Eye movements in an Action Game Tutorial

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Abstract
Action games are controversial and discussed, at the same time they fascinate players all over the world. One way to find out what this attraction is about is to use eye tracking to explore them. This method can show explicit eye gaze direction within the game environment and at the same time point out what the mind determine as important in the different interactions in an action game tutorial. This study wants to lay out the foundations of players´ eye behaviours in the light of training, learning, social behaviour and if there are any visual reinforcements between interactive media compared to a natural situation. Action games are today classified as entertainment products with built in simulation paths at the same time as some organisations bring in commercial games for professional training or evaluating its profit. A study made last year at Rochester University showed that non-video game players could improve their visual attention. In this study, eight subjects were playing and the recording tracked every eye movement and step in choice. The results revealed that facial interest is secondary in task progression, eye behaviour patterns are similair to eye behaviour in car driving and re-fixations occured after search and shooting partly independent of background. The essay will be characterized of topic discussions.

1. Introduction

Game industry today is bigger than film industry and the large user groups consuming games are spread all over the world. Games can be played at home either on platforms as X-box, Playstation, Gamecube, Pc, Mac or mobile either off-line or on-line, singleplayer or multiplayer. The large user groups stretch from teenagers up to middleagers. Counterstrike is currently one of the most popular online multiplayer games.

This essay is an empirical explorative data driven study that will show tendencies and general eye behaviour patterns in interactive situations. Since not much theory is found within the action game genre combined with the eye behaviour field, this study is conducted. Usability tests within the action game genre that presumably have been done seem to be unofficial and not published to a broader audience.

The main purpose of the study is to investigate eye behaviour in a game environment, namely an action game tutorial, to make it possible to lay out the foundations of players' eye behaviours in how players direct their gaze, what they fixate at, where they fixate and when they fixate certain things. Fixations are not just fixations, fixations tell us also about the ongoing mind, fixations show what is important in presence. Eye-mind hypothesis says though that what is fixated is not necessarily indications of what people thought they were looking at.

The society has an infrastructure that makes us communicate in different media. Therefore it is important to know how we consume these media and if there are differences regarding our natural environment compared to the artificial environment in games. Especially these aspects are relevant for the production of interactive products and also what the outcome will be when using these.

Interaction products are used in professional environments such as simulators, in entertainment such as games with simulation paths built into the game, in schools as pedagogical alternatives etc. With situated learning the goal is often to bring in natural environments through artificial computed ones so students and people in general are able to relate to natural circumstances, so-called simulations.

Games are interactive products that are built up with code in programming which import graphical files. These files generate representations of certain environments and characters/objects that are the visual content in the game. Sound is either stand-alone files or complementary to the graphical content. To this, different default interaction patterns are added depending on what the goal is and what gameplay value this will give. The main challenge, for game developers, is to give an exciting gameplay, which is fun and triggers motivation for the player. Today there are different commercial genres to choose between. These genres are either divided from literature point of view, from sports or from problem solving considerations.

At the University of Rochester in New York a pair of researchers have discovered that action games improve visual attention. The research suggests that action game playing might be a useful tool to rehabilitate visually impaired patients or to train soldiers for combat. "It is certainly good training for people in situations where they need to detect things in their visual environment at any time in any location, like ground

troops going through uncharted territory"[1] Daphne Bavelier, associate professor of brain and cognitive sciences emphasizes.

Games have interaction as a main component, while film is a ready-made linearly distributed story. Games also have an internal goal with a rewarding system that keeps the player occupied. To make progress the player has to learn various operations and the game environment. These circumstances can be compared to classical stimuli-response-result experiments where people or animals learn different patterns with either rewarding or punishment as direct feedback also called associative learning[2]. Social learning theory differs from behaviourism in that it stresses the importance of vicarious learning, learning by observation.[3]

The ongoing debate about action games, what they do to us is also an important factor that is another side of action games. How do we interact and how do we perceive the content while playing? As a starting point we can consider games to be multimodal so they activate our different senses. Secondly "it is well known that exposing an organism to an altered visual environment often results in modification of the visual system of the organism" [4]. Thirdly the game and its rewarding mechanism can be compared to classical stimuli response methods and its associative learning skills.

This study will above all concentrate on the visual information and will stay with the explicit intake for now within a psychological perspective. Since digital games are distributed on different platforms this study will mainly consider a computer mediated action game tutorial, but will be discussed and related to simulation and natural conditions. Influences and the ambition in many cases are to produce a natural mapping from the real world into an artificial world and therefore we deal and experience the game content in different ways, regarding to our cognitive and cultural variation.

The study is based on tables and diagrams with descriptive data, which will show tendencies. From this data, the questions and hypotheses have been formed during the analyses. Factors of uncertainty such as the ergonomic seating position during interaction must be considered as well as the keyboard placement and the mouse placed in front of and beside the current display.
Conditions like this can affect the results.

1.2 Approach

Lots of research has been done regarding learning and social-learning theory within a psychological perspective as well as in the field of eye tracking. Human looking behaviours in different media with their visual stimulus and their reinforcement on each other when it comes to use them interwoven with an everyday context, this study have as approach. This study has no chance to answer upon this, but has as purpose to lay out a base for further investigations. It does this with its results of studying one set medium and its circumstances. The results are compared with other related studies,

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[1] Roach, J., "Video games boost visual skills, study finds" for National Geographic News, 2003, http://news.nationalgeographic.com/news/2003/05/0528_030528_videogames.html
[2] Psykologi, ett integrerat perspektiv av Michael Eysenck, Studentlitteratur, Lund. 2000. p. 114.
[3] Atkinson, R., "Introduction to psychology", 10th edition, 1990. p. 425
[4] Bavelier, D. & Green, S., "Action video games modify visual selective attention", Nature, Vol.423, 29 May 2003.

which have been performed. Eye tracking is seen as a method to aquire more knowledge in this field.

1.3 Background

To understand this study and its starting point, a background will be presented.

1.3.1 Definition of a game

To be able to relate to the content of this study a definition has to be made of what a game is. I will here use a gathered definition of Craig A. Lindley, professor of Game Development at the University of Gotland: "A game is a goal-directed and competitive activity conducted within a framework of agreed rules."[5] The rules within a game offer the player what can be done and not, also the behavioural consequences of actions may be within the world of the game. To learn to play a game and making progress is about how well the player interacts within the gamesystem and its rules in a way that supports progress. This means that the player has to learn a pattern of interaction with the gamesystem.

1.3.2 What eye tracking can show

With eye tracking you are able to track explicit eye movements as fixations and saccades and this data can further tell the mental state in form of mental workload. When a fixation is produced, the eyes are still and a saccade is a movement from one fixation to another. In the centre of the retina there is a circular area called the fovea, which humans use to make detailed observations with. An angel of two degrees covers this circular area. The area around is called the peripheral area but has not the same resolution as the fovea, just 15-50 % of its resolution capacity. The angels of the peripheral view though reach up to 130-160 degrees view. These two areas process visual information in a pre-attentive stage over the whole visual field followed by a serial attentive procedure where one or some objects can be more detailed investigated before a head or the eyes change direction.

The graphical environment is meant to be a representation of the narrative context but is this context of importance compared to the problem solving of the built in tasks? The necessary and less necessary information in the display area will show when subjects direct their gaze to certain objects, which are of interest. When a player moves within a level, environment, and has knowledge of what the purpose is to progress, the eye behaviour of the player can be tracked and analysed. A fixation tells us that visual information has been processed more deeply and detailed.

Visual game contents are explicitly processed through retina in the eyes as well as the sound from the ears and an implicit process which signals different neurons and regions in the brain to either decide what to do in presence or in the near future. Motor system, memory, embodied cognition and emotions are all components in this process.

In our everyday lives our eyes are one of our main instruments that help us to navigate in the world. We read our environment very much from this organ, if not impaired.

[5] Lindley, C.A. "Game taxonomies: A high level framework for game analysis and design", Gamasutra, 2003. url: http://www.gamasutra.com/features/20031003/lindley_01.shtml

1.3.3 Game playing increases attention

This former study shows on positive effects of training and the experiments were carried out as abstract tests. The study can be seen as a base for this conducted study but with the difference that this study wants to see what is happening with the eye behaviour while playing.

Bavelier and Green published their results in a study from the Department of Brain and Cognitive Sciences, Centre of Visual Sciences at Rochester University, New York, last year 2003.[6] They claim that playing activity has potential consequences on perceptual and motor skills. They also expressed that it is well known that when exposing an organism to an altered visual environment, it results in a modification of the visual system of the organism. Perceptual learning tends to be specific to the trained task. They meant that generalization to new tasks is rarely found and refer to ten studies made before within the field of learning. In their experiment they wanted to establish changes in different aspects of visual attention and compared video-game players with non-video-game players.

First they used a flanker compability effect test to determine whether video-game playing increases attentional capacity or not. The task measured the effect of a so-called “to-be ignored” distractor on a target task. The hypothesis that video-game playing increases the capacity of the visual attentional system will with such test be approved or not. If video-game players had greater attentional capacity they should exhaust their visual attention more slowly than non-video-game players when targets became more difficult. The hypothesis was approved.

The second test was an enumeration task, which is a test where subjects have to report how many squares are presented in a briefly flashed display. Video game players showed higher accuracy and independency of numbers than non-video game players that then also supported the hypothesis in experiment one.

A third question remains if video-game playing also facilitates processing outside the training range; in this context the training area means 10 degrees from fixation. To get an answer to this a third test was conducted, a “useful field of view” task which measures participants´ ability to locate a target amongst destructors. The results from this test showed that video-game players outperformed non-video-game players. Allocation of spatial attention over the visual field showed that video-game players observed even targets outside the training area.

In the fourth test they brought in the time factor. Factors as acting rapidly on several visual items altered the ability to process items over time, which is inherent to most action games. The attentional blink task considers the difficulty to subjects to report a second target when it pops up a few hundreds of milliseconds after the onset of a first target. A variant of attentional blink task was used where subjects had to identify a first target and then detect a second target. Video-game players outperformed non-video game players on second target indicating less attentional blink that also indicated that video-game training increased task-switching abilities.

[6] Bavelier, D. & Green, C. “Action video game modifies visual selective attention” Nature, Volume 423, 29 May 2003.

The final experiment with its results is the one, which has got the most attention from public. It is a training experiment formed to see if there are differences between video-game players and non-video-game players. To not conduct a potential split between the subjects, the non-video-game players underwent action-video-game training in which they were asked to play the game *Medal of Honor: Allied Assault* (Electronic Arts, 2002), extent from fixation about 13 degrees (height) x 16 degrees (width). The game simulates Second World War combat situations, which uses a first person view. This game was chosen because this was a game similair to those played by the video-game players. Their period of training was 10 days with 1 hour-day-practice. A control group was trained over the same time of period but on the game *Tetris* (Original Tetris, AcademySoft Elorgwich, 1987). The extent from fixation is about 13 degrees (height) x 9 degrees (width). These to games had the conditions that would be appropriate for the test. Tetris contains a challenging in visuo-motor component and focusing on one object at a time while action games require that attention is distributed and switched around the field in the environment. Before and after training Bavelier & Green tested the subjects on the 2nd, 3rd and 4th tests. All subjects improved their scores on the video game, which they were trained. Action-game training led to greater performance. In the 2nd test, enumeration increased by 1.7 items in individuals trained on action games. The control group showed no improvement. The 3rd test showed that training on action video games enhanced "the useful field of view" and lead to faster recovery from the attentional blink. Visual attention increased with 30% in a 10-day practice.

Bavelier & Green concluded the experiments and meant that action-video-game playing pushes the limits of three rather different aspects of visual attention as has shown in the experiments. They stated further that even if video-game playing may seem to be rather mindless it is capable of radically altering the visual attentional processing through its juggling of various tasks as detecting new enemies, tracking existing enemies and avoiding getting hurt among others. These aspects could further be valuable in treatment of visually impaired people or for soldiers in combat training where the content of course will be appropriate to the goal.

1.3.4 Game playing for learning

Last year, December 2003, FOI, Swedish Defence Research Agency, published a report that presented the results of testing the usefulness of game consoles in the Swedish Armed Forces. Their investigation was done to validate benefits of game based training in education. The theory approach was training, education, economy and simulation. The author initially brought up (Prensky, 2001) and explained that a growing number of companies bring in game-based learning in a variety of forms and its use in industry, organisations, polices to products and skills.[7] The aim of the study was to find out if education in defence could be more efficient and effective. Their goal was and is to see how they can conduct training and education while integrating technology and learning via simulation. This study used PC, Xbox, Playstation 2 and Game Cube that can be viewed as low-cost simulation tools. User tools comparisons were toward PC. The experiment was conducted within the Swedish Army Combat School where 48 cadets participated playing a commercial game on each of the four platforms. The game they played was *Ghost Recon* (Ubi Soft Entertainment, 2003)

[7] Rencrantz, C., "Game based training and education ", ISSN 1650-1942, Command and Control Systems, Linköping. December, 2003.

and was selected because it included terrain and tasks relevant for the Swedish Army. Also “Blue Storm” and “Iron Dragon” were used. The games could be viewed as simulations. The procedure for the experiment started out with outdoor training a couple of days before the game experiment in order to give the subjects real life conditions first and make further tasks related to natural conditions. Movement and firing did not work the same way in these two environments. The report pointed out that there were some disadvantages whereas the knowledge of this technology is useful or not in its present form and the lacking research. The results were mainly based on the data from the questionnaires to obtain information about behaviour, awarness and attitudes. As many as 77% said that they could consider game-based training in the future if they were instructors. The test panel concluded that the lack of scientific research conducted on gaming and training (learning) is not included in the report since there is not much to bring in depending on no research has been done.

2. Experiment

This study will refer to visual behaviour and the players/subjects who interact within the environment. Counterstrike tutorial version 1.0 is chosen since it includes basic elements the player train on in a single player mode, off line. The tutorial is also chosen since all subjects have to have the same conditions, so data can be compared. To be able to lay out the foundations of players´ eye behaviours, the simplest events have to be investigated first. Therefore the full version is not used in this experiment. The action game environments in Counterstrike have “natural” environments and strive for high realism. This particular tutorial takes place in a training camp where the player practises different tasks.

2.1 Stimuli

The interaction of a player happens in a first person perspective, which means that a player has a normal view of a situation due a restricted view angel (the screen) compared to a normal situation. You never see your own character in the environment. You have a `point of regard´ which means that you instrumentally are the film camera. What you see and how you move in the environment will be directed by the keystrokes that are pushed down on the keyboard or by the mouse.

Summary:

Stimuli:	Counterstrike tutorial v. 1.0	Sound:	Stereo
Computer:	PC	Condition:	Single Player
Resolution:	800 x 600 Pixels.	Connection:	Off-line
Graphic:	3D	Average playtime:	13 min. [result]
Perspective:	First person		

2.1.1 The Action Game

Counterstrike (Valve/Sierra, 1998) is one of the most played online games today with a global arena. The MOD, modification, belongs to the series of Half-Life and is the most popular. The purpose with this MOD is to provide the player with an experience that a trained counter terrorist unit or terrorist unit might have.[8] In the full version game you decide which team you will join; the terrorist or counter terrorist (police) team. The game has four different operative missions, which are: Hostage rescue, bomb/defuse, escape and assassination. Hostage rescue and bomb/defuse are the two

[8] http://www.counter-strike.net/manual.html

main missions in this experiment but includes also two shooting simulation scenarios with 5-6 moving targets in each and a smoke grenade simulation. Between the missions the player is moving in rooms and corridors. Each round of Counterstrike lasts from 3 to15 minutes in an original round, depending on what server you are connected to. In this tutorial you have unlimited time.

2.1.2 The goals and the rules

The goal of the gameplay is teamwork and to demolish and to shoot as many terrorists or counter terrorists as possible. The points or the money the player get are from these operations. In an action game the individual goal and the goal of the team is to survive. The time is an important factor, also rapidness, tactic and strategy. You cannot win in Counterstrike if you aren't working with or for your team. In this tutorial when you play without a team, the main purpose is to try different scenarios and understand what will come in a full version. The tutorial itself has a goal to provide learning and understanding for the environment.

2.1.3 Graphics

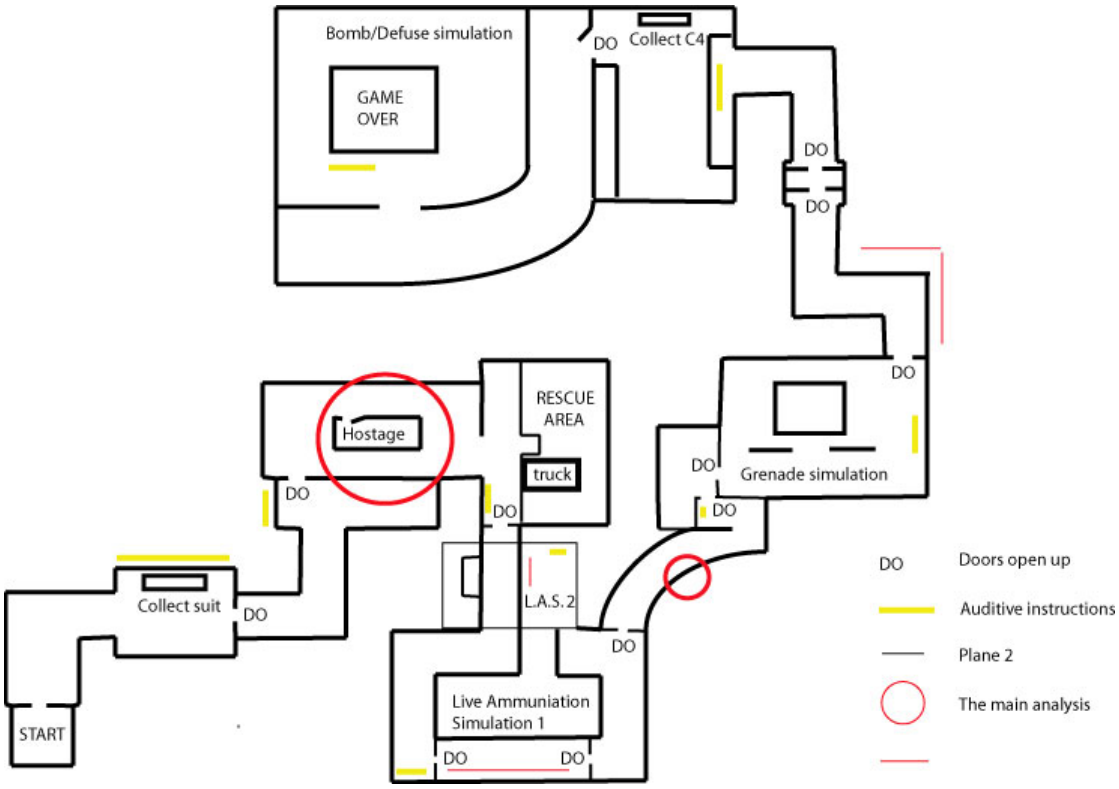
The tutorial of Counterstrike v.1.0 strives for realism and the environment and the weaponry are natural mapped, not fine detailed photo realistic mapping but closely. Graphics made for this game uses mostly 3D Studio Max software.

2.1.4 Camera options

As player you have just one life each round. If the player gets killed, the player turns into an observer mode, a third person perspective, where you can see your own character. In the tutorial the subject has unlimited numbers of lives. In the tutorial it appears a tilted camera perspective when the player is killed. There are three observer modes, which not are investigated here as ghost-cam, locked chase-cam and thirdly a free look chase-cam.

2.2 Typographic map

This overview shows the paths in the tutorial where the subjects go from start to the end. The end is where the text says game over in the typographic map.



Typographic illustration over part of CS Tutorial v.1.0 made by Charlotte Sennersten 2004

3. Empirical Study: Materials & Methods

Since literature does not offer enough information to answer the questions about eye behaviour in action games/tutorials, a data driven study was carried out, to obtain the missing information. In this chapter the methodology is described. Since this is an explorative behavioural data driven study, the hypotheses and the questions will be presented in the `Conclusion´. From here till `Main discussion´ the term subject/s will be used instead of players.

3.1 Problems of experimental design

To be able to validate my data, the parameters have to be the same for all subjects to be able to compare different eyemovement behaviours. During the experiment, the subject's eye movement were registered in order to obtain the following data: 1) when a subject interacts through keyboard; 2) where the subject looks in order to estimate when and where a subject looks in a certain way.

While setting up the experiment I had following considerations:

- Problem: The task has to be the same for all subjects.
  Remarks:
  The task should enable to stimulate the subjects to participate. Every subject has to be able to perform the task. Production of my own game setting had taken too much time.

Solution: Use of the Counterstrike tutorial where all subjects had to move through the same paths and therefor be able to choose and participate in there own way due to the game rules.

- Problem: The depth cues cannot be tracked.
  Remark:
  To know where a subject looks within the game environment can sometimes be hard when foreground, middleground and background can't be parted.
  Solution: In data analysis, it is important to consider this lack of information and therefor be aware of the fixations on an object and when it appears beside or above. If the background is "clean" with no objects to concur with, the eye fixation will then be counted as belonging to the foreground.

- Problem: No key logging
  Remark:
  The key logging is not part of this study because the lack of a possible software which could track this data. There are spy programs that could be of help but the time was a limit. So reaction time is not considered.
  Solution: The interaction of the subject is counted when it happens on the display.

3.2 Methods

The requirements of the experiment were to get the needed data as eye movements from an action game stimulus. The importance of using an everyday product as a subject stimulus and not abstract tests are for two reasons. 1) Experiments are often considered to not be ecologically valid enough compared to every day environments; 2) to use a product that is known for the subjects and is used in an every day context.

3.2.1 Experiment design

The experiment was designed to find out where and what the player directed attention to, during gameplay. Since no tests had been done before, I had to constrain the experiment to just consider visual attention in a single player mode, off-line. The subjects played individually in a free examination with six parted instructions given before the experiment started. The stimulus was a tutorial version 1.0 of the game Counterstrike where the subjects moved in a first person view through the game environment. The subjects played the tutorial and the eyetracking data, as fixations and saccades, were recorded.

3.2.2 Subjects

The experimental subjects used in this experiment were mostly students, gamers and males. One woman attended and had the same status as the male attendants. Most of the subjects came from a media education. The subjects were skilled gamers which were an advantage so there would not be any disturbances while playing such as finding out keystroke interactions and the need to try paths over and over again, which would stop the visual flow patterns in the game environment. The average ages of the subjects were 25 years, with 7 males and 1 female. The subjects were paid for their travel expenses. To avoid distorted measurements by unnatural behaviour of subjects, the subjects were not told on beforehand what the experiment was about. Instead they were informed that the experiment was about gameplay and the camera that would be used would just track their pupil size.

3.2.3 Instructions and session procedure

The subjects played the Counterstrike tutorial with free examination in a task related environment. Before each experiment an introduction was held verbally from a text description. 30 minutes were planned for each experiment and 30 minutes for answering an inquiry. The total duration of one experiment, consisting of two sessions, was about 1 hour.

Prior to each session

The preparation prior to each session consisted of the following steps:

1. Instruction:
    1. Information about the default control settings. The most common used.

B	Buy menu
E	Use key
,	Buy primary ammo
.	Buy secondary ammo

W or UP ARROW	Move forward
S or DOWN ARROW	Move backward
D or RIGHT ARROW	Move right
A or LEFT ARROW	Move left

Move mouse	For 360 degrees visual field
LEFT MOUSE BUTTON or ENTER	Fire
RIGHT MOUSE BUTTON	Zoom

    2. Do not move when auditive instructions are given. You can look around with the mouse though.
    3. Start moving when speaker is ready.
    4. Do not move too close to the simulation doors so they start flickering. The program will then crash.
    5. When moving, move fluently forward.
    6. The session is over when you have defused the bomb.

2. The head mounted eye tracker was placed onto the subject's head and adjusted so it would not disturb or glide.
3. The subject was seated in front of the computer screen and encouraged to sit as subject usually sits when playing. A paper with an original control menu from Counterstrike was placed beside the keyboard, if needed.
4. To correct for individual differences, the eyetracking system was calibrated for the subject's eye.

3.2.4 Eye movement measurements

To measure the eye movements of the subjects the pupil-centre/corneal reflection method was used. This method determines the orientation of the eye from the relative locations of the pupil and one reflection. An infrared light shines on one of the eyes of the user, which causes reflection. The eye gaze system is designed to determine where a user directs attention on a computer screen, the coordinates the system produces can

be interpreted as coordinates on a virtual plane in front of the experimental subject. If subject looks outside this virtual plane the eye fixation is said to be “plane not found” by the eye tracker. When the subject’s point of gaze remained inside a small circle (with a diameter of 20 pixels) on the virtual plane during three frames (taken at 20 ms interval) of the camera, the eye gaze system reported a fixation. The average of the three points of gaze was reported as the new fixation point. The movements of the subjects were also tracked by a motion sensor, which can be found in the data-logging file.

We measured the eye movement of the right eye, if not the person had a dominant left eye or some other eye problems to the default eye. During calibration, crosses were projected on the screen in a matrix-like way on which the subject had to focus on one cross, one after another. The error between the measured point of gaze and the projected point of gaze was determined by the system. The calibration procedure was repeated until this error levelled under a value of 3.8 mm.

Measurements used a head-mounted equipment, a SMI iView© eye-tracker, which is a monocular 50 Hz pupil and corneal reflex video imaging system.

5.4 Materials

5.4.1 Experimental set up

The experimental set-up consisted of one table where the computer screen and the keyboard were placed. The subject was seated in front of the screen and the keyboard. Two speakers were placed on the floor underneath the table. Between subject’s table and the tracking computer, a fond was placed to not disturb the experiment.

4. Analysis

The main purpose in this phase is to see if there are individual patterns or group shared similarities. The raw data information consists of a video film with a red ring, which shows where the subjects fixate while playing and also the generated sound from the game environment. Secondly a computer file with coordinates is logged which shows where the subject has looked within the screen. Further the data shows pupil size related to workload, fixation times, blink frequency and body movement.

All tracked data has been time coded. Time code was not viewable at top left corner twice then the analysis had to use the time code of the video player. All analysis is through inspection of videodata. There is no software to use for analysing raw data so this is manually done. The raw material was mainly analysed in 40 frames per second intervals from video with fixations marked as a red circle on the top on the stimuli environment. The saccades are not viewable in the video logged data though.160 pages transcribed data was generated and documented in word documents and 10 pages excel generated tables and diagrams. Out of 8 recordings, all recordings are analysed.

The results were drawn from 17 moments from the playable stimuli distributed from one experiment. From every playable session, which varied from 10 min 20s to 20 min 34s, 7 moments were deeply analysed.
When fixations have not been viewable within the action environment the subject has either concentrated on keyboard or key instructions beside the computer.

5. The explorative study and its results

In this chapter, the results of the experimental data will be presented. The hypotheses and the questions are to be found in the `Conclusion´. This study will not show any statistics, just main patterns. The main concern is to see how visual attention is performed in first person perspective during interaction in an action game tutorial environment with a single player offline stimulus. The individual and shared visual patterns, which have shown in this experimental data, will form the basis for these assumptions. The analysis is based on;

1. what subjects look at in an artificial environment
2. when they have a time aspect to consider and
3. when the interaction is task related.

Parts of the results are presented as diagrams, which show numbers of viewable fixations on actual object and what part of object that has drawn attention. I will present four results in three chapters and the separate discussions are presented under `5.4 Discussion over the results´. Former studies will be related in each chapter before the discussion over the results. Finally an over all discussion will be held where the different results will be summarized. In `5.1´ the results from the hostage room and the recognition of the hostage will be presented with diagrams, tables and an illustration. In `5.2´, two illustrations will be presented to show where main fixations were put while subjects moved in the corridor environments. In `5.3´ a model is presented that will represent recognized search behaviour with a repositioned fixation pattern that differs from subject to subject. The model shows also general eye behaviours in relation to the screen-centred aim point.

5.1 Facial interest in hostage room (See typographic map, p.12.)

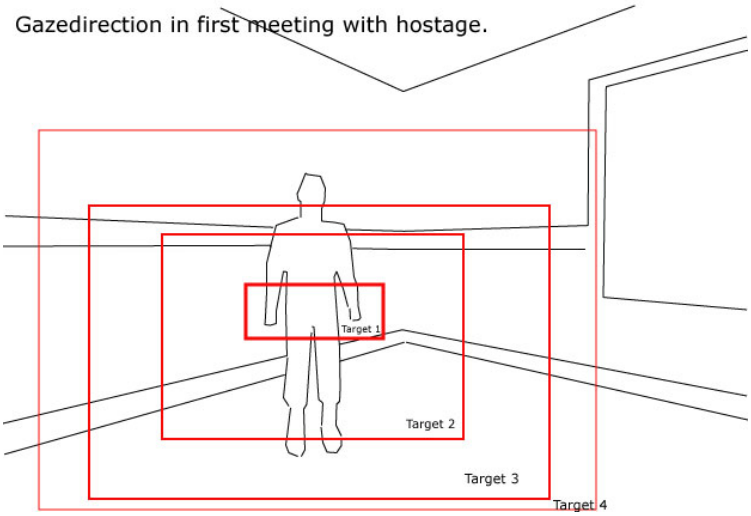
The first meeting with hostage in hostage room occurs differently for each subject concerning eye behaviours. Depending on how easy or how hard each subject had to find its way into the hostage room, different eye behaviours occurred. Half of the subjects had no problems before entering the hostage room and the other half of subjects had to run around or tried to push the door but did not succeed to get in first, because the player had to push the door straight on it and not from a side angel. I will from this analysis present the individual data for each subject to show the differences in visual attention and how each subject related to what part of body that gave most information in this context when the subject met a person, the hostage. The diagrams do not show in what order the fixations came, just what parts that have been fixated.

The x-axes in the diagrams point out target 1, target 2, target 3 and target 4 which are four main areas on the body.

Target 1	Stomach, hips, lower arms and hands.
Target 2	Chest, upper arms, upper legs, lower legs and feet.
Target 3	Throat and shoulders.
Target 4	Head / face

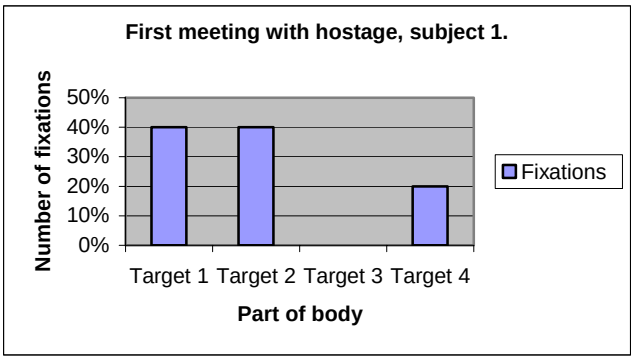
In the analysis separation has been done between left and right side of body and when fixations has been centred but here, this data is put together as whole.

The illustration that follows show the targetgroups and the four areas described above.

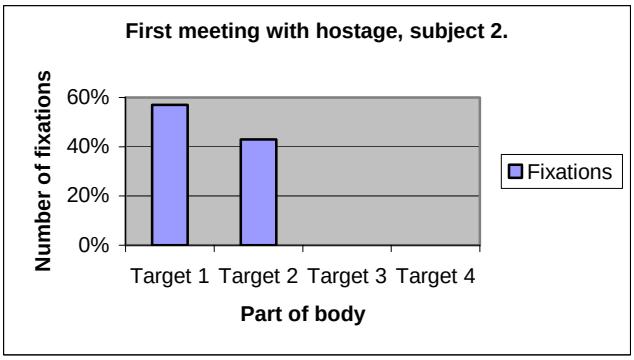


First fixations tend to hit target 1 and target 2.
See original picture on page 23.

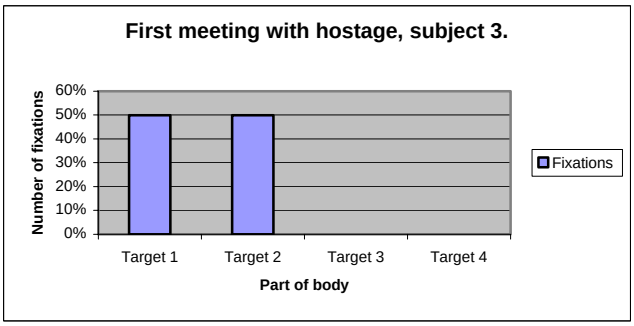
When subjects got into the hostage room they did not know what to meet in there. When they had opened the door and turned 90 degrees to the left the hostage was standing in front of the left corner of the room. They moved directly up toward the graphical representation, the hostage. They knew before hand to use the “use” key, which is key “E” to get the hostage to follow. Two subjects had to look at the key instruction when this operation was to be done. When the subject has pushed the “use” key an auditive confirmation was given from the hostage with the replica “get the hell out of here” to the subject, also a text showed and points were added. After this event the subject turned left or right in a 180 degrees turn and moved out from the room through the door were the subject came from. The goal was to bring the hostage from that room through a corridor to a truck placed in the rescue area. The looking behaviours from these meetings are presented in the diagrams that follow. The meetings are related to the first meeting in the hostage room and just related to eye behaviours in that room. They are presented isolated subject by subject to show individually variations. 8 diagrams follow.



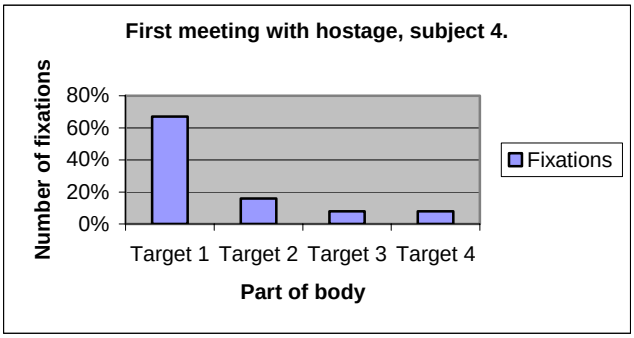
Time(s) spent in hostage room:
01:25:06-01:30:04 min. makes 5s.
Total playtime: 10:20:00 min



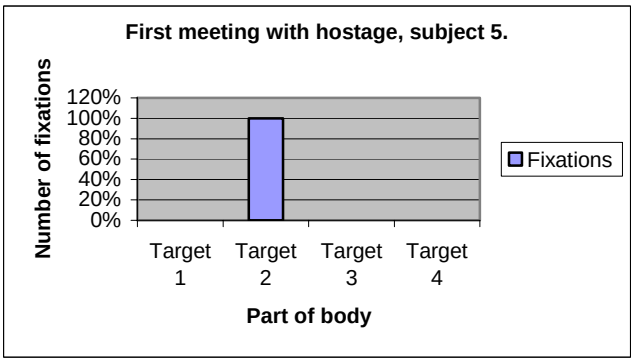
Time (s) spent in hostage room:
02:05:06-02:13:13 min. makes 8s.
Total playtime: 12:04:14 min.



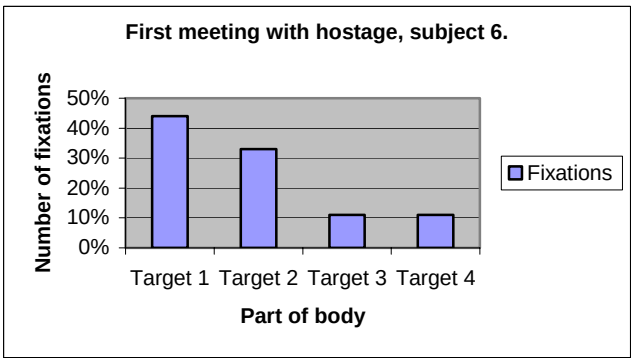
Time (s) spent in hostage room:
01:34:04-01:40:09 min. makes 6s.
Total playtime: 11:18:01 min.



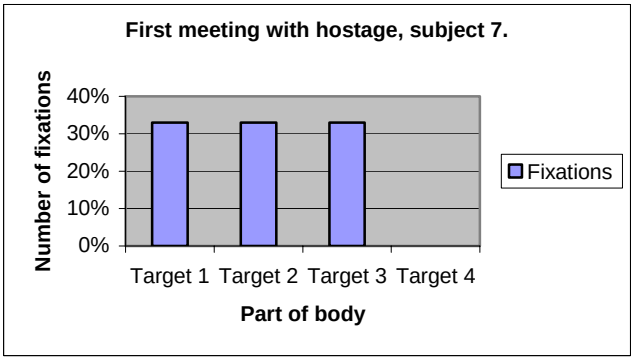
Time (s) spent in hostage room:
01:27:08-02:24:04 min. makes 57s.
Subject looked at key instructions.
Total playtime: 10:40:24 min.



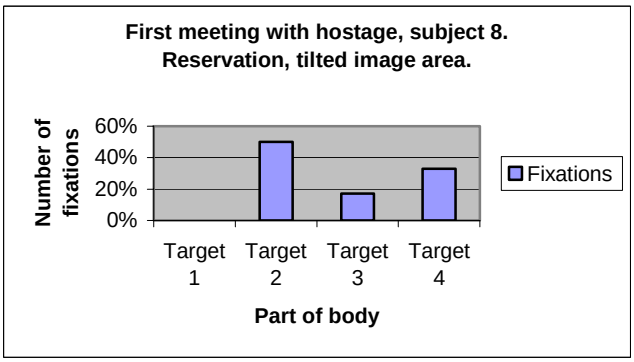
Time (s) spent in hostage room:
02:37:16-02:41:09 min. makes 3s.
Subject got a short instruction, how to enter the door.
Subject had to restart 5 times because buy option didn't work with freely choice. Subject missed to follow the auditive instruction with buy recommendation.
Total playtime, last round:
11:21:17 min.



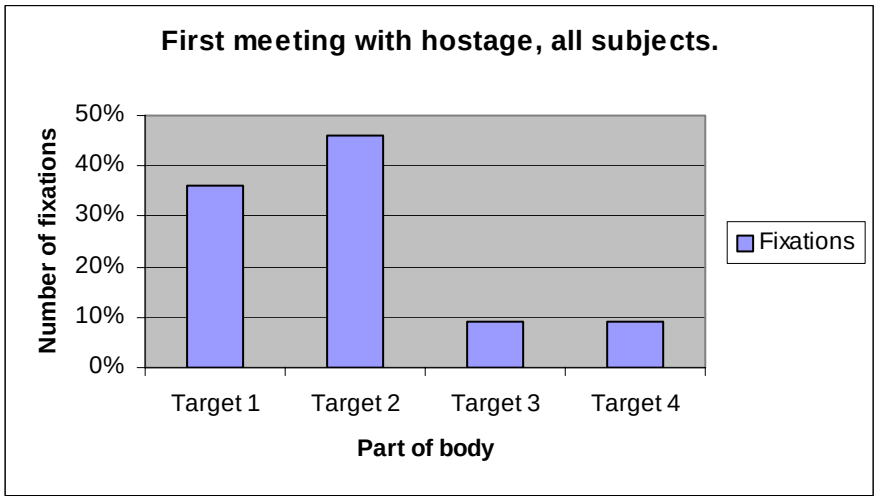
Time (s) spent in hostage room:
04:02:16-04:09:10 min. makes 7s.
Subject got a short instruction, how to enter the door.
Total playtime: 14:42:20 min.



Time (s) spent in hostage room:
01:40:12-01:49:05 makes 9s.
Total playtime: 11:50:03 min.



Time (s) spent in hostage room:
02:38:17-02:54:03 makes 16s.
Total playtime: 20:55:22 min.



The diagram shows a median value of fixations over all subjects.

These different eye behaviours show that there are individual differences but also a strong tendency in a general pattern connected with the task. Initially almost all subjects are directing their gaze toward the hands of the hostage. The most fixated area during exposures is target 2 with chest, upper arms, upper legs, lower legs and feet. Subject 5 did just fixate that area and ignored the others. The time of exposures for each subject differs from 3-57 seconds but in general for exception of subject 4 the median value is 7.7 seconds. The different exposure times could be a factor of the knowledge of the environment since before. All subjects have reported on before hand their pre-knowledge of action game environments before the test. The median attention toward face is not more than 10%.

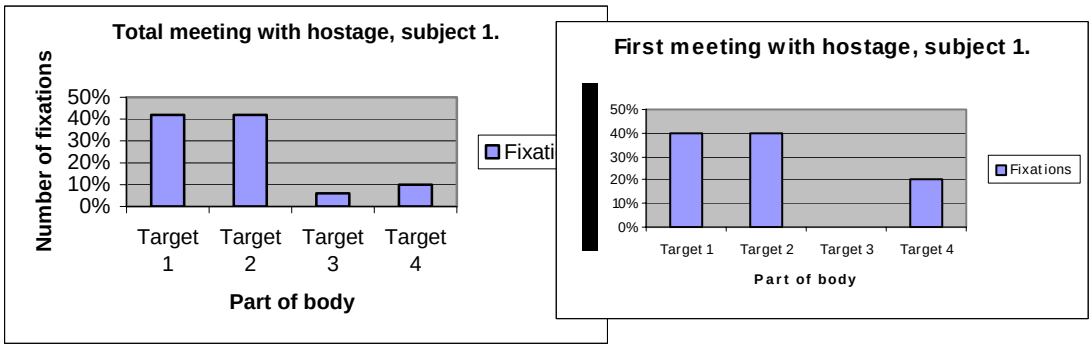
When these results are compared to the answers given in the individual inquiries to what they have looked at when they met the hostage, it shows the opposite. The subjects had 7 alternatives to choose between when they were asked to mark one or several alternatives of body parts they looked at in the meeting. All subjects have marked the face alternative. The main focus is initially on target 1 areas and target 2 areas when analysing the eye tracked data.

Question8	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8
Stomach								
Chest	X				X			
Face	X	X	X	X	X	X	X	X
Arms								
Hands								
Legs								
Feet								

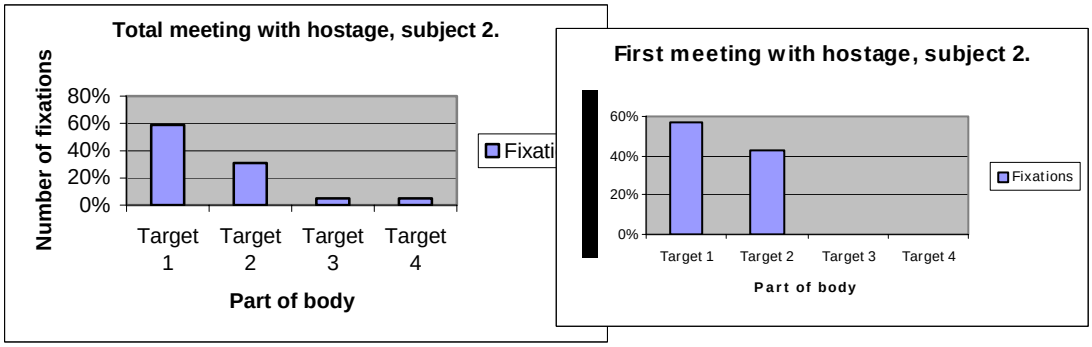
Subject´s answers of question 8 in inquiries. The question and instruction were: When you saw the hostage, where did you look at him? Make a circle around the alternative you think is most appropriate to you, you can choose more than one, if you like.

These comparisons in what is shown in data from eye tracking and the answers from the inquiries seems to show a social cultural expectation of what is percieved from a self-conscious point of view regarding what is empirically shown in data. In natural environment contact, the social value of looking each other in the face is a strong predictor of good behaviour. The results could also be a factor of periphery input instead of foveal.

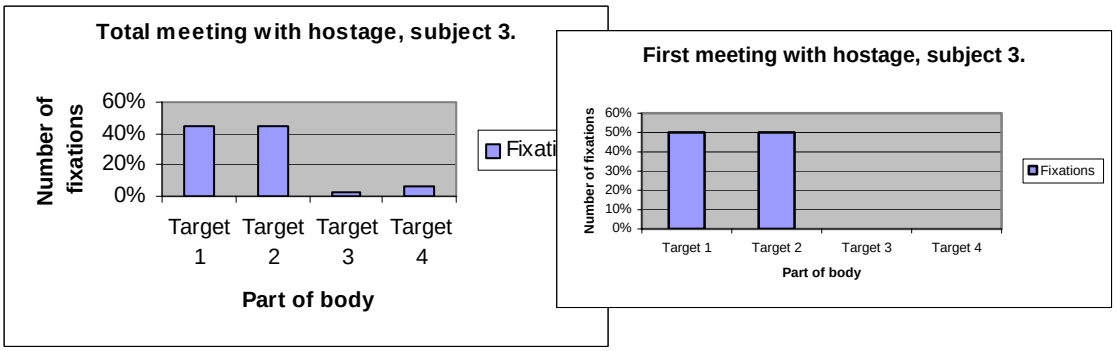
In the following diagrams all hostage exposures are stated. The task was to bring the hostage to the rescue area and this procedure was done differently. Some subjects would check that hostage followed and some did not, so this total amount of exposures are presented which shows that time aspect is one factor of behaviour. The longer time and more exposures make facial interest increase to a certain extent. Over again I will present the individually differences through diagrams. On the left side the diagram is placed that shows total exposures and the right diagram is from exposures in hostage room.



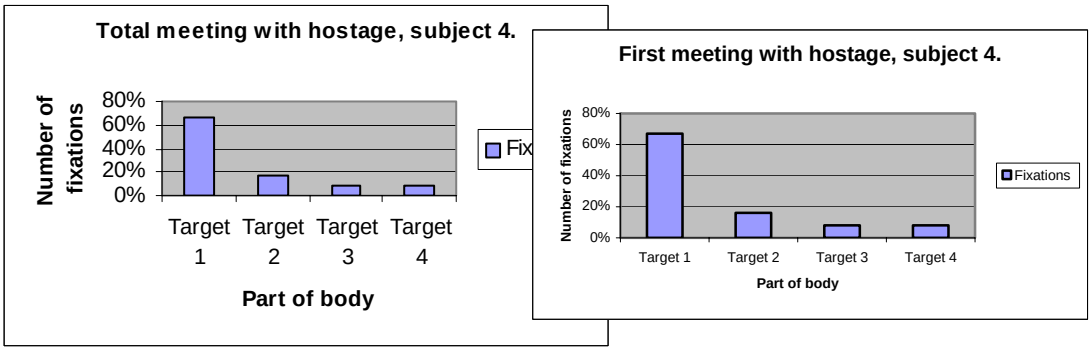
Subject 1, tends to fixate target 3 more and target 4 decreases. The visual attention becomes more evenly spread even if the main attention remains between the targets.



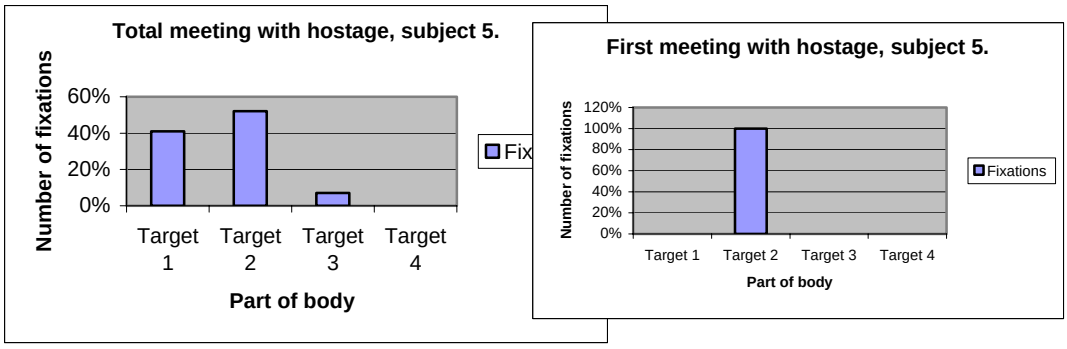
Subject 2, tends to increase target 1 but decreases target 2. The visual attention becomes more evenly spread where target 3 and 4 now increase slowly.



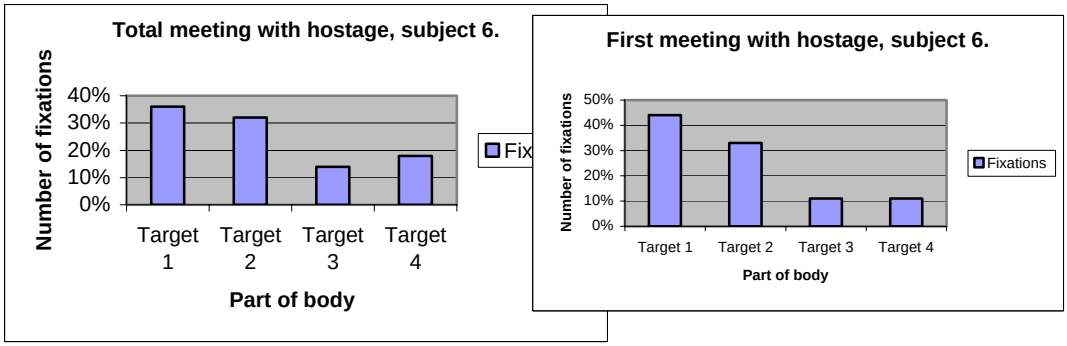
Subject 3, decreases attention toward target 1 and 2. The visual attention increases on target 3 and 4 so interest becomes more evenly spread, target 4 increases most.



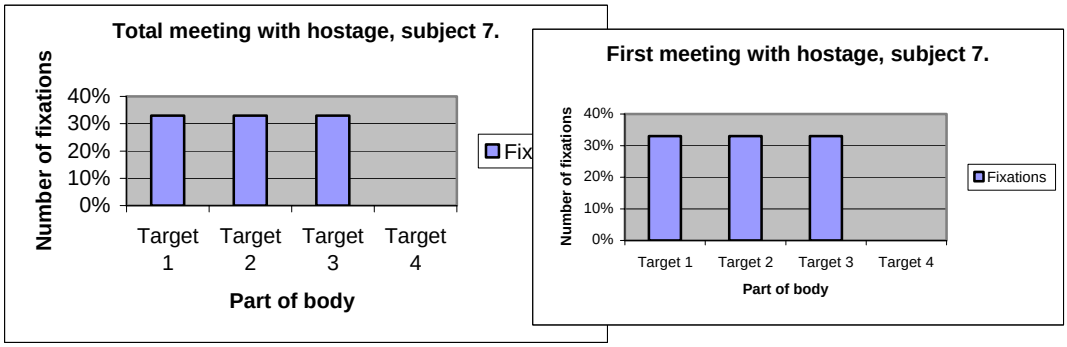
Subject 4, did not do any look backs to check if hostage followed so the relations in visual attention remain.



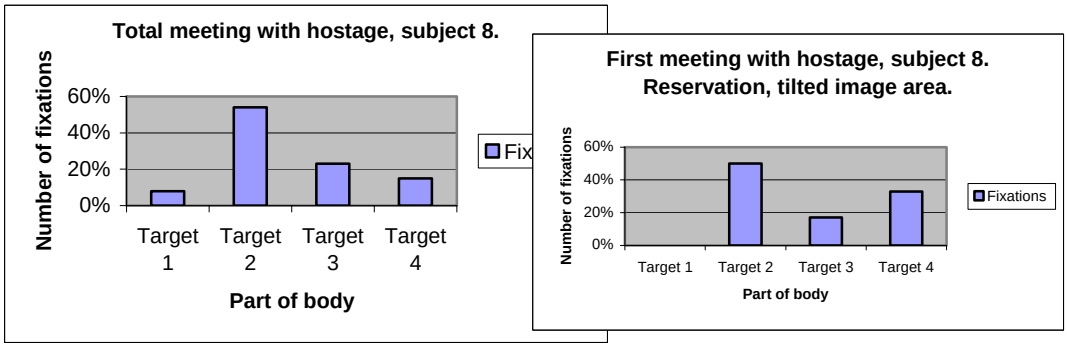
Subject 5, did radically change attention to other body parts while leading the hostage to rescue area. From just fixations on target 2 attentions are, as well, spread to target 1 as target 3. Target 4 remains with no fixations.



Subject 6, increases attention very much to target 4, almost 8 %. Target 3 though increases not very much but slowly. Target 2 remains and target 1 decreases almost 6%.



Subject 7, does not make any look backs when to lead the hostage to rescue area so the relations between the targets remain.



Subject 8, does change the attention parameters when moving toward the rescue area. Target 1 has increased 8%, target 2 decreased a little, target 3 decreased 4% while target 4 decreases almost 11%.

For subject 2, 3 and 6 the face interest increased regarding time. For subject 1 and 8 the facial interest decreased. Subject 4 and 7 did never look back so they stayed the same. Subject 5 looked back on the way to rescue area but did not fixate the face even if there were several meetings after hostage room. The median value from these data show no more interest toward face, the figure stays with 10%. The time aspect, with more exposures, shows that visual attention is more evenly spread over the different target areas.

The hostage, the player is to rescue. First person view.

5.1.1 Former studies

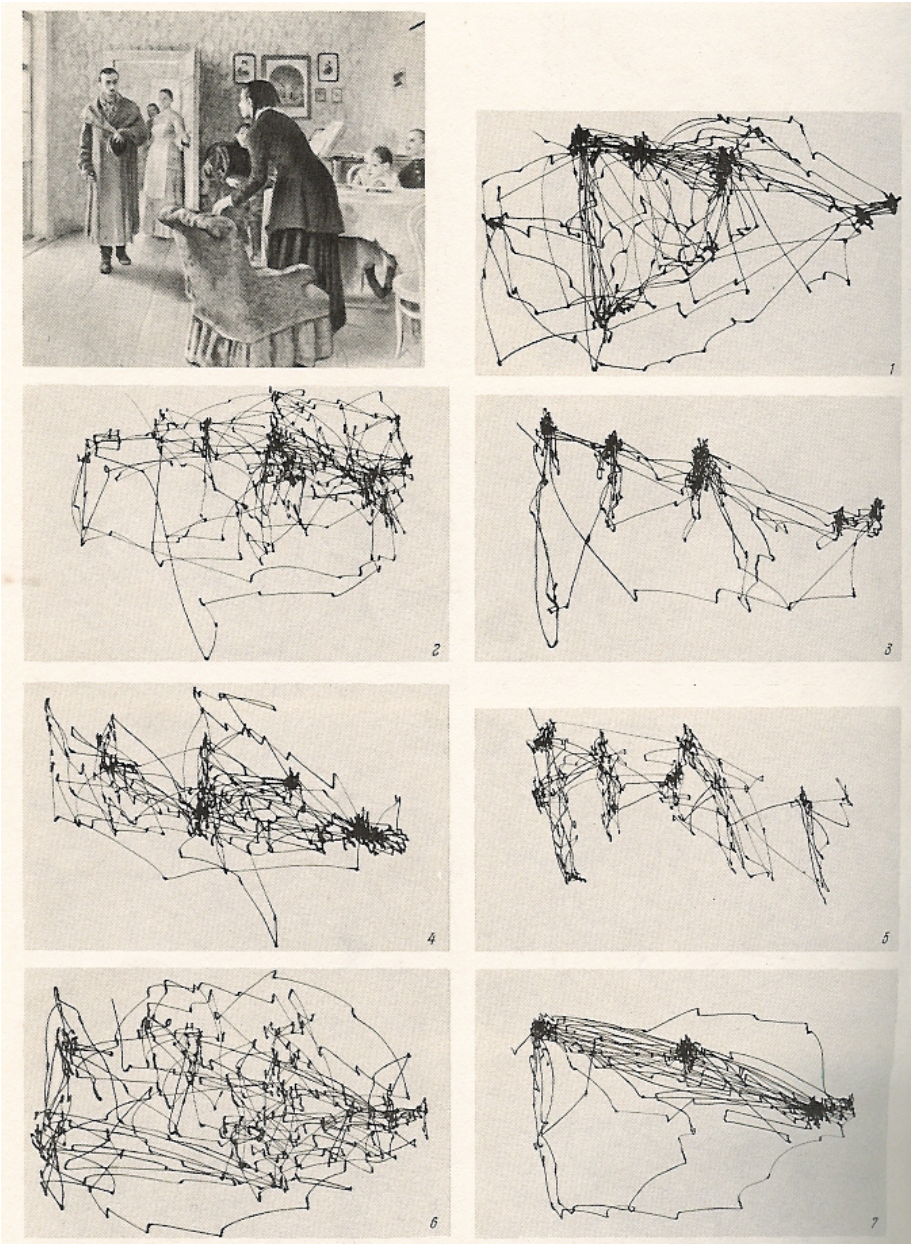
The results will be related to former studies, which will be presented here, and the discussion will come in the end of this chapter.

5.1.1.1 Yarbus

Year 1967 an eye movement study was carried out by Yarbus where he used a still picture called "An Unexpected Visitor" made by Repin.[9] He wanted to see if different eye behaviours occurred if different tasks were given to the subjects. First he had 14 subjects to investigate the still picture with free examination while their eye movements were recorded. The data showed that the faces of the people in the picture drew more attention than the bodies and the bodies more attention than to objects in the room and last the background. Further on he tested each subject with task specific instructions. The subjects should look for different status and relationships within the still picture compared to the free examination. Each record lasted for 3 minutes. The given tasks were for example estimation on the material circumstances of the family

[9] Yarbus, A., "Eye movements and vision", Institute for Problems of Information Transmission, Academy of Sciences of the USSR, Moscow. Plenum Press, New York, 1967.

in the picture, remembering the clothes worn by the people, remembering the position of the people etc. Yarbus meant that the face with its eyes and lips, both for people and animals, are the most mobile and expressive parts of the face and these elements are communicating mood, attitude and steps he/she may take next moment. Since eye movements reflect inner thoughts there will be variations between subjects' eye behaviours. Hence, Yarbus concluded that depending on task, eye movements varied.



(Fig.109) The subject examined the reproduction with both eyes.
1) Free examination of the picture. Before the subsequent recording sessions, the subject was asked to:
2) Estimate the material circumstances of the family in the picture.
3) Give the ages of the people.
4) Surmise what the family had been doing before the arrival of the "unexpected visitor".
5) Remember the clothes worn by the people.
6) Remember the position of the people and objects in the room;
7) Estimate how long the "unexpected visitor" had been away from the family.

5.1.1.2 Gestures in face-to-face communication

In 1999, Gullberg & Holmqvist´s released the results from their findings from a study that dealt with perception of gestures in face-to-face interaction.[10] The speech channel and the complementary gestures to speech in dual experimental settings showed the eye movement patterns of the listeners while listening to the narration. The aim of the study was to find out if gestural information was processed in periphery based on the norm which Argyle-Cook (1976) and Kendon (1990) pointed out, which showed that listeners usually look at the speaker's face in face-to face interaction even if gestures are complementary to speech and should then draw all attention. With eyetracking technique they stated that the fixations of the listeners could be precise and of bigger value than results from former studies where dual contact have largely been filmed from interlocutor's side. They wanted to test three hypotheses, which assumed: Firstly peripherally articulated gestures are fixated more often than centrally articulated gestures. Secondly, gestures are fixated more often when the comprehension of the oral channel is hindered. Native viewers thus fixate proportionally more gestures when listening to non-native narratives than when listening and thirdly, listeners fixate gestures more often than average if these gestures have been auto-fixated by the speaker. The structures of the subject group in correlation to the hypotheses were formed with four native speakers of Swedish and four native speakers of French. The results showed that listeners fixated the speakers´ face, gestures and a few other objects. Data showed that listeners on average spend only 1.6% of the time looking at other things than the speaker's face.

5.1.1.3 Gestures in live human interaction and on video

Another experiment of Gullberg and Holmqvist, which is not, yet published, is still investigating the role of the speaker and the listener, the addressee. The new setting deals with gestures in live human interaction and on video. The social aspect and the size constancy depending on medium are two factors that can vary their result compared to a natural setting. Three experiments were held to compare visual behaviour towards speakers and their gestures displayed and exposed with three different condition settings, stimuli variation; live visualisation face-to-face as the conditions in a former study (Gullberg, 1999), life-sized video as analogue VHS projected with a video canon and also a video presented on a 28'' TV screen. Three main things have been explored: The amount of overt visual attention to the face across all three conditions, the amount of overt visual attention to gestures, globally, and the amount of overt visual attention to specific gestures. To maintain the question of how visual attention is functioning concerning face- or gesture interest in a dual context the hypotheses are: If there is a social norm for maintaining eye contact in social interaction that governs overt visual attention toward the face and away from gestures, this norm will be neutralised on video. Also they assumed listeners, addresses, to look at fewer gestures when stimuli were TV-video screened than if distributed on a life-sized video. Thirdly they expected addressees to look at gestures initiated by the speakers own first look on gestures like a mirrored reflection of what

[10] Gullberg, M. and Holmqvist, K. "Keeping an eye on gestures: Visual perception of gestures in face-to-face recognition", Pragmatics and Cognition Vol. 7(1), 1999. 35-63. John Benjamins Publishing Co, Amsterdam, Netherlands.

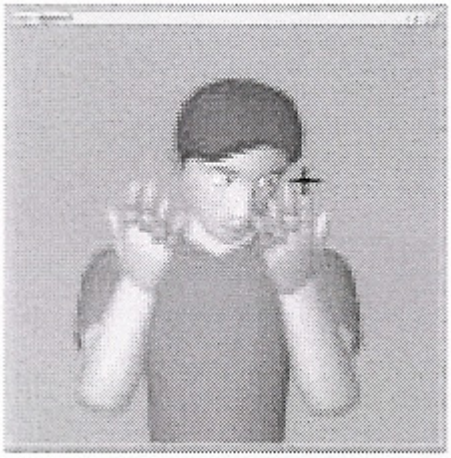
the speaker does, does the addressee which they relayed to automatic shift of attention in addresses (Driver, 1999 and Langton 1999). They point out that they have no predictions for gestural holds since there is just one study made before and there is no comparable data to rely on.

Average viewing times in percent on targets across conditions.

Fixated objects	Live	Video Life-size	VideoScreen
Face	95.6	94.2	90.8
Gestures	0.5	0.4	0.2
Body parts	1.3	1.4	5.6
Obj in room	2.1	1.4	2.7
Empty space	0.4	1.1	0.3
Other (the original live addressee)[i]	0	1.4	0.4
	100	100	100

In all three conditions, more than 90% of the time is spent on the face.

5.1.1.4 Animated agents

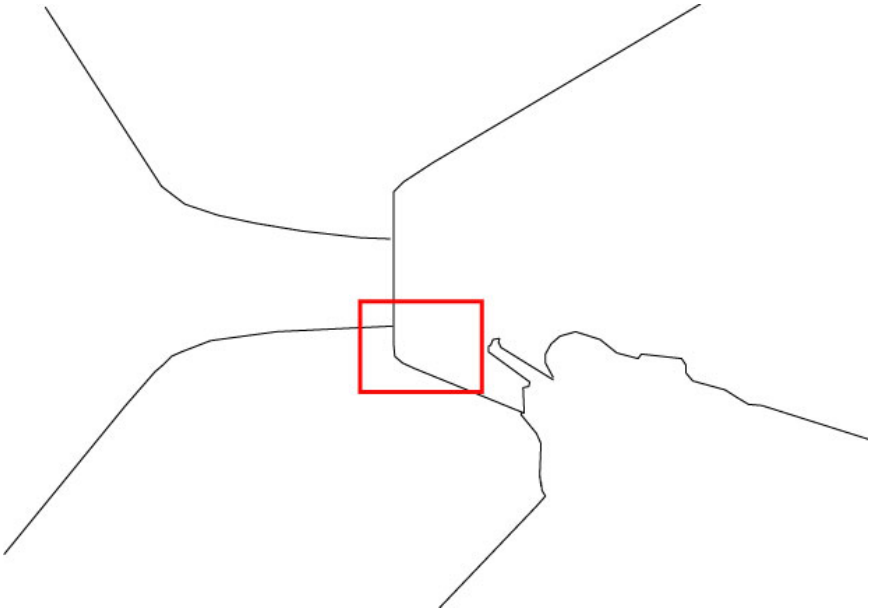


1998, Nobe et al. in Japan conducted an eye gaze experiment with anthropomorphic agents and its hand gestures, in order to achieve optimal communication with a human user. The main interest laid in how a human user utilized gestural information that a human like agent produced, so a full under-standing of the message with synthesized speech could be achieved in a real-time setting. The main focus laid on how human listeners watched the agent while it performed. They used six different stimuli, which differed in verbal content. The same time as the agent showed different facial expressions, and the hand positions differed to see if these generated different looking behaviours by the subjects. They had made a derivation between center-center, lower periphery, upper center/periphery, right center, and upper right center of the rectangular stimuli. The exposure times for each stimulus ranged from 0.66-4.62 seconds. They calculated on fixation pauses were the maximum fixation ranges was 2 degrees and the minimum fixation time was 1 second. The tracking system could then calculate the existence and the duration of fixation pauses, these were later on generated upon the screen where movements of hands and gestures were produced. The results showed that gestures with longer duration tended to attract much attention, also strokes and post-stroke holds. The meaning lies within the gesture stroke. Subjects looked at the face of the agent, especially when an angry face was exposed. The hand gestures in the six stimulus attracted attention and the one-handed gesture attracted even more. The results were of importance when they evaluated human-agent-interaction systems due the limit of 3 subject's attendances. Their results showed that total attention to gestures ended on 70 %.

5.2 Eye behaviour in corridors

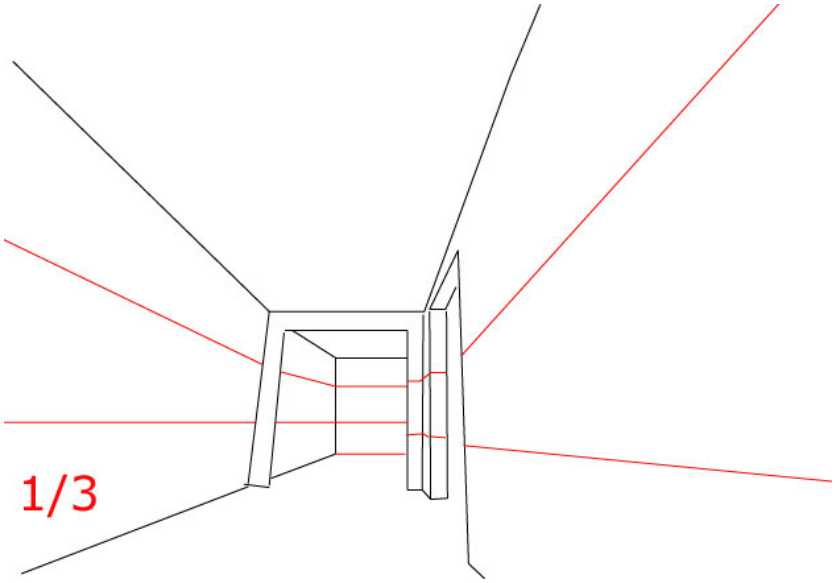
The paths the subjects have to operate through are restricted with walls, which can differ from open spaces regarding search behaviour. The detection is more focused on the pathway straight ahead and openings, with different light conditions. The visual attention focuses on detection of pop-outs. A fast reaction has to be considered so the subject can prevent these pop-outs, with belonging actions, in time.

In this sequence the subject have passed hostage rescue, the Live Ammunition Simulation I and the Live Ammunition Simulation II. The subject is on its way toward the Smoke Grenade Simulation.



In curved corridors the main fixations fall on the inner curve.

Further analysis show that while subjects move in corridors the fixations are mainly directed from floor and one third up on the wall and on the floor ahead.



From the results of the curved corridor and the 90 degrees corridor the hypotheses and the questions will be stated in the `Conclusion´, p.38.

5.2.1 Former studies

The results will be related to former studies, which will be presented here and in the discussion at the end of this chapter.

5.2.1.1 Car driving

1978, U.S. Army Research Institute for the Behavioural and Social Sciences in Alexandria-Virginia made a study on eye movements behaviour while driving a car. They looked into how subjects directed attention on straight roads, curves, through traffic and familiar routes. Initially the author made a distinction on the visual input while steering a car. Firstly 90% of the total relevant information driving a car is visual. Secondly, the visual modality enables information from a greater distance than from hearing. The distance makes the driver plan for future activity. Thirdly, the visual modality enables information about directions, distances, forms, velocities etc. The advantage, as the author pointed out, of doing a study with eye movements is to see parts of selected manifests in a pattern of fixations and for security considerations. The overall goal of these kind of studies on car drivers were to find cues about the optimal visual design of road surfaces and its nearby surroundings so rational information could be adjusted to meet these kind of goals. The subject or the ordinary driver plans the driving and processes information in order to get as fast as possible to a destination, detect “pop-outs”, survival etc. Cohen mentioned how to avoid uncontrolled information input from the peripheral vision. That was to load each subject with a great amount of information to be processed in a short time. The importance of the fovea guarantees the fastest information input possible and should then decrease uncontrolled information input. In daily traffic situations drivers do not always have relevant information supporting their driving. Bhise and Rockwell (1971) showed that a car driver could steer the car with peripheral vision under simple conditions. That means that the subjects fixated something else than the road and was probably occupied by the instruments in the car but could steer anyhow. This kind of interference should be avoided in an experimental design if the goal is to use relevant information in an investigation. The results from chapter 4.1.1, curves vs straight roads, show that information available from a curved road is completely different from that obtained on straight roads. Cohen relates to Shinar´s, McDowell´s and Rockwell´s (1977) findings, which showed that both kinds of curves, left and right, an asymmetrical pattern of eye fixations were observed. In a right curve most of the fixations were concentrated on the right side of the road. In a left turn though the fixations were on the road’s whole breadth. The visual activity depends of the path of driving and the driver needs more information in a curved path than in a straight one. (Illustration on the eye-behaviour in curves, see next page.)

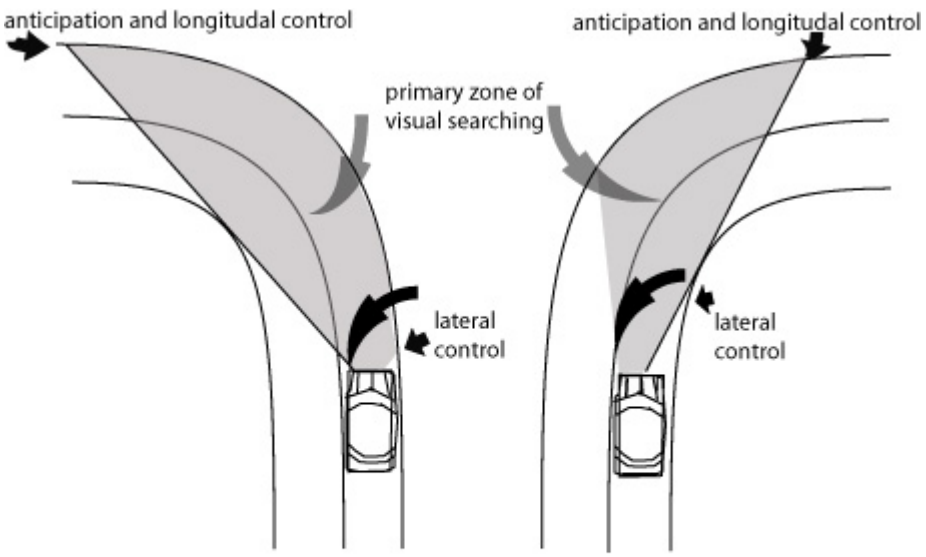
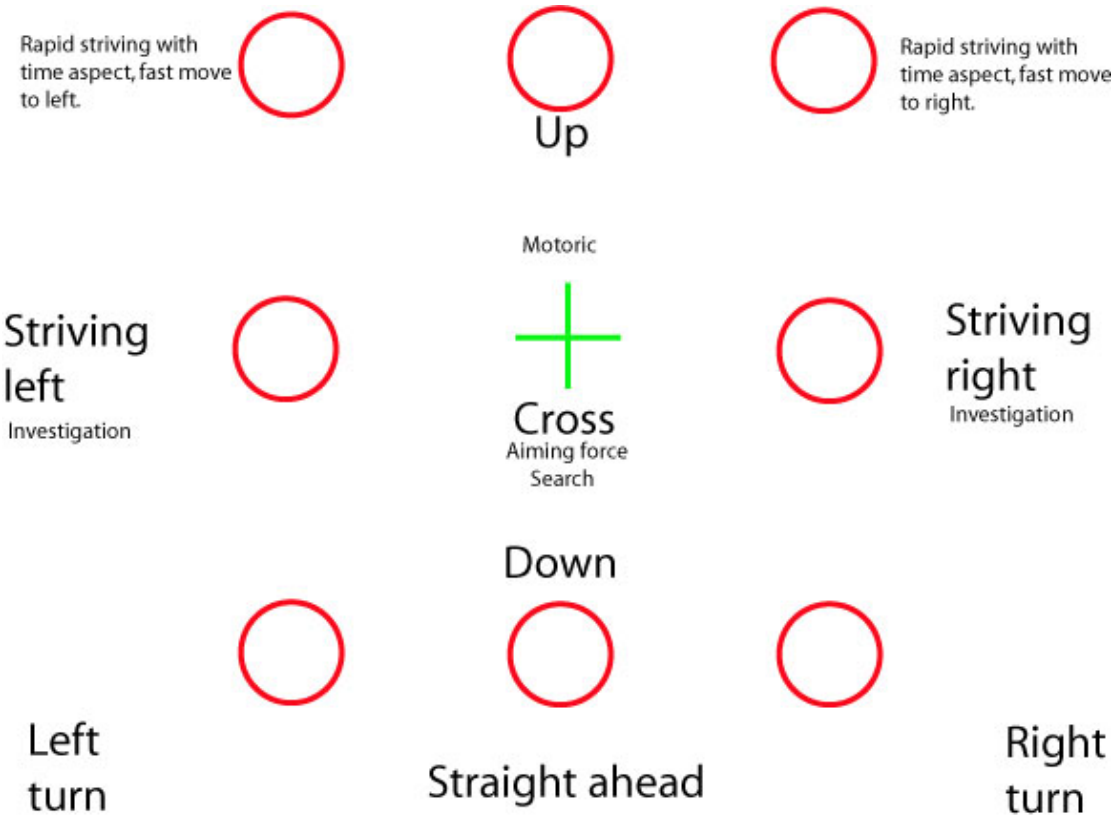


Figure 3: The schematic presentation of the primary zone of visual searching in a left and in a right curve. The angular distance of this effective zone is limited in every curve by the direction of fixations devoted mainly for lateral control. This angular distance is greater in a curve to the left than to the right. Therefor, because of the time sharing between both functions, a greater amplitude of eye movements is evoked in a curve to the left than to the right.

5.2.1.2 Car driving while operating a CRT touch panel

1988, Zwahlen et al. gathered 8 subjects to investigate looking behaviour and lateral path deviations when driving in a straight path while operating a simulated CRT touch panel display. Radio and climate controls were to be manipulated while driving. There were four conditions in this experiment: high position, low position, not looking outside while operating and looking outside permitted while operating CRT touch panel. 40 mph was the speed the subjects should keep while performing these various tasks. In their introduction they started out to mention how CRT panels in automobiles have been adapted from aerospace, defense, static business etc. without any concerns about human factors differences between these modes of use. They mentioned that it is hypothesized that if more than three looks are required inside the vehicle to obtain a specific chunk of information during a relatively short period of time (4 seconds) then the task becomes uncomfortable for the driver in respect of visual, safety and performance aspects. Before each experiment the subjects were instructed to concentrate upon either successful operation of the CRT touch panel or upon both the CRT operation and their driving performance. The subjects were told to look up at the pavement ahead as often as necessary to obtain a proper lateral lane position. When they reached the speed they should complete the following operations: They should turn on the radio, they should adjust the volume, and they should select a band, when station was selected they should use a memory button and finally a dynamic noise reducer was turned on. The second task was to maintain operations of the climate control and the steps were to turn on the heat, setting the temperature and the fan speed should be adjusted. The results showed that subjects did not use the opportunity fully to look outside while they were operating the CRT, so they did not improve the standard deviation of the lateral lane position. They concluded that values that reached unacceptable values after 2 to 4 seconds, of occlusion of visual road-traffic input while working with the CRT inside the car, are considered to be too dangerous. Therefore full safety and performance could not be reached.

5.3 Re-fixations in a live ammunition simulation



This model is illustrated from the video data and its transcription from Live Ammunition Simulation, which is concluded here. The cross in the centre pops up when the subject enters the simulation areas. This model is based on looking behaviours referring to the cross, which is operated from mouse and hand. The cross is the aim point in these operations. Aim point and eye fixations relate to each other in search, finding targets, shooting and after shooting. Each subject seemed to have individual re-fixations after search for targets. After analysing these sequences the most common area for re-fixations is between northeast position and southeast position. The southeast position can be due to the graphical arm that is placed from this corner. In search, the fixation diverged with cross. In finding the targets the cross seemed to function faster than the fixation. The cross was mainly first on target when a low sound foreboded an event. Fixations seemed to not go directly on target instead they were positioned nearby with an undefined ratio, 4-6 degrees.

Four subjects seemed to fixate the graphical aim point of the weapon that has no functionality in these actions. A subject which had north-east position turned around 180 degrees, probably to be able to use the re-fixation better since the targets were on left side (first) of subject, which then could be more effectively used. Very seldom cross and fixation joined together.


The first target in the live ammunition simulation.


The second target in the live ammunition simulation.

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8
North								
North-east	X							X
East			X					
South-east		X	X		X	X	X	
South				X				
South west				X				
West								
North-west								

Re-fixations for subjects in the Live Ammunition Simulation.

Four extracts from `Live Ammunition Simulation´ that describes were main interest were in some of the shooting sequences. Analyses show different eye behaviours regarding task. Subject 2 shows mainly fixations on weapon during operation, subject 3 has fixations on weapon and its aim point while shooting; subject 5 and subject 7 fixate the weapon when cross is on target and for subject 7 many fixations are on the graphical aim point more frequent. The graphical aim point on the weapon has no functionality in these situations, the centred cross is the working aim point.

5.3.1 Former studies

Have not found anything to relay on except for Yarbus.

5.3.1.1 Yarbus

The only former study I can relate to in these findings is to Yarbus (1967). He saw re-fixation patterns when subjects eye movements were recorded. If something was interesting for the subject, the subject returned to the same spot over and over again. The stimulus was a 2-dimensional plane picture.

5.4 Discussion over the results

The following discussions over the results will here be presented. First the individual results will be discussed separately and in the end of this chapter they will be united as whole.

5.4.1 Discussion over facial interest

The non-interest or the lack of interest toward the face region can be of many reasons but three feasible reasons will be presented here.

Firstly, if you have played action games before, the attitude and pre-knowledge can affect the behaviour since the subject knows nothing will be gained out of this region in regard of money or points.

Secondly, the time issue combined with the keyboard placement can affect the overall looking behaviour to be head-down. Fixations are directed to the lower part of the screen and the keyboard. This can be an effect of a mental prevention of “pop-outs” where the player looks for shadows and hazards. Since the action is carried out from the keyboard, the safety lies within that region.

Thirdly, eye behaviours that show in data are fixations that mean that visual information has been processed in the fovea but not in periphery. The periphery processing occurs but a fixation is considered to be most and deepest processed. The foveal vision is constrained to 2 degrees of the visual field while the peripheral view is 160/130 degrees in a natural situation. Here it can be considered to be 20 degrees. The theory of visual attention claims that visual information are processed when a fixation occur. If data has shown no interest toward face, why do the subjects say that it’s almost the only region they directed gaze toward? Either, they have processed the information in periphery, and felt that they really had processed the visual information or they automatically thought that they had fixated the face without knowing not so. Their answers can be a reflection of social cultural behaviour or they rely upon peripheral attention and answer “face” because it is a graphical representation to not consider as face-like. The peculiarity is that no other body parts were chosen, except for subject 1 and subject 5. The body parts would also have been processed in periphery as well. Longer time exposures show that facial interest increased for subject 2, 3 and 6 but it was not a general pattern.

Other explanations when operating in a task related environment like this could be that subjects do not want to fixate faces. The subjects rather stay anonymous to the person when it is a context of this genre. Yarbus study on stills showed that the face drew more attention than the bodies and the bodies more attention than to objects in the room and finally the background. If it could be that in an action game environment, the peripheral looking behaviour exists on the foreground and the focused attention stays on the middle- and background. Subjects tend to look through or beside the characters because of the context; the main goal is to detect hazards.

The goal of the task will probably direct attention. Does this mean that the task determines how we focus and indirectly the eye behaviour is steered by the task? In the police, police officers are trained to direct attention toward the hands when they are to catch a person in a room or outdoors. The hands are considered to be the largest threat in a situation like that.[11] Is the visual consciousnesses build on what is rewarded or not?

Gullberg och Holmqvist´s results from their first study showed that facial interest in a spoken context, in a realistic environment, were focused on the face and not the gestures. 1,6% of the fixations were outside the face region in their result.
In their second study they tested the realistic setting over again but added two parameters; the social aspect and the size constancy depending on medium. But it

[11] Sand, U., Polismyndigheten i Skåne, shooting instructor, piketen (SWAT), personal communication.

showed even if the distribution were on a TV-screen or a life-sized screen the facial interest stayed over 90 % with small variations. Hence, in this case even if the social cultural behaviour has no relevance in an artifical setting, the social behaviour remains. It can be that natural mapped moving pictures, which film can represent, produce a “cheater” upon the visual system as well as upon the social behaviour.

In Nobe´s study with the anthropomorphic agent, subjects tend to look mostly on the gestures, 70% of all fixations. The face was recognised if the agent showed a very different expression as for example an angry face. The hostage in this experiment and Nobe´s agent is similair to the hostage but with the difference that the hostage is in a full picture view while the agent is presented from waist to head. These two different formats due to the size show that computer mediated characters draw more attention on gestures than to face. The hostage does not use many gestures and neither does the face express very much in terms of mimics or directed gaze that could be considered to be contactable.

It seems that these results from different studies show a tendency of what can be called “the computer graphic quality” or “the natural quality” (film) of how we direct gaze. “The natural quality” seems to be independent of medium choice concerning TV distribution, life-sized screen compared to a natural setting. “The computer graphic quality” seems to direct gaze more to gestures regardless of the specific task. Important when comparing eye behaviours in different media it seems that we copy natural facial interest to some media then it could appear the other way around when it comes to non facial interest. Non facial interest and no personal awarness of eye behaviours in one context could then follow into other contexts as an effect of learning. So what is social behaviour when it comes to digital environments? The social aspect in a face-to-face communication in a natural environment is seemed to be sorted away when the stimulus has “the computer graphic quality”, so the confidence of what is “real” seems to be very important when we operate in artificial environments. This can be totally different in other game genres though.

The task it self can replicate an anonymous eye behaviour by the subjects because the subject does not want to look at the face. This anonymity is not just a phenomenon in explicit eye behaviour. It can as well exist in mental forms especially in digital role-playing. Anonymity can for example be formed out of distance/height, task and speed. A pilot in a helicopter or a plane can experience anonymity to a target depending on distance and height in aerial work operations. People, houses and mountains get smaller when you increase the distance/height.[12]

So the following reasons can be an explanation of the non-facial interest captured by eye tracking related to visual attention:

Anonymity	Task
“The computer graphic quality”/	What is rewarded
“The natural quality”	Time issue
Ergonomic design as seating	Social behaviour
Foveal or peripheral processing	Mental state
Pre-knowledge of context	Reinforcement between media

[12] Svensson, A., Helicopter pilot, personal communication.

5.2.2 Discussion over eye behaviour in corridors

The results from the curved path and the concentration on the inner curve show that subjects look for enemies or unplanned events that can pop-out and be devastating for their own progression. Likely to car driving and Cohen's findings the goal is to survive and therefore an attention is directed to this area. The situation in car driving is to stay on the road, in the game environment it is to move on in the corridors but the same pattern seems to follow. Even if a subject can move over on the left side in a curve, in action game tutorial, it seems like subjects stay in the centre probably because the curve also function as cover and protection. We have one setting in a digital game context and one experiment in a natural situation and it seems like eye behaviour patterns correspond even if they are performed in total different media with different scale (size) constancies, peripheral view and distances.

Also what was pointed out in the previous chapter and its discussion was the concern of "the computer graphic quality" and "the natural quality" as a `natural representation´, but here the natural environment seems to not differ from the computer made graphic. The similarities between these two experimental conditions are the first person perspective, a velocity (driving and running (moving)) and the goal of survival. The differences are the light conditions and actually the risk of dying in a real environment, which is not in a game environment, not physically. In a game context the death is emotional.

Looping (cyclic events) and automation of performance cause less visual attention. In practice it´s just to keep one key down, "W or UP ARROW", when to move straight ahead and in a turn you either choose "D or RIGHT ARROW" or "A or LEFT ARROW" when to turn right or left. Less visual attention when action-video game playing seems to increase visual attention, how is it related? If events seem to be repetitive like in corridors or straight roads, if the visual stimuli do not change it will tend to be too procedural so no effort is taken in action by the subject. The visual attention will fall in redundancy. The increased attention will be challenged in a full version game where the subject doesn't know where and when something will happen. This can also be connected to the head-down behaviour in these corridors, if nothing happens, a person does not put full attention to the ongoing task. The subject could be bored or could also have this search behaviour because, as said before, there could be shadows falling on the floor that work as predictors to the subject. Related to car driving and former studies it seems that subjects can follow the road and use peripheral vision while they concentrate and focus on other operations in rather low velocities. A straight road is not hard to follow if there are not hazards in the surrounding, loads of traffic, bad weather, bad road conditions etc. The bad things about low awareness when operating are the not-expected events that can follow. This kind of high and low attention within a game shapes a rhythm and a feeling within the game but can also be the end for the subject.

This experiment has used a stationary computer with the keyboard placed in front of the screen as they usually are combined in homes. The seating, the keyboard placement and the height of the table and the screen can be components which can be factors of the head-down behaviour which also can direct the eyes to fixate the lower part of the environment. In comparison with Zwahlen´s study the keyboard and the CRT can be regarded as interaction panels that seem to draw much attention of the

subjects. As in Zwalen´s case the subjects should maintain on a straight road that the subjects more or less saw as no problem. It was a problem for the safety though.

5.2.3 Discussion over re-fixations in a live ammunition simulation

In this case the re-fixation seems partly to exist free in space and to a graphical object, the weapon. When the re-fixation occurs free in space it's positioned the same after search whatever background there will be. Subject 2 and 8 had these re-fixations patterns as well as subject 4 with the southwest position. The south-east position will not always be right on the weapon, the position can lie between the graphical aim point and the target, the south east position is in relation to the centred cross. The re-fixation seems to work as resting and power recharge rather than for interest. And they are cyclic and occur after searching and shooting. The limitation of not being able to track depth can be a disadvantage when re-fixations are directed independently of background. The fixations on the graphical aim point of the weapon are strange because there is no functionality connected to this part. A mental pre-knowledge of its functionality shows even in an artificial context when it has no purpose.

These graphical areas can also be seen as objects with a structural meaning, as parts of the narrative context.

5.4.4 Over all discussion over the results

The results of this experiment have shown where and when a subject direct attention which is dependent on task, the time issue and the present goal so survival can be assured trough interaction.

The first person view in the curved corridor shows similarities in eye behaviour as in the car driving study. It seems that they are processed the same though the movement is a camera glide through corridors. In both cases the driver or the player is sitting and is actually not moving physically and the head are more or less fixed straight ahead. The peripheral visual view is 130/160 degrees in a natural situation but only 20 degrees in a computer situation due this difference in peripheral view the results in these two studies show similair eye behaviours. The "the computer graphic quality" made agents or characters seem to attract fixations on gestures and the rest of the body rather than just the face. This can be since the social reduced need of face-to-face communication, the current task and the "the computer graphic quality". The decreased need of "the natural quality" does not show remarkably when communication is distributed on TV or life sized screen in the former studies. The re-fixations, which show, after search and shooting, seem not to be of interest-character rather re-charging- or pause-character to start out a new search.

The juggling of tasks and the abstract tests with pop-outs and destructors in Bavelier´s & Green's study could mean that their subjects with non-video game experience improved their peripheral view. The peripheral views support the foveal region. A danger or a moving target is processed from a peripheral view to warn the visual field from fast moving targets. This could be said over the results of non-facial interest and the live ammunition simulation where fixations not always, or seldom, are on target. The target, the subject has found, is already processed in the eyes and will then prepare for new pop-outs.

To summarize these findings it seems that environmental aspects are easier to copy from one medium to another, the eye behaviour follow. Face contact seems to be more sensible where character design has to bring in "the natural quality" to also open up for new solutions of more humanlike characters into an environment. If the goal is to keep an anonymous behaviour we have to consider both an effect of learning that possibly can be copied over in other contexts and a possibly change in social face-to-face communication. Likely fixations can lie on graphical objects even though they do not have any functionality when the goal is to operate and relate to totally different functional goals, as the weapon and its graphical aim point.

These behaviours can also be, because objects within a narrative context have a structural meaning.[13] Clive Fencott at Teesside University in England has made a Perceptual Oppurtunity Model, which can be of help to categorize different fixation patterns. "PO´s are a content model for interactive media and Virtual Environments in particular and were initially developed to assist in the teaching of VE design (Fencott, 1999a). The model addresses the psychological and communicative qualities of a VE that seek to gain and hold the visitors' attention through the human senses and perceptual system. The perceptual is about details that arise naturally from the spatial world and involve the visitor both consciously and unconsciously."[14] This model can be used which can further show interaction potentials of the character within the narrative, point of interactive significance and the different kinds of meaning within a game environment.

The first foundations of players´ eye behaviours are laid but remains with further questions.

6.0 Final discussion

This chapter will be related to learning and the derivation of simulation, game and the player as "me". One of the questions is how eye behaviour in different media can reinforce on each other when interaction products as action games are used in different situations. Also how reinforcement can occur between genres this could give totally different results, this question will not be brought in here though.

"The rules for connecting a text to physical reality are somewhat complicated and to learn these is a big part of what modern education is about"[15] To apply these words to the artefacts we have with their picture contents and interaction possibilities, the focus moves from transformation of knowledge towards mapping of reality. These are aspects of a social cultural change as well as a psychological. Sherry Turkle from MIT describes the subjective relations we have with our artefacts. The intimate relationships which one user expressed as, I become my computer. This statement can also be considered to be stated if I become my character? Historically psychoanalysis put people as objects but today the objects have become "objects", what Turkle call *object relations' theory*. The object can be seen as a "second self" or "identity" but today with multiplayer systems it´s not longer just a peer-to-peer relation, the whole world with its different environments is our field.

The situated learning in digital environments tries to contextualize de-contextualized content where content and meaning are communicative aspects. Our beliefs of

[13] Lindley, C. A., professor of game development at the University of Gotland, Sweden.
[14] http://www.fencott.com/Clive/UnderstandingVR/FiveVEsCompared.html
[15] Säljö, R., "Lärande i praktiken, ett sociokulturellt perspektiv ", Prisma , 2000, p.16.

learning are steered of linguistic pictures, the metaphors, analogies and parables that we use in everyday life. Associative learning and social learning are very much shaped of the culture we consume and live in.

In a gameplay situation, which can be considered as entertainment we can argue that we play for fun and the goal, is not to learn. Learning though, exists in almost everything we do but in different ways. A player learns an individual gameplay pattern, a play style that becomes the signum of the player. The patterns, through interaction and eye behaviour, are affected by those situations that arise within the game world, which includes thinking in terms of problem solving and progression. Visual attention must be synchronised with short reaction times.

Facial interest in an action game does not seem to matter in terms of gameplay and play for fun, this is surely so. But if we consider how we indirectly choose to direct our gaze, either if information is foveally processed or in periphery, we adopt an eye behaviour that can tell where and what is most interesting in real-time presence. In a natural face-to-face communication we look upon each other to see where our mates direct attention to, the gaze of others can tell us about interesting ongoing information in the surrounding. Also we can read our mates to determine in what mood they are in, their attitude and what state they are in. In a multiplayer context the interactions and tracked eye behaviours probably are formed upon the group mixture where you as player have to find out what will come next, a future planning which assure presence.

Lindley states that a simulation can be defined as: “A representation of the function, operation or features of one process or system through the use of another. Simulations like flight simulators are often interesting from the perspective of skill development; they are not interesting as games or stories, but for understanding how a particular system functions in different circumstances.” A flight simulator is often constructed in scale 1:1 and the goal is to keep the environment as realistic as possible to provide an authentic working environment for the people who interact. A flight simulator has limits as well, compared to a real flight operation and often this is compensated with higher workload so the person will have the same pressure as in a real situation. A simulator is placed on ground and therefore the safety is no risk. “The more realistic a flight simulator is, much easier it will be to fly in real” [Dave Grossman, Killology Research Group-USA] (“Dödligt spel”/TV4, 2004). The report of FOI says that simulation can be explained as a representation of reality, an imitation of a real process and refer to Stanton (1996).[16] What is then the difference between a game and a simulation? Alfredsson[17] points out an important aspect of what the difference is between an entertainment product and a simulation in a professional context, the workload is a fun component in commercial games, which are not the criterions when a professional is considered.

The problem or the fuzzy derivation particularly in the action-game genre is the mix of learning a pattern of interaction with the game system and the included simulation tasks that involves how a particular system functions in different circumstances. If simulations by Lindley´s definition not are interesting in terms of game value then the action games maybe should not be considered to belong to games at all. Action games

[16] Rencrantz, C., ”Game based training and education ”, ISSN 1650-1942, Command and Control Systems, Linköping. December, 2003. p.8
[17] Alfredsson, J, In charge of the lab of eyetracking at FOI, personal communication.

are more or less skill based straight through. Interestingly, eye behaviour in consideration to a representation of a function, an operation or feature of one process or system through the use of another will definitely consider the possibility of reinforcement, which visual content can force upon eye gaze or eye gaze can force upon visual content.

If there are different ways to direct visual attention depending on either “the computer graphic quality” or “the natural quality” this is an important result to have in mind when to decide feel and touch in a game already in the pre visualization. Also when interactive products are used in a simulator, there are aspects to consider if the goal is to train natural situations. There can be differences regarding these different looking behaviours. So the training can be useless if not these parameters are investigated. The field of situation awarness is important in training, operation and the construction of an interactive product to decide if the goal is to progress for fun or for training for seroius events concerning workload.

When to progress in a commercial product often the restricted group or the individual build the mind around gameplay from an entertainment point of view but with serious intentions of how to progress otherwise the game is worthless. In a professional context often a group is lead and instructed with considerations of why and how an interactive product is used and how this relates to a natural setting. The switch between scale differences with distances and tasks are discussed to understand the artificial aspects into the operative missions. These aspects are seldom considered in an entertainment context so the rules behind are not shown or discussed since they would maybe destroy the feel and touch of the product. The rules become more or less open versus closed depending on user.

When using interactive products in a learning perspective there is a pre-knowledge to consider which is about the individually learned eye behaviour from a home context. The pre-knowledge can affect a controlled learning situation or likely a natural one.

The different media and the different goals of games, simulators and natural settings are melting together which indicates that more research has to make serious attempts into this field. The knowledge cannot lie within personal opinions and the research has to keep up. Otherwise academic research will not be considered in valuable perspectives when different aspects are focused. The ad hoc hypotheses in public media will form the understanding and that is the most threatening scenario we can meet.

In car driving and face-to-face communications, which are very different in task, show that eye behaviour when distributed in other media are almost reflected as in a natural environment. So if a behavioural tendency shows in a computer-mediated medium, it would preferably be tested to find out if the same conditions would occur in a natural environment. If not, we have products that can affect our visual system. Also the social culture perspective will be influenced as well as our society. Since our brain has information limitations it could be that the juggling between different media contexts are too demanding, so all different formats have to be compromised into a one-set-comparison due its parts.

These issues that have been raised are considerations to implement to find out if better solutions can be developed to improve action games to meet the need for cognitive variation that can be further investigated in the field of Human Computer Interaction and related academic disciplines.

7. Conclusion

The hypotheses and the questions are formed out of these results. The hypotheses are stated from the analysis of the data and will be presented as hypotheses. The questions that are formed are also raised from the analysis of the data but cannot be answered in this essay but can be further investigated in the future. The former studies have been of tremendously help to point out certain aspects and findings which has functioned as support when some of these hypotheses or questions have been formed, especially the forming of question 1.

The hypotheses are:
Hypothesis 1: Repeated exposures show different eye behaviours as according to the theory of task related eye behaviours.

Hypothesis 2: Eye behaviour in car driving in a natural environment is applicable in curved corridors within the action game environment.

Hypothesis 3: Re-fixations in space independently of background function as rest- and power recharging in an action game environment instead as attention of interest.

Hypothesis 4: The motoric is mainly faster than the eye in these simulations when a sound forebodes an event.

The questions:
Question 1: Can lack of facial attention in an artificial environment affect natural face-to-face communication depending on frequency in use?

Question 2: In what way can facial attention be increased if game value is added to this region?

Question 3: Can looping (cyclic events) and automation of performance cause less visual attention?

Question 4: Can the keyboard and its placement underneath the display affect eye behaviour to be head-down performed, fixations on the lower part of the screen?

Question 5: Can the main eye behaviour in these paths be because subjects look for shadows?

Question 6: Does “the computer graphic quality” compared to “the natural quality” have different values in an action game context?

8. Future

Almost all former studies from this or last year show a need of research for different perspectives that are involved in the development of interactive products which game development is part of. The main focus I would like to stress is not just the content

and its interactive value. It is the lack between programming and graphic and what games do to us. To design good products this concern has to be brought in into the developmental aspects. Traditional graphic knowledge, which is developed for print, has sometimes no relevance into a medium like this when a time factor and movement are the main concerns.

To make further researches so all findings can be integrated in an eye behavioural scheme, which can further on be developed to a visual grammar based on eye behaviour in games, simulations and natural circumstances.

To get a closer understanding of an action game content the retrospective walk through would be of big importance to these findings so a subject could comment on his or her own eye behaviour straight after the experimental session. This study has used skilled players. In further research it would have been of big value to have non-game players and also a large group of women.

More eyetracking studies that can show our every day behaviour in terms of how we direct gaze in doings, especially those that are implemented in games. Also a need to eye track several people at the same time while playing in multiplayer situations to find out how people choose to operate in a group and to learn how each player operate in gameplay which includes strategy and tactic. These findings can also be of big interest for other branches than just the game industry, the question of how we operate in networked systems with avatars/characters. Researches in other existing game genres are also of great value.

Research of learning as associative learning and social learning would increase the understanding of both negative and positive effects of this field. Important for the education field is to understand game culture and how conventions and non-conventions are produced and why they attract big user-groups.

In terms of how our society develops and communication systems function the discipline of Psychology needs to look into emotions and social culture values in both identity and the relation to the artefacts. If our society replaces people with computers and its content there will be other references for people than just people. People can become secondary and the content of computers more valuable, graphical representations that are produced within the computer become more real than ordinary people. The fascination over the cloning fulfils the artificial dream to become reality.

In Neuroscience and Cognitive science fMRI studies could help us to see if differences occur when using different media and genres. What regions are activated more when certain interactions do occur and what regions are activated when subjects are exposed with natural people compared to computer made characters. What happens when rewarding and failure are looped over and over again?

In Visual Science, size constancies could be tested to see if we use the perspectives and the digitalised scale system into our natural environment or the other way around. How do we modulate our senses in a virtual reality environment?

The discipline of Linguistic can look into what happens when using different communication media as multiplayer systems. What is processed in terms of language use, memory and stories of played through paths and reaction times with workload. The discipline of Media can go into how people choose their use of media in terms of involving themselves. To play Counterstrike can be one way to deal with what is going on in the world concerning terrorism and can be seen as a complementary to media reporting.

Criminology, in terms of visual content could investigate if there are aspects of using products for special goals. Why is Counterstrike mentioned in all shootings that have happened in the high school in Colorado, the sniper shooting in Washington and the shooting in Germany at Gutenberg gymnasium? A reason to look into `dehumanization´ and `humanization´ caused by game playing.

Virtual reality and the use of social simulations with patients and the technique of mixed reality where graphic and reality are two mixed components. The whole world can be looked at as an artefact of itself but how do we adjust as biological creatures? How does our brain know what is real and what is virtual?

Art and classical composition with foreground, middle-ground and background where foreground often is pictured as the ground in focus. Are these aspects when it comes to computer graphic and action games?

In game development, considerations and circumstances can be tried out where the creations of the characters have more normal face expressions, eye expressions and visual deixis (to follow another character's attention).

The need of shaping new game genres that explains more adequate what is happening in a game that can complement the traditional classification.

The list can be much longer and there are lots of perspectives and different approaches that can add more knowledge into this field, the field of games!

Please contact me if you have any ideas or suggestions,
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