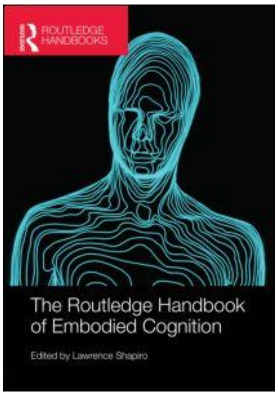

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Embodied Interaction, Coordination and Reasoning in Computer Gameplay

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18

EMBODIED INTERACTION, COORDINATION AND REASONING IN COMPUTER GAMEPLAY

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Embodied cognition has received increasing interest, as seen in research on the many subjects ranging from sensorimotor processes to cultural aspects (e.g. Clark, 2011; Gibbs 2005; Robbins and Aydede, 2009; Shapiro, 2011). There is no one unified conception of the mind, but a general claim is that cognition is grounded in bodily experiences and is distributed across brain, body and environment (e.g. Clark, 1997, 2011). Cognition is a complex phenomenon, and as stated by Gibbs (2005, p. 9), it is "what occurs when the body engages the physical, cultural world and [it] must be studied in terms of the dynamical interactions between people and the environment." This chapter will discuss embodied interaction, coordination and reasoning in computer gameplay, and the construction of a cooperative two-player computer game to accord with the embodied nature of cognition and action. The computer game discussed here, "The search for the gold reserve," was developed specifically to be installed as an integral part of an adventure tour in a military fortress. The game was constructed so that players' whole bodies would be engaged in the gameplay, thereby enhancing the gameplay experience. Playing the game is an "embodied practical activity" (O'Connor and Glenberg, 2003) comprising a mesh of interrelations between the player's own body, co-players, the players' cognitions, game devices and the physical context of gameplay, virtual environment and sociocultural aspects. Hence, interaction will be considered in terms of players' interactions in the real and the virtual environment, in which coordination is essential for solving the tasks encountered in the computer game. As players coordinate their cooperative actions to solve the tasks encountered in the virtual environment, reasoning comes forth as an embodied process with a close intercoupling between players' perceptions and actions (to include language would reveal further aspects of embodiment, but language is not in focus here[1]). The discussion will bring out sensorimotoric, contextual and sociocultural aspects of embodiment,[2] as embodiment concurrently cuts across the different aspects. Sensorimotoric aspects are mainly discussed in relation to the game's input/output devices, and the intercoupling between players and the game. Contextual aspects are brought forth by the game environment and the game's relation to the whole adventure tour, and sociocultural aspects come to the fore through players cooperative problem solving. The different aspects are not discussed separately, but rather as they occur, intertwined, during the gameplay.

Computer game and setting

The computer game was developed to be a part of an adventure tour in an old military fortress located in Karlsborg (south Sweden) (the game development project is described in Wilhelmsson *et al.*, in prep.).[3] The fortress itself was built during 1819–1909, and it is now a base for military garrisons, but its unique features have also made it quite a tourist attraction. The adventure tour integrates historical environment, facts, a semi-fictional adventure story and a computer game. Hence, the computer game is set in, and reflects (through its design of graphics), a historically correct environment. The framing story and the different elements of the tour are designed to smudge the borders between the physical environment (the fortress) and the virtual world. The overall scheme of the adventure tour is a search for the national gold reserve that has been stolen and relocated somewhere within the fortress. The framing story is also a battle between good and evil, where visitors are intended to feel they are helping the heroes to find the gold and to reveal the villain. The scene is set by an opening 3D movie[4] with live actors, which provides the historical context for the tour and introduces the characters involved. The heroes of the adventure are two siblings, a boy and a girl, and the villain is Sgt. Stålhammar. The gold reserve has been transported to the fortress in threat of war, but it has been stolen by a character called "the Rat," on behalf of Sgt. Stålhammar. The Rat has also drawn a map of the hiding place, and at the end of the movie, the map ends up torn in two pieces, with one part of it in the hands of Sgt. Stålhammar while the girl and the boy get hold of the other part. Then one of the hero characters, either the boy or the girl, appears as a game master (a young male or female) in the movie salon, and tells the visitors that Sgt. Stålhammar will be coming after them as well, since he has seen them. They all need to escape him, to help the hero/game master find the stolen gold. The game master then continues the adventure by bringing the visitors through some of the old parts of the fortress's vaults. The adventure tour includes, for instance, solving puzzle games, the computer game with renderings of the actual environment, and it finally comes to a dramatic ending in a treasure vault.

The computer game is played in pairs and it is constructed so that players stand side by side on a step platform facing a jDome, a large half sphere on which the game is projected (Figure 18.1). The game is controlled through the step platform[5] (by movement) with input/output functions, and a hand-held device attached to the step platform by a thin wire (a Gametrak[6]). The setting provides a game environment with eighteen jDomes, which makes it possible for up to thirty-six players to play simultaneously. In contrast to games controlled by, for instance, mouse and keyboard, the game construction allows players to control the game by bodily movements of arms/hands and feet (Figure 18.1).

Some of the requirements that had to be considered when developing the computer game were the target audience (children, 7–13 years of age), the playtime would be 10–15 minutes, there could be no violent contents and the game should not require any training, yet it should be intriguing. To create and withhold interdependency between the overall design of the tour and the game, Caillois's (1958/2001) taxonomy for games provided a basis, with the basic polarity between *ludus* (rule-governed play) and *paidia* (free play and improvisation) as the point of departure. The participants are part of a rule-governed, arranged adventure, but should also have the feeling of "free play" along the tour. As a narrative vehicle, the overall structure of the adventure tour is scripted and the outcome of events is completely determined before the tour begins, in terms of *what*, *how* and more or less *when*, things will happen. The different rooms included in the adventure tour (with e.g. problem-solving activities) were labeled *agôn* (skill), *alea* (chance), *mimicry* (to mimic) or *illinx* (vertigo) in order to create varied scenarios and experiences for participants. The same categories were also used for the design of the computer

Figure 18.1 The game is controlled through hand-held devices and a step platform, which facilitates a high degree of bodily movement. (Copyright Jan-Olof Fritze.)

game, where settings and characters from the opening 3D movie and the following parts of the adventure tour are integrated in the game environment. The game is designed in an arcade style, and it is quite self-explanatory, which is necessary as players only have one game session and no training. As visitors enter the game location, the game master informs them that the game is played pairwise and that it is controlled through the step platform and the hand-held devices. After the initial introduction, players grasp what to do very fast and once the game is on, their attention is focused on it, and the handling of control devices recedes into the background.

Embodied cooperation and reasoning

The game has three playable rooms, where players need to cooperate to succeed with different tasks. In the first playable room the task is to extinguish a fire with water hoses (Figure 18.2). Each player controls a water hose with the hand-held device, and water pressure is gained by moving on the step platform. Most players become intensely engaged in their movements and adopt different strategies of moving, such as "running" or jumping up and down. Regardless which strategy they chose, there is no obvious logic in how such movements could build up water pressure, but as discussed by Keating and Sunakawa (2011), digital technologies alter what is possible in virtual worlds and players adapt to interactions that "violate some of the constraints of physical spaces" (p. 195). Small movements of the hand-held device could be used to control objects on the screen, but that is not how players use it, or engage in the gameplay.

The pair of players in Figure 18.2, a boy and a woman, are aiming their water hoses towards the flames and their bodily orientation and the way they hold their control devices show they engage their whole bodies, not just performing small movements with their arms/hands. The boy to the left has put his hands together, holding the control device as if holding an object that requires the use of both hands, which would be the case had it been a real hose. As he aims the water hose to the left, he is turning his arms and upper torso to the left. His arms/hands are overly oriented to the left (the angle of hands/arms in relation to the orientation of the hose) as

Figure 18.2 Players cooperating to extinguish the fire. The hand-held device is connected to the step platform by a thin wire (not discernible). The woman standing behind the players is the girl hero character/game master. (Copyright Tommy Holl.)

if trying to convey the water hose even further to the left, although it is already as far to the left on the screen as possible. The woman on the right is slightly leaning to the right with her arms oriented to the right, and she is also holding the control device with both hands. The players coordinate their bodily movements to cooperate in extinguishing the fire by each focusing on different parts of it.

The step platform encourages players to also use their feet to control elements of the game, in this case to gain water pressure. Moving on the step platform provides a quite natural mode of action/interaction as players are standing on it, and running, jumping, etc., are the kind of actions that the object affords (Gibson, 1986). The step platform is also an output device that produces vibrations (of varying force) under the players' feet to create a sensation of vibrating ground. With regard to perception of the environment, Ingold (2011, p. 45) notes that "it is surely through our feet, in contact with the ground (albeit mediated by footwear), that we are most fundamentally and continually 'in touch' with our surroundings." As such, the step platform "grounds" players in the physical environment, but also in virtual space; observations show that most players run or walk on the step platform, when the game characters move on in the game environment. Further grounding in virtual space is developed through facing the large jDome screen, which has quite an immersive effect (further discussed below). The synchronized unfolding of events on the screen, input (movement) and output (vibrations), enhances the players' bodily gameplay experience and possibly the feeling of being "in" the game.

The game has verbal instructions for the fire-extinguishing task (a voice), but as players are solving the task, their real and anticipated bodily movement is shaped by their perception of what happens on the screen, rather than the voice, and the visual experience is a temporarily external pattern of skilful activity (Gibbs, 2005). When aiming the water hose to extinguish the fire, players are not performing abstract reasoning on how to solve the problem, or calculating the best angle for where to aim the water hose (or trying out all possible angles of aiming), and they do not reason about how much movement is required to sustain enough water pressure. Rather, players "call on external resources to perform specific computational tasks" (Clark, 1997, p. 68), and resort to the more primitive task of action-perception (Shapiro, 2011). The task of aiming is performed directly on the screen, intercoupled with perceptions of body movements, water pressure/the water's reach, and the flames diminishing or growing in different spots. Hence, the graphical elements representing real-world objects, and the hand-held devices, temporarily become external resources for embodied reasoning on aiming and creating water pressure, and for solving the problem of how to extinguish the fire, without conscious, deliberate thinking. As such the graphical elements and the hand-held devices provide cognitive scaffoldings for solving the task, and the perceptual information guides the players' actions and allows epistemic actions that offload cognitive effort (Clark, 1997; Kirsh, 2009).

In the temporally bounded action of aiming (as well as the other tasks to be solved in the game), the boundary of cognition extends beyond the brain, and the problem-solving task is temporarily intercoupled with the physical and virtual environment. In the words of Wilson and Clark (2009), internal and external resources are fluently tuned and integrated, forming a "transient extended cognitive system" that incorporates technological and sociocultural resources. It is a one-off temporary relationship that "meshes the problem-solving contributions of the human brain and central nervous system with those of the (rest of the) body and various elements of local cognitive scaffolding" (ibid., p. 65).

Reaching into virtual space

In the next playable room, players have to cooperate to catch rats that are running away with gold coins in their mouths, and collect the coins. One player has to grab a rat by its tail and lift it up in the air so the co-player can take the coin from the rat's mouth. Each player controls a virtual hand that basically performs three actions – grab, lift, let go – which are brought about through the player's real-space arm/hand movements. A player does not need to make any wide arm movements to activate the virtual hand's grab, lift and let-go features, the virtual hand only needs to be positioned correctly on the screen, in relation to the rat and the co-player's virtual hand in the action sequence. However, similar to the previous fire-extinguishing task, in these cooperative tasks players coordinate and synchronize their body movements and actions in physical and virtual space, and the body becomes a resource for the players' cognitions in a tightly coupled action-perception loop. The task of catching rats is a high paced dynamical one, and players have to act fast to catch any of the rats that appear on the lower edge of the screen, running up the street ahead of the players.

Figures 18.3–6 show a sequence with two players interacting to catch a rat and take the coin from its mouth. The sequence begins as Player 2 (P2, to the right in Figure 18.3) has just grabbed a rat by its tail, and both players are focusing on the actions on the screen, which provides a joint attentional scene (Murray, 2006). P2's virtual hand is formed in a fist-like grip of the rat's tail, and he is lifting the rat upwards by lifting his own arm/hand and the control device. Meanwhile, Player 1 (P1) follows P2's movement by moving his arm/hand and virtual hand upwards to the right.

Figure 18.3 Player 2 (on the right) has just grabbed a rat by its tail and is lifting it up in the air, while Player 1 joins in by moving along his virtual hand. (Copyright Jan-Olof Fritze.)

In Figure 18.4, P2 then holds the rat up in the air so that P1 can move in to take the coin. P2 has raised his hand above shoulder height, and he is holding the control device with three fingers (thumb, index finger and middle finger) while the other two fingers are semi-extended. It is a precision grip that suggests he is literally holding the rat's tail with his own three fingers, rather than manipulating the device and the virtual hand to hold the rat. The gesture crosses the boundaries of real and virtual space, and the player's use of the hand-held device becomes an act of embodying (Hirose, 2002; Wilhelmsson, 2001), in which the device extends his capabilities of perceiving and acting in virtual space, and it ceases to be an object sensed for itself. A typical example of embodying discussed in the literature is a practiced blind person's use of a stick. As the person gets accustomed to using it, it is no longer sensed for itself – instead the stick becomes part of the body, through which the ground is perceived directly (Hirose, 2002). The use of the hand-held device, and by extension the virtual hand, extends the player's action-perception capabilities, although the player acts on visual feedback rather than haptic feedback as when probing with a stick. Considering P2's precise finger grip when holding the rat, the game is, as described by Grodal (2003), a medium for simulation of basic first-person experiences that allows an experiential flow "by linking perceptions, cognitions, and emotions with first-person actions" (p. 132). The simulation of holding the rat then, is an act of virtual embodying that allows reaching into virtual space.

There is a significant difference in P2's gesture and the fist-like grip of his virtual hand on the screen, which suggests the player tunes in on the *action* rather than identifying himself with the virtual hand. Through his gesture and arm movement he embodies the action of holding the rat by its tail in both real and virtual space, which also suggests that the boundary between real and virtual space is changeable. P1 is holding his control device in a different manner than P2 (lower edge, Figure 18.4), but neither is his hand congruent with his virtual hand. P1's virtual hand is wide open with fingers extended while his own hand is formed in a three finger precision grip,

Figure 18.4 Player 2 holds the control device as if holding the rat by the tail. (Copyright Jan-Olof Fritze.)

holding the device with the other two fingers folded along the others. It could be more cumbersome to hold the device with a more open hand, but the hand's configuration suggests he is also tuned in on the action rather than identifying himself with his virtual hand.

In Figure 18.5, P2 has lowered his arm/hand and the virtual hand somewhat, and keeps it rather steady, while P1 is moving his virtual hand closer. At first, P1 makes a few quick moves of his arm/hand up and down, and sideways, and the virtual hand overshoots the target. Both players then adjust and fine tune their arm/hand movements, and virtual hands, for horizontal alignment.

In Figure 18.6, the players have also adjusted their movements and reached vertical alignment of their virtual hands, and so P1 is now in position to grab the coin. The coordination of bodily movement and actions requires not only synchronization in virtual space, but also coordination of bodily movements in physical space. It is a cooperative game with players standing close to each other (with ground space restricted by the step platform), but it requires coordination so that players will not bump into each other or occupy each other's action space. The alignment of bodily movement, then, is directed towards the players themselves, towards each other and with regard to actions in virtual space.

Active participation and immersion

As discussed in the above examples, solving the tasks in the computer game requires cooperation, coordination and synchronization of actions in both real and virtual environment. While playing the game, players pay joint attention to events on the screen and even as they need to make prominent body movements, such as "running," they do not seem to be consciously aware of the

Figure 18.5 The players synchronize and align body movements and virtual elements, for Player 1 to be able to grab the coin that is glimmering in the rat's mouth. (Copyright Jan-Olof Fritze.)

Figure 18.6 The players have synchronized their virtual hands and the rat, and the coin can now be taken from the rat's mouth. (Copyright Jan-Olof Fritze.)

control devices. Rather, their use of the devices seems quite unaware and seamless and, in terms of Pine and Gillmore's participation-connection categorization (in Ermi and Mäyrä, 2005), the gameplay is an "escapist experience," characterized by *active participation* and *immersion*. Ermi and Mäyrä (2005) distinguished three dimensions of immersion in their SCI (sensory, challenge-based and imaginative immersion)-model of gameplay experience, which includes:

- *Sensory immersion*, which relates to the audio-visual surrounds of players. With modern technology – such as "large screens close to the player's face and powerful sounds" (ibid., p. 7) – real-world sensory information is easily overpowered and players become entirely focused on the game.
- *Challenge-based immersion*, which refers to the achievement of balance in challenges and abilities.
- *Imaginative immersion*, which refers to the (possible) use of imagination to empathize with characters or just enjoy the game's fantasy.

The whole gameplay session lasts only about fifteen minutes, yet the game has quite an immersive effect. Considering sensory immersion, players do indeed have a large jDome screen close to their face, there are powerful game sounds (voices and music) and the overall sound level in the game environment is quite loud when all game stations are occupied. However, sensory immersion in this case is not a matter of "audio-visual overpowering" of real-world sensory information, which is instead augmented by haptic feedback through players' feet. Also, the hand-held device provides real-world sensory information in that it is a hand-held object, and its use for controlling the game also strengthens the player's connection with the game's virtual world. Real-world sensory information then, is "built into" the game through the game's input/output devices, which accords with Ingold's (2011, p. 133) view, that "[h]aptic engagement is close range and hands on. It is the engagement of a mindful body at work with materials and with the land, 'sewing itself in' to the textures of the world along the pathways of sensory involvement."

Challenge-based immersion might not seem obvious, considering that the game is quite self-explanatory, only lasts a short time and the tasks to be solved do not require much learning or rehearsing. Yet the game is challenging enough to require certain motor skills (e.g. fine-tuning of hand-eye-control device-virtual element) and cognitive skills (e.g. focused attention and joint problem solving) in order to solve the tasks, which creates a balance between challenges and abilities.

Imaginative immersion might also seem less salient, especially if the game was considered in isolation. However, the game is part and parcel of the narrative that frames the whole adventure tour, and characters are carried over from one part of the tour to another. When the characters – heroes and villains, introduced in the opening movie – (re)appear as animations in the computer game, players recognize them and continue the adventure of pursuing the gold in the heroes' company, while continuing to avoid the villains. Imaginative immersion then, ensues from the game in combination with the overall narrative and structure of the adventure tour.

The different dimensions of immersion contribute to the positive gameplay experience in the present case (as confirmed by our investigations[7]). Ermi and Mäyrä (2005, p. 2) consider gameplay experience to emerge "in a unique interaction process between the game and the player." However, the gameplay experience discussed here emerges not just "between the game and the player," but rather from a unique interaction process that cuts across different aspects of embodiment, as mentioned in the introduction of this chapter. The structure and narrative of the adventure tour and its constituent parts are closely interwoven, and, as seen in Figure 18.2, all elements momentarily converge at the time of the computer gameplay. Characters and settings from the opening 3D movie and the fortress's milieu are present in the real and the virtual game environment, and the game master who appears both as an animated character in the game, and live (standing behind the players in Figure 18.2), is enacting and carrying out the overall narrative.

The gameplay experience also relates to the players' embodied experience of moving by their own feet through the entire adventure tour. According to Ingold (2011), the most fundamental mode of being in the world is "wayfaring" (as opposed to being "transported"), which he describes as taking place on a meshwork of paths along which the wayfarer moves. Albeit the tour is a micro-scale temporal event compared with a lifetime of wayfaring, the tour is metaphorically and literally a meshwork of paths. The individual game-player's embodied experience of "being in the game" is as much a socially and culturally embodied experience, as it is sensorimotoric; it comprises a rich interplay between the player's body-based cognitions, socially shared activity (e.g. joint problem solving), and cultural experiences, traditions and values (e.g. preknowledge of situations, customs; cf. Rogoff, 2003). As visitors move throughout the setting and engage in the gameplay, cooperating in the search for the stolen gold, they also share a social and cultural experience that intertwines mind, body and world.

Summary

The computer gameplay discussed in this chapter is very much an embodied process of coordinated interactions in physical and virtual game environment, and reasoning is a process that momentarily extends the boundaries of brain and body, and of real and virtual environment. While common game controls (e.g. mouse and keyboard) pose a challenge in that they delimit the use of bodily resources and modes of interaction, and possibly as a consequence, also players' cognitions, the computer game, "The search for the gold reserve," was constructed to enhance the gameplay experience by allowing players to act in accordance with the embodied nature of cognition and action. At the same time, the computer game, its construction and placement within the fortress's historical setting, and the gameplay experience, show that embodied cognition is an intermingled mesh of sensorimotoric, contextual and sociocultural aspects.

Notes

1 Analyses of observations and interviews are still a work in progress, and will also include language to reveal further aspects of embodiment and multimodality.
2 A similar conceptualization has been used for situated/embodied cognition and computer gameplay (Susi and Rambusch, 2007; Rambusch, 2011).
3 The game was developed in a project that has been running since 2010. The first version (Beta 1) was ready in 2011, and the second version (Beta 2) was ready and installed in the fortress in 2012. The project is funded by Karlsborgs Turism AB.
4 The movie is produced by Edithouse Film Works and Big5 Film & TV Productions AB.
5 The step platform originated in a research project in which a cave-based firefighter-training game was developed (Backlund, Engström, Hammar, Johannesson, and Lebram, 2007; Lebram, Backlund, Engström, and Johannesson, 2009), but the platform was modified to allow two players to use it simultaneously. The new step platform uses technology similar to what is used in "dance mats" in *Dance Dance Revolution* (Konami, 1998) to register player input.
6 The Gametrak is a system of motion-sensing technology, with very accurate position tracking.
7 So far, the results from 160 questionnaires, show that visitors are very satisfied with, for instance, the computer game's graphics and that it is played cooperatively, and they easily understand how to play the game.

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