embodied and situated aspects of the human interaction with games are discussed more in detail.

4.2.1 Off-loading activities in game play

The offloading of cognitive work onto the environment has been proven to be an essential part of human thinking (cf. section 4.1.3), an aspect that also needs to be taken into consideration when studying game play. For example, in Escape from Monkey Island (EFMI), you get a sheet with clock times and compass headings on it, which comes in handy when you try to find your way through a marsh. The only problem is that the sheet is not visible during the navigation through the marsh, which requires you to keep all the clock times and compass headings in mind (see Figure 2). From own experience I know that this is not an easy task and after having gone in the wrong direction for the tenth time I got tired of it and wrote all necessary information down on a piece of paper. This is a very clear example of how we off-load cognitive workload onto the game environment, which in this case also included a piece of paper.

Figure 2: Navigating through the marsh can be tricky

Some people, however, might consider this cheating since a piece of paper is not part of the game as designed by the game developers (cf. Kücklich, 2004; Consalvo, 2005). The game-structure (the rules of the game) can, in other words, also affect the ways in which computer game players make use of their game environment. The example might even display a serious usability problem because the game interface prevents you from structuring the virtual environment. Most researchers interested in usability aspects would thus probably argue that, because of limited cognitive capacities, computer games need to be designed in a way that does not require extensive structuring of the game environment. It might not be as simple as it sounds, though. Computer games that do not require people to off-load parts of their cognitive work onto the environment may not always be that successful as one might expect. The constant and active adaptation of our environment is part of what we are, who we are and is subsequently also a very important part of our interactions with computer games because it allows us to be active rather than reactive.

Still, many computer games do not offer many opportunities for the off-loading of mental workload onto the game environment, and people playing computer games are often also distributed over several locations and time zones. An interesting and relevant question accordingly is how people deal with at times static virtual environments that allow very little or no adaptation at all, how and under what circumstances they use environmental (virtual) resources as cognitive aids and to what extent off-loading extends into the 'real world', which might also include other people. Many games such as StarCraft and Counter-strike are team efforts and teams can develop complicated strategies and advanced divisions of labour.

4.2.2 The body in game play

Human thinking is largely related to bodily experience (section 4.1.6), which of course also has an impact on game play (cf. section 3.3). In computer games it can cause considerable confusion, though, since you often have two bodies: a physical one and a virtual one. Which arrow key would you, being Guybrush Threepwood in EfMI, press to move to the right (see Figure 3)? "From *his* perspective or from *my* perspective", you might ask. Well, that is the problem here – if you want go to the right from *your* point of view you have to picture yourself as *Guybrush* and press the *left* arrow key.

Figure 3: Moving to the right – which arrow key to press?

Obviously, controlling a game character witht the arrow keys on a keyboard is not that easy, something that also might explain the success of the more intuitive, graspable game pad. Controlling a character with an analog thumb stick is often experienced as being more 'natural' since the movement of the hand to some extent mirrors the body's movement. The most natural ways of moving in and through a virtual environment, however, would probably be provided by input/output devices that allow the player to move as they do in the real world, that is, instead of controlling a character with the buttons on a keyboard or game pad the player would ride a bike, walk on a 'walk pad' or use the game controller like a tennis racket. Controlling a character with more intuitive input devices might also make it easier to avoid confusions as described above since the activity of, for instance, walking might facilitate and enhance the identification with a game character.

These are basically just plausible guesses, though. So far, very few empirical studies have been carried out concerning the impact of different input devices on people's game play and gaming experience.[7] Moreover, people playing games can often play for hours without realising the time spent, which, of course, is not possible if they actually have to walk. No one has the energy for such an extreme playing session. Also, people who sit in front of their computers can eat and play simultaneously which a person riding a bike would probably find somewhat difficult. Many games with their game structure and game world are thus likely not fitted for 'natural' control entities. This raises important questions regarding the impact of different control entities on game play in terms of gaming

[7]The idea of providing players with more intutive game control devices seems, nonetheless, to be rather intriguing, which, for instance, explains the recent development of movement-sensitive controllers such as Nintendo's Wii or Sony's Playstation 3 (will be launched late 2006 to early 2007).

experience and performance (cf. section 3.3). More intuitive interactions with computer games might not only be related to more 'natural' kinds of input devices, but also to other game play aspects that, so far, have not been recognised yet.

There is also an increasing number of studies providing significant evidence that a shared understanding between individuals is grounded in the human ability to recognise and simulate the actions of con-specifics. A shared understanding between clan members in games such as StarCraft and Counter-strike should thus be based on the same underlying mechanisms. Still, clan members are often distributed over several locations, that is, the actions that need to be understood are supposingly the actions and movements of a game character, not the ones of a human being. This seems not to be a larger problem, though, since an interview with a hardcore Counter-strike player (cf. Ip & Adams, 2002) indicated that there are players who are able to recognise their online-peers by means of how their avatars move and play. This makes you, nonetheless, wonder what those players actually recognise, because it cannot be the distinct movement of a game character. Humans are very good at recognising biological motions (Johansson, 1973), but the motions of game characters usually display only one type of motion pattern, that is, it cannot be the motions alone those Counter-strike players recognise and understand.

5 Studying human-computer game interaction

Computer games have become a major factor greatly affecting society, politics, and the everyday lives of people. An increasing number of people spent more time in 'virtual worlds' than what they do in the 'real world' (Castranova, 2001) which is a very good indicator that computer games have become a thriving and lifestyle changing part in those people's life. This has not gone unnoticed in the scientific community and now computer games are a priority on many research agendas.

Games are being approached from a wide range of perspectives, but since game research is still a very young discipline, no clear consensus exists on what to study and which methods to use. Inspite of various approaches to computer games, however, developments towards certain directions exist. In the field of game studies, the focus has mostly been on the games themselves, that is, the game structure and the game-world, while the social and psychological sciences have been more interested in both the negative and positive effects of computer games on people (cf. section 2). In the field of HCI, the understanding of games and game play is rather limited and superficial even though games are being addressed from many promising research directions (cf. section 3). Surprisingly and for largely incomprehensible reasons, research on games with the player and the activity of playing in focus has so far been very rare in the different research fields. This has both its advantages and drawbacks; this 'void' in game research opens up a wide range of opportunities for research on this particular issue, but it makes it also difficult to decide where to start in studying human interaction with computer games.

5.1 General research questions

Having a background in cognitive science, I would like to argue that an embodied and situated cognition perspective can greatly broaden our understanding of how an (on the surface) individual game play in front of a computer is distributed across different places and persons, how people, inspite of sometimes limited interaction techniques, communicate with each other, how they learn from each other, how they make sense of and solve problems in virtual environments provided to them. Throughout the paper, but in section 4.2 in particular, I have identified a number of questions and problem areas that will serve as research guidelines in the years to come:

(1) What does the game environment afford to a player in terms of action opportunities and how does this affect game play in terms of performance and game experience?

(2) How and under what circumstances do people use environmental (virtual) resources as cognitive aids when playing a computer game and to what extent extend off-loading activities into the 'real world'?

Both questions are, of course, closely interrelated since the operational part of game play, that is, how we physically use the interface, also has an impact on how we interpret the game-world and, subsequently, how we make use of environmental resources. *The overall issue, accordingly, is the detection and study of affordance patterns in computer game play.* On a general level, the intention is to integrate theories in the area of cognitive science into the area of game studies, i.e. the aim is to further the understanding of *computer games* and *the activity of playing them.* The intention is not to simply use computer games as an area of application for embodied and situated cognition theories, but these theories shall provide the theoretical foundation for the exploration and identification of some of the underlying mechanisms involved in computer game play.

It might be worth discussing what kind of computer games I actually have in mind when referring to the human interaction with computer games. There exist important distinctions between games played on handhelds, PC's or consoles (cf. section 2.2). However, so far, we know very little about people's off-loading activities in game play and what actions different game interfaces afford, which is why a broad approach is needed to gain a deeper understanding of human interaction with computer games. The focus, subsequently, is on PC, online, and console games. Without a doubt, this leaves a lot of games to choose from, but at this research stage I cannot limit myself to a specific game genre without risking missing crucial aspects.

5.2 Work in progress and future work

This paper can be considered an important first step towards a better understanding of the human interaction with computer games as open questions and problems have been identified. Future steps involve both *empirical* and *theoretical* research to find answers to some of those questions.

Work in progress An important part of my work during the last couple of months has been the presentation of research findings, which includes a number of articles and abstracts that have been submitted to journal for publication and various conferences and workshops:

- Rambusch, J., & Ziemke, T. (2005a). *Embodiment aspects in human computer-game interaction.* The European Conference on Computing and Philosophy, E-CAP 2005, Västerås, Sweden [Oral presentation].
- Rambusch, J., & Ziemke, T. (2005b). The role of embodiment in situated learning. In B. Bara, L. Barsalou, & M. Bucciarelli (Eds.), *Proceedings of the 27th Annual Meeting of the Cognitive Science Society.* (pp. 1803–1808). Mahwah, NJ: Lawrence Erlbaum.
- Rambusch, J. (in press). Situated learning and Galperin's notion of object-oriented activity. The 28th Annual Conference of the Cognitive Science Society. Vancouver, BC, Canada, July 26-29, 2006.
- Rambusch, J., Jakobsson, P., Pargman, D., & Ziemke, T. (submitted). Understanding computer games: The integrative gameplay framework. (Submitted for journal publication)
- Rambusch, J., & Ziemke, T. (to appear). *The embodied and situated nature of computer game play.* Workshop on the Cognitive Science of Games and Game Play, Vancouver 2006 [Oral presentation].
- Rambusch, J. (to appear a). Riding a bike in Paperboy: A case study. Accepted for presentation at "The Virtual – a room without borders?", 15th–16th September 2006.
- Rambusch, J. (to appear b). *The situated nature of computer game play.* Graduate Student Conference in Cognitive Science, Montreal 18–21 august 2006 [Oral presentation].

Most of these publications have been concerned with theoretical issues and open questions, however, empirical studies have been an essential part of my work as well. One of the questions identified in this paper has been what different game interfaces afford to players in terms of action opportunities and how this affects the outcome of the game and the game experience. A case study has thus been undertaken to investigate the *impact of different input devices* such as game pad and a modified training bike on people's game play (Rambusch, to appear a). The main hypothesis is that people controlling the game PAPERBOY with a game pad play the game in a different way than do people who control the game character with the modified training bike. The analysis of the data collected is in progress. I'm also involved in a number of other studies which study different aspects of game play. One of these studies intends to investigate *expertise and learning processes* in FPS games such as COUNTER-STRIKE, while another intends to explore the *affordance of sound* in game play.

Large parts of the studies have been (will be) undertaken in the game research lab at the University of Skövde, which is specifically designed for research on the human use of and interaction with computer games. The laboratory is equipped with video surveillance technology to monitor and record user activities and all technology necessary to play computer games on different platforms with different kinds of control systems (e.g. game pad, keyboard).

Future work Theories of embodied and situated cognition provide the basis for research on game play, however, these theories need to be more explored with regard to the questions identified throughout this paper. The next steps involve the writing of a thesis proposal and thesis methods as well as more in-depth discussions and presentations of research findings.

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