LUND UNIVERSITY

SWAET 2010

The 5th Scandinavian Workshop on Applied Eye Tracking

May 5-7
2010

The 5th Scandinavian Workshop on Applied Eye-Tracking

SWAET 2010
Program & Abstracts

Lund University
May 5-7, 2010

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SWAET 2010 – Workshop program

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Oral presentations I

Thursday 6 May

Eye movements during mental imagery are not perceptual re-enactments

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Several eye tracking studies have reported that spontaneous eye movements occur during visual imagery and that these eye movements closely reflect the content and spatial relations from an original picture or scene (cf., Johansson, Holsanova & Holmqvist, 2006). Laeng and Teodorescu (2002) also showed that participants who fixed their gaze centrally during a scene perception did the same, spontaneously during an imagery phase. They concluded that eye movements during visual imagery are reenactments of those during perception. However, in this study relatively simple stimuli were used.

The purpose of the present study is to replicate Laeng and Teodorescus' (2002) method of central fixation during perception, and investigate if the central gaze effect during imagery appears when pictures of high complexity and verbal scene descriptions are used as stimuli.

Eye movements were recorded - using the SMI RED 250-system - for 20 participants in three different conditions: a control condition, a fixed-picture-condition and a fixed-verbal condition. All three conditions started with a perception phase followed by an imagery phase. The imagery phase was similar for all conditions, i.e. participants looked freely at a blank white screen. But the perception phase was different for each condition.

In the control condition a complex picture was shown for 30 seconds. Then the screen went blank and the participants recalled the picture from memory by orally describing it. In the fixed-picture-condition another complex picture was shown for 30 seconds. Participants were in this condition instructed to maintain fixation on a cross at the center of the picture. Then the screen went blank and participants, who were now free to move their eyes, recalled the picture from memory by orally describing it. In the fixed-verbal-condition a verbal scene description was played from speakers in front of the participants. During the scene description the participants were instructed to maintain fixation on a cross at the center of the screen. The scene description lasted for 1.38 minutes. Then the screen went blank and participants, who were now free to move their eyes, recalled the scene description from memory by orally retelling it.

Eye movements were analyzed in two regards. First, the overall spatial dispersion of the eye movements was analyzed for the perception phase and the imagery phase. Second, the method from Johansson et al. (2006) was used for detailed analyses of how eye movements corresponded to directions and positions in the verbal descriptions of the imagined picture or scene.

The results from the control condition confirmed previous results that eye movements during imagery reflect content and spatial relations from the perceived picture. The two experimental conditions revealed that despite central fixation during perception eye movements were spread out and reflected spatial positions and directions during imagery for both the picture and the scene description. This contradicts the results by Laeng and Teodorescus' (2002) and we propose that eye movements during imagery are more complex than mere re-enactments of perception.

The results will be discussed in relation to current theories on eye movements during mental imagery and important methodological issues, such as idiosyncratic eye movements, will be highlighted.

Practice eliminates "looking at nothing"

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A growing body of research shows that people fixate on blank locations if a relevant visual stimulus previously occupied the location; the so-called "looking at nothing" phenomenon (Ferreira, Apel amp; Henderson, 2008, Trends in Cognitive Science, 12(11), 405). "Looking at nothing" is presumed to indicate an attempt to retrieve information that a task calls for from the environment. With practice in a task, in which the presented information is constant, the memory representation of information is strengthened and information retrieval from the environment becomes unnecessary. Thus, practice could diminish "looking at nothing". Alternatively, "looking at nothing" might be stable through practice, because it is triggered by the activation of an integrated memory representation that includes spatial indices. We report an experiment that tested whether "looking at nothing" diminishes with practice.

The experimental task was a variation of the task used by Richardson amp; Spivey (2000, Cognition, 76, 269). At the beginning of each trial, participants listened to four sentences, each of which was associated with one of four quadrants on the screen. After every set of sentences, participants heard a fact that was related to one of the sentences and had to judge whether the fact was true or false. During this verification period, only the four empty quadrants were visible on the screen. Whereas in previous studies sentences changed from trial to trial, we presented the same four sentences in every trial to induce practice. In this study, each sentence consisted of three different facts describing attributes of a fictional city (e.g., "There is a place with a purple lighthouse, a sickle bay, and a wooden church"). These four sentences were repeated at the beginning of every trial. Immediately afterwards, participants responded to one out of twelve possible facts (e.g., "There is a place with a wooden cottage."). Every fact was probed once so that every participant completed twelve trials. If practice eliminates "looking at nothing", we predict that for the first trials participants will fixate more frequently in the quadrant where the sought information was presented in comparison to the other quadrants, whereas during later trials they shall not.

Gaze behavior was recorded from 19 participants with a remote eye-tracking system from SensoMotoric Instruments at a rate of 50Hz. Four adjacent areas of interests (AOIs) were defined that corresponded to the four quadrants on the screen. The number of fixations in every AOI was counted per person and per trial. We compared the data for three levels of practice (trials 1-4, trials 4-8, and trials 8-12).

Performance rose significantly over all levels of practice indicating that the sentences were memorized. During the first four trials, fixations in the critical quadrant were more frequent than in the non-critical quadrants replicating previous findings on the "looking at nothing" phenomenon. During the middle and last four trials, participants did not look more often to the critical in comparison to the non-critical quadrants. Therefore, we conclude that "looking at nothing" occurs if an attempt is made to retrieve information associated with a location in the environment as long as the information is not strongly represented in memory.

Learning Perceptual Skills for Medical Diagnosis via Eye Movement Modeling Examples on Patient Video Cases

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With progressing technical development visually complex and dynamic displays are increasingly in use for medical diagnosis. This includes so called patient videos cases, where patients are taped on video while displaying behavior that is suspected to be diseased. Medical students show severe difficulties when diagnosing based on those videos, in particular on a perceptual level. Medical education has found that for stating correct diagnoses besides biomedical knowledge (knowledge of scientific facts) also clinical knowledge (actual experience with patients) is crucial. One important aspect of clinical knowledge that medical education has hardly focused on, yet, are perceptual skills, like detecting and interpreting features relevant for diagnosis. Diagnosis of diseases that manifest in occasionally occurring behavioral patterns, like seizures, is very difficult on a perceptual level: the important features relevant for diagnosis might be short-term, subtle, time-sensitive, and not salient compared to other features.

Thus, this study aims at fostering perceptual skills in the example of pediatric neurology. In a prior study on instructional design we showed that in a locomotion classification task perceptual skills could be conveyed by means of eye movement modeling examples (EMME). EMME are based on learning from cognitive modeling, where an expert model verbally explains how he is going about performing a cognitive task (i.e., externalizations of cognitive processes). EMME add to this approach the eye movements of the explaining expert model (i.e., externalizations of perceptual processes).

The current study applied EMME to medical education. We recorded a didactically behaving expert pediatrician's eye movements and verbal explanations while he was diagnosing two patients taped on video. 60 medical students saw either those patient video cases with the verbal explanations only (control condition), those patient video cases with the verbal explanations and an additional display of the expert's eye movements as a circle (circle condition), or with blurring areas the expert did not attend to instead (spotlight condition) while their eye movements were recorded. The spotlight was implemented by foveating the videos, i.e., compressing the videos on non-attended areas. Afterwards, participants watched three novel patient video cases without EMME while their eye movements were recorded. After each case they had to interpret the behavior of the patient based on a multiple-choice questionnaire.

Results show that the spotlight display guides the attention of the medical students during example study significantly stronger compared to the other two conditions ($p=.03$). Moreover, when studying the novel patient videos cases, medical students of the spotlight condition had higher dwell times on areas relevant for diagnosis ($p=0.3$) and they interpreted those areas more correctly ($p=.01$) compared to the other two condition. These findings show that guiding students' attention during studying modeling examples based on an expert's attention allocation may foster learning of perceptual aspects of clinical knowledge if implemented in a spotlight manner.

Objective, subjective, and commercial information: The impact of presentation format on the visual inspection and selection of Web search results

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Today, the World Wide Web is a major information source. Due to the relatively low barriers to publishing, information quality, however, varies greatly on the Web. Besides scientifically sound, objective information, the Web also provides subjective opinion-based and commercial information. Though, in the results lists returned by search engines such different types of information are usually presented mixed together. Moreover, in many cases popular commercial or social Websites that may be doubtful with regard to their motives or expertise are listed among the highest-ranked search results. Accordingly, in order to avoid the selection and use of incomplete, biased, or even false information, Web users may not only be required to critically evaluate the topical relevance of search results but also their quality - especially when dealing with controversial issues. Previous research, however, has shown that usually most attention is given to the search results on top of the list, which are also the predominantly selected ones (Granka, Feusner, amp; Lorigo, 2008). Analyses of verbal protocols showed that evaluation criteria with regard to information quality (e.g., credibility, trustworthiness, reliability) are uttered only rarely (Gerjets, Kammerer, amp; Werner, in press). A potential reason for the neglect of information quality might be the lack of salient quality cues on the Web: Search result descriptions of standard search engines are mostly confined to topical information and the list format suggests a processing of the results from top to bottom.

The aim of the present study was to investigate whether a tabular interface which presents search results grouped in three columns according to the categories objective, subjective, and commercial information supports searching for and selecting neutral, unbiased information as compared to a standard list format. Sixty university students participated in a Web search experiment addressing a controversial topic. Participants either used a Google-like list interface with nine search results per page or a tabular interface with the same search results presented in the columns objective, subjective, and commercial information. For each participant the search results were presented in random order. Furthermore, in the tabular interface the order of the columns was permuted. To investigate participants' gaze and selection behavior during Web search eye movements and mouse clicks were recorded with a Tobii 1750 eye tracker. As dependent variables (1) the total dwell time on objective, subjective, and commercial search results, (2) the average time to first fixation on objective, subjective, and commercial search results, and (3) the selection frequency of objective, subjective, and commercial search results was analyzed.

Results revealed that in the tabular format commercial search results were visually inspected significantly shorter than in the list format. Furthermore, objective search results were fixated significantly earlier and subjective and commercial search results significantly later than in the list format. Moreover, as compared to the list format, in the tabular format objective search results were selected significantly more often and commercial search results significantly less often. To conclude, the presentation of search results in a tabular format with additional quality-related cues indeed seems to support Web users in searching for and selecting neutral, high quality information.

Eye Movements and levels of attention: A stimulus driven approach

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Previous research has found that levels of attentional processing can be observed in eye movement parameters, with patterns in the relationship between fixation durations and saccade amplitudes reportedly corresponding to dorsally driven spatial pathways and ventrally driven object identification pathways in the brain. We present a series of studies investigating subjective cognitive states of attention through the analysis of eye movement parameters.

In the first study, a stimulus based approach is used to alter the encoding of pairs of stimuli which are similar in terms of bottom-up properties. These stimuli include (1) possible and impossible shapes, and (2) simple visual scene pairs, with one alteration of either contained objects or object location. The explicit task was to identify a 'where' or 'what' difference. Eye movements were recorded on the EyeFollower from LC Technologies, (binocular, 120Hz, accuracy 0.45 degrees). Parameters of fixation duration and saccade amplitude were shown to differ significantly with cognitive task on these stimuli. In a second study, processing differences are explored at an individual differences level, assessing whether eye movement parameters might offer a measurable, behavioural output of the differential organisational and attentional mechanisms suggested by cognitive styles (CS) literature. A standardised test of CS is used to assess individual differences of 67 participants on wholist-analyst and verbaliser-imager cognitive style scales. Those showing a clear stylistic preference in the 1st and 4th percentiles of the scales differ in parameters of fixation durations and saccade amplitudes, in presumed rates of ambient and focal processing. Furthermore, wholists are shown to distribute attention across a larger area of Impossible shapes than analysts, going against the general and statistically significant tendency to focus fixations on smaller areas of impossible objects than possible objects across the sample.

Results are discussed in light of the encoding differences proposed to account for these images being differently remembered in the literature. Finally, eye movements of a clinical group (people with Williams Syndrome (WS)), who have known structural, functional and behavioural abnormality associated with "where", but not "what" levels of attention are also recorded while judging the where-what stimuli. Previous research has found grey matter volume reduction in the parietooccipital and intraparietal sulcus in WS, interrupting the dorsal stream. The WS group (n=16) is compared to normal participants on the same where-what stimuli described above as well as on global/local image pairs, where a target stimulus is arranged above two similar stimuli which differ from the target either according to the global arrangement of elements, or the shape of local elements. The number of elements and their sizes relative to the configuration were varied systematically. Finally, WS participants were compared to normal participants on simple black and white photos of scenes which were degraded in order that they were locally (foveally) minimally informative. Characteristic eye movement patterns are identified in WS, apparent when cognitive demands emphasise global configurations of objects, or when local (foveal) information is of poor quality. These differences in eye movements are apparent even when the semantic content of a degraded scene is correctly verbalised.

Player's gaze in a collaborative Tetris game

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We have studied collaborative interaction in a collaborative version of the Tetris game using dual eye-tracking. Tetris is a fast paced arcade game where individual players have to place falling tetrominoes (also called zoids) on a stack. Players can rotate the zoids counter-clockwise by 90 degrees, translate zoids left or right, move them down one row or drop them (they fall down on the stack). The goal of the game is to create rows filled with zoids. Whenever one or more horizontal rows are filled with zoids, the rows disappear and the stack moves down by an equivalent amount.
In the collaborative version of the game that we developed, two players share the game field and each control their own zoid. One player's zoids appear on the left side and the other's appear on the right side of the game field. We were interested in two aspects of the game and their relationship with characteristics of the gaze.

The first aspect concerns the effect of collaborating with another player. More specifically we were interested in pair composition, namely to investigate how the play with a more or less expert player influences behavior. Previous research has shown that experts and novices do not look the same way at the game. Experts usually spend more time looking at the stack (searching a good spot) than time looking at their piece (controlling the zoid's movement, checking the result of rotations). Do experts adapt their behavior when interacting with novices? Do novices copy experts' performance and adopt a more expert way of looking at the game?

The second aspect concerns the coordination of collaborative activity. Playing together results in situations where the players have to coordinate their moves, either because one player wants to place his zoid on the other player's side, or because the players are in competition for the best position available on the stack. How are players handling coordination ?

The two players' gaze, actions and dialogue was recorded using synchronized Tobii 1750 eye-trackers. Three dynamic areas of interest were used to analyse gaze : fixations on the player's own piece, on their partner's piece as well as on the contour of the stack of fallen pieces. We classified players as novices and experts based on their performance at a solo playing session. The coordination requirements of the game was also operationalized as a qualitative variable.

We present results of an exploratory principal component analysis. The first factor opposes experts and novices via the ratio of fixation duration on one's own zoid and the ratio of fixation duration on the contour. The second factor reflects the requirement for coordination by extra collision avoidance actions and a longer fixation duration on the partner's zoids. Our results show that novices adopt a more « expert » way of looking at the game when playing with a more expert player and that expert players slow down the pace of the game when playing with a novice so as to « play for two ».

Naming associated objects: Evidence for parallel processing

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Earlier research has shown that speakers naming object pairs in noun phrases, such as 'dog and bell', are able to retrieve their names in parallel, but often fail to do so. The conditions for the occurrence of parallel object processing are largely unknown. Here we examined how associative relatedness between the objects to be named affected the speakers' processing strategies.

The first two experiments used a gaze-contingent display change paradigm. In Experiment 1, the participants named object triplets in a fixed order (left - right - bottom object). From earlier experiments, we knew that they would usually inspect the objects in the order of mention. During the saccade from the left to the right object, the right object presented at trial onset (the interloper) was replaced by a new object (the target). We orthogonally varied the relationship between interloper and target (conceptually related vs. unrelated, e.g. two different locks) and the relationship between the interloper and the left object (categorically related vs. unrelated, e.g. ear-leg vs. ear-hat, or associatively related vs. unrelated, e.g. lock-key vs. lock-scissors). Replicating earlier findings, we found that the targets (the right objects) were fixated for a shorter time after related than after unrelated interlopers. This demonstrates that the speakers had processed the right object to some extent before fixating upon it. However, the size of this preview effect was independent of the relationship between the interloper and the left object. Thus, the interlopers were processed equally efficiently regardless of whether they were related or unrelated to the left objects.

This pattern of results was replicated in Experiment 2, where the participants named pairs of objects that were associatively related or unrelated and where the left objects in the pairs were repeated four times within a test block to facilitate their processing. In addition, in highly associated left object – interloper pairs, associative relatedness was found to affect processing of the *left* object. Speakers looked *longer* at the left object when it was accompanied by an associated than by an unrelated interloper, consistent with parallel processing of the associated objects and interference among them.

In Experiment 3, the participants named pairs of associatively related or unrelated objects. There were no display changes. Each left object was repeated eight times within a test block. As in Experiment 2, the left object was processed more slowly (i.e., inspected for a longer time) in associatively related than in unrelated pairs. The reverse held for the right object. This pattern was not replicated in Experiment 4, where the left objects were only repeated once per block.

We will discuss how the difficulty of processing the fixated object and the relationship between the fixated and the extrafoveally viewed object jointly determine the speakers' processing strategy.

Reading Text Messages - An Eye-Tracking Study on the Influence of Shortening Strategies on Reading Comprehension

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The emergence of email, Instant Messaging and text messaging has not left language use unaffected. Texters, for instance, use abbreviations such as "2day" or "tmrw" instead of "today" or "tomorrow" respectively in order to save typing effort, space and time. So far, several linguistic studies have looked at what kinds of abbreviations are commonly used in these novel modes of communication (e.g. Baron 2008, Crystal 2008, Frehner 2008), while the processing of these shortenings has been neglected. To our knowledge, the only study investigating the processing of text messaging language published to date was conducted by Perea, Acha and Carreiras (2009) on Spanish.

Looking at English, this paper will present an eye-tracking study investigating if the unconventional spellings used in text messaging lead to processing difficulties for the recipient. For authentic text messages, we measured first fixation durations, second pass reading times, regressions and total reading times of words with homophonic (e.g. "2day") and consonant spelling (e.g. "tmrw") in comparison to their non-abbreviated counterparts.

Twelve native-speakers of English read 32 short text messages, half of which included commonly used shortenings which were collected from corpora of authentic text-messaging exchanges taken from Baron (2008), Frehner (2008) and Crystal (2008) as well as an additional online questionnaire. During naturalistic reading, participants' eye-movements were recorded by a video-based infrared eye-tracker (SMI Hi-Speed 500). Statistical analyses showed elevated reading times of shortened versus fully spelled forms, implying processing difficulties on the part of the recipient. This effect was strongest in first fixation durations ($F1(1,11)=42.249$, $p<0.001$; $F2(1,29)=55.764$, $p<0.001$). Furthermore, differential effects were observed for homophonic versus consonant spelling ($F1(1,11)=5.214$, $p=0.043$; $F2(1,29)=5.897$, $p=0.022$), which suggest different degrees of processing difficulties depending on the way in which the standard spelling is changed.

In this talk, we will present the eye-tracking study and its results, illustrating that using shortenings may be beneficial to the sender but might cause on-line comprehension difficulties in lexical access (homophonic spelling) and syntactic integration (consonant spelling) for the recipient.

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Eye movement measures to study the online comprehension of long (illustrated) texts

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When studying the online comprehension of long texts, the unit of analysis is typically larger than a word or phrase, usually a sentence or sometimes even a paragraph. The computation of sentence-level eye fixation parameters for multiple-line screens is a non-trial endeavor. When reading long, multiple-line texts readers often make look-backs to a previous sentence well before completing reading the sentence from which the look-back is initiated. In such cases, the use of standard fixation measures would yield erroneous results for the first-pass reading. The correct measure should also include in the first-pass reading the fixations made later to the unread part of the sentence. The first-pass reading of sentences may also be broken down into two temporally separate phases when an illustration simultaneously present with the text is looked at in the middle of text reading. An analysis tool is described that yields correct first-pass measures for such cases. The program also clusters first-pass fixations into those falling on unread parts of the sentence (progressive fixations) and those falling on sentence areas that have already been fixated (reinspective fixations). Moreover, it registers both the destination and the launch site of look-back fixations. The details of the algorithm will be described with the help of examples of reading data. The program accepts as input Eyelink and Tobii data files. It will be made freely available in the internet.

Oral presentations II

Friday 7 May

Self-directed Learning Skills in Air-traffic Control; A Cued Retrospective Reporting Study

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Future changes in aviation technologies require Air-traffic Control (ATC) professionals to be able to adapt to these coming changes in their profession. To be able to adapt to new situations, professionals must be able to define learning needs, set learning goals and identify human and material resources (e.g. task selection) to fulfil these needs. These skills are called self-directed learning (SDL) skills. As a consequence, in ATC training, SDL skills should be developed in an adaptive training system. However, in order to self-direct learning, insight in to past performance is necessary. It requires a self-assessment from a present situation. Self-assessment can be seen as a part of self-regulated learning (SRL). Cued retrospective reporting (CRR) is a verbal reporting procedure based on a cue (e.g. gaze replay), in which participants verbalize their thought processes during task performance after completing the task. CRR not only provides insight in the participants' thought processes during task performance, but it might support the participants' regulation process too. This leaves the following first research questions to answer: first, is there a relation between learners' SRL-skills their SDL-skills? Second, improves self-assessment and SDL after a CRR?

Participants are 18 ATC-trainees who performed a 10-minute radar task on the training simulator. CRR was used to measure SRL-skills during task performance. The cue used here comprised the screen playback of the task with recordings of participants' own eye-movements superimposed onto it. Eye-movements were recorded with a Tobii 1750 remote eye-tracking system. Fill out forms were designed to support the self-assessment and task selection procedure. The quality of task selection was used to measure the SDL-skills.

After task instruction, participants fulfilled the first 50 seconds of the task while their eye-movements were recorded. Next, participants practiced cued retrospective reporting. Then they got the final task instructions and they fulfilled the rest of the ATC task while again their eye-movements were recorded. They filled out the forms about self assessment and task selection and, subsequently, they did their cued retrospective report. To measure the influence of CRR on self-assessment and task selection, the participants where asked to correct their own self-assessments and task selection after their CRR.

Voice recordings of CRR were typed out literally resulting in protocols. In these protocols, the use of SRL skills was scored. To determent the quality of self-assessments and task selections before and after CRR, all forms were compared with expert's assessments and task selections of the participants.

Drivers' characteristic sequences of eye and head movements in intersections

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Driving is a complex task and driving through an intersection is often experienced to be even trickier. The research question of this work is to determine if there are characteristic sequences of eye and head movements as a driver approaches, enters and exits an intersection.

Grasso (1996; 1998) and Imai (2001) have studied the relationship between eye, head and body movements of pedestrians. When turning a corner, the walker's gaze is directed in the turning direction in advance of the body movement and leads the body trajectory. Further, it is shown that the gaze anticipates the locomotion heading by 25-30° depending on the walking speed. In the context of driving, Land (2006) argues that there are similar characteristic sequences of actions that coordinate head and vehicle movements. For example, when negotiating a right turn (Sweden), the driver's head starts to turn right before the vehicle begin to turn to the right. When the vehicle enters the turn, the driver's head leads the vehicle heading and is directed to the same side as the turning direction.

We borrowed the idea of the head anticipating the vehicle heading in right turns and extended it to left turns. A semi-naturalistic study was conducted that collected eye and head movement data. Ten driver participants repeatedly entered a T-intersection in Göteborg, Sweden, and made all six possible passes through the intersection. Each lap included two straight ahead passes, two left turns, and two right turns through the intersection. All drivers made ten laps in an instrumented vehicle with a non intrusive 4 camera eye tracker device (SmartEye Pro 3.5) mounted on the dashboard. A GPS transmitter collected vehicle dynamics and position. Roof-mounted cameras recorded the driver's front view.

The data set of all drives was divided into each of the 6 types of possible passes. In this paper, we report data from drives with no other traffic present. Raw data were collected as a function of time and filtered to include only data in the immediate vicinity (-70 m to +30 m) of the intersection. By using the absolute position of the vehicle and the vehicle heading together with the data from the eye tracker, we were able to plot and analyze the eye and head movements as a function of distance to the centre of the intersection. In keeping with the gross scale of the distance (between -70 m to +30 m), we analysed the gross motor behaviour of the eye and head movements and determined the magnitude, position, direction, and sequence of larger looks to both the left and right.

By analysing the gross motor behaviour of the eyes and the head, we are able to test the hypothesis about the sequence of eye and head movements as the driver approaches, enters and exits an intersection. The turning cases in the intersection (2 right turns and 2 left turns) conformed to the hypothesis that there is a characteristic sequence of gaze and/or the head movements followed by a characteristic range of vehicle headings. These eye and head movements were found to generalise across drivers.

Based on our results we believe that sequences of characteristic gross motor eye- and head movements that are followed by a characteristic range of vehicle headings in intersections can inform the design of active safety systems.

Comparing the value of different cues when using the retrospective think aloud method in web usability testing with eye tracking

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Research has shown that incorporating eye tracking in usability research can provide certain benefits compared with traditional usability testing. One of the most commonly used methodologies when using eye tracking in usability studies is to use retrospective think aloud (RTA) interviews. Using RTA means asking the participants to verbalize their experience of using the interface tested after the task is completed. Some kind of memory aid is commonly used to help the participant remember their interactions with the interface. Tobii Technology has, in a study testing the usability of a commercial web site, evaluated the impact of four different RTA scenarios where different stimuli were used as memory aids during the interview: an un-cued RTA, a video cued RTA, a gaze plot cued RTA, and a gaze video cued RTA. In this study, four conditions were to be tested meaning that enough participants had to be included in every group to allow comparisons between the different conditions. 6 participants were recruited to test each condition. This means that, in total, 24 participants were included. In order to ensure homogeneity among the participants, they were given a pre-test questionnaire. The research was conducted in three public places located in the centre of Stockholm, Sweden.

Results indicate that using any kind of cue during an RTA interview promotes the participants to contribute with more words, comments and helps to identify more usability issues compared with not using any cues at all. The memory aid that produced the highest quantity of interview data, in number of comments and number of words, was the gaze video cued RTA, followed by the gaze plot cued RTA. Another interesting finding was that using a gaze plot as a cue proved to perform almost as well as using a gaze video, being especially good at producing visual and cognitive comments while simultaneously identifying the same amount of usability problems as the gaze video cued method. Differences in the types of comments produced during the interviews and the types of usability problems mentioned were also observed. Eye movement cued RTA methods tended to stimulate participants to make more visual and cognitive comments, while video cued RTA methods produce somewhat more manipulative comments. No clear patterns were observed for the different categories of usability problems described in the different groups, but the participants in the cued RTA groups mentioned more usability problems than those in the non cued RTA group. Our research clearly shows ($p = .05$) that using any kind of cue helps participants in remembering their interactions. More surprising is that our findings indicate that using different eye tracking visualizations as cues for RTA interviews can stimulate participants in providing different kinds of feedback. Hence, depending on which kind if feedback is desired, different cues can be selected.

Gaze behavior and instruction sensitivity of Children with Autism Spectrum Disorders when viewing pictures of social scenes

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The autism spectrum, also called autism spectrum disorders (ASD), is a spectrum of psychological conditions characterized by widespread abnormalities of social interactions and communication, as well as severely restricted interests and highly repetitive behavior. Studies have shown that the ASD group view social visual information differently than those who don't have this diagnose. One such difference is that they spend less time focusing on faces and eyes when they look at pictures. This can lead to difficulties interpreting social codes and emotions transmitted through television, films, games and commercial educational software. Children with ASD are exposed to educational multimedia to the same extent as other children, if not more, but may perceive the content differently. In this study we investigated some of these differences. The main question in the experiment was whether precise instructions on what to look for may compensate for initial differences in gaze behavior. The experiment can therefore also be seen as a more general methodological study where the importance of instructions for gaze behavior is investigated.

15 children (age 7-16) diagnosed with ASD were compared to a control group consisting of 36 children (matched for age and gender). Stimuli consisted of 3 series of still images, containing a varying number of persons engaged in social interaction. Some of the persons on the pictures could be described as important for the social scenes (salient), others were less important. Different objects were deliberately placed into the scene as distractors. A 500 hz iView X™ Hi-Speed eye-tracking system from SMI was used. Binocular recordings of gaze were used. A repeated measurements design was applied in the study.

The three experimental conditions was first a "free view" condition, where the instruction was just to look at the pictures. The second instruction was to look at "the most important" , and the third was to look at the "main character" in the pictures. Dependent variables in the experiment were time spent (fixations) viewing salient vs less salient persons and objects, and saccades.

Results showed that the ASD-group spent significantly more time viewing parts of the scene not containing salient faces or distractors, compared to the non-ASD group. We also found significant effects on saccade-faxation ratios and saccadian amplitudes. Instructions had a huge effect on gaze behavior for both groups, but did not completely remove the initial between group effect from the "free-view" condition. A number of questions were raised regarding limiting factors when doing eye-tracking experiments on the ASD group, and some of these may be good to know for other practitioners doing eye-tracking research.

Impact of cognitive workload on gaze-including interaction

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Using gaze data to intentionally control a computer system gains in importance in modern human computer interaction as it offers a way of contactless and fast interaction. Nevertheless, designing such interaction in that context is a special challenge as the gaze has special features that might hinder interaction efficiency. Apart from being "online" all the time, our gaze is influenced by task-related knowledge (top down) and salient features of our environment (bottom up, Cave & Wolfe, 1990). Additionally the kind of task, task know-how and task difficulty can lead to changes in eye movement behaviour. Regarding cognitive workload e.g. Gray and Schoelles (2004) found that imposed cognitive workload leads to a more data-driven behaviour.

If our gaze is that sensitive, what will happen if we use it to interact with a computer system in situations of increased workload? How will this affect the performance and efficiency? Does a gaze-including kind of interaction reach its limits in such a context? In order to derive design notes, we conducted a study investigating the influence of cognitive workload on different kinds of interaction. Subjects had to perform a simple visual searching task with four different kinds of interaction: gaze-based interaction with (1) 500 ms and (2) 250 ms dwell time respectively, a (3) combination of gaze to navigate and a key press to activate elements on the screen, and (4) mouse interaction. Additionally the level (low, medium, high) and the kind of induced cognitive workload (higher task complexity vs. simultaneous performing of a secondary acoustic task) were varied. The latter was realized as between factor, apart from that it was a partly randomized within design, i.e. each subject had to perform the task with each kind of interaction and at each level of workload.

Gaze data was recorded with the 50 Hz remote eye tracker iView X RED by SMI, and our software framework iCOMMIC (integrated Controller for Multimodal Interaction; Dzaack et al., 2009) was used for the online data-processing and realization of the different kinds of interaction. Apart from the gaze data, reaction times, errors and subjective ratings of experienced stress were recorded from 39 subjects (19 female, 20 male, mean age 26).

The subjective ratings indicate that workload was successfully induced. Regarding the performance data, results show that the imposed workload indeed has a different influence on the different interaction forms. Among other things we found a highly significant interaction between the level of workload and the kind of interaction for the reaction times. Additionally we found that in the 250 ms and 500 ms dwell time conditions false response errors significantly increase from medium to high workload, a result that cannot be found for the combined and the mouse interaction. Currently we are putting emphasis on the gaze data analysis in order to get further clues. The results will be presented at the workshop.

Interaction with mainstream interfaces using gaze alone

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Hitting small targets in mainstream computer interfaces using gaze alone is not easy - in some cases, it is close to impossible. Even though there are some tools especially designed for facilitating gaze accessibility to mainstream interfaces, there is little scientific research available to support their design and development.

Our work presents a new application that allows a user to control the conventional Windows interface and still be able to perform small-target selections with gaze only. The application combines several of the well-known tools for gaze-based selections and a new and more accurate tool (Skovsgaard et al., 2010).

The core functionality of the application has been adopted from different experimental systems and the graphical user interface (GUI) has been designed using NeoVisus gaze driven interface components (Tall, 2008). To free up screen estate, the application collapses into a single gaze component. When gazed at, the GUI expands into a simple menu structure. The application supports three levels of operational speeds for the tools (i.e. slow medium, fast) and is capable to emulate the most commonly used mouse operations (i.e. drag, left- and right click and double-left click). The application supports the standard dwell tool, magnification tool (Lankford, 2000), continuous zoom tool (Skovsgaard et al., 2008) and discrete zoom tool (Skovsgaard et al., 2010). To avoid the Midas touch problem (Jacob, 1991), the application can be paused at any time.

The tools in the application have been developed and improved through several controlled experiments. For instance, our research has shown that the dwell tool should be used for fast and approximate selections. When pixel-level precision is needed, one of the discrete tools (i.e., magnification or discrete zoom) should be used. We believe that the flexibility and user control our application provides will enhance the accessibility of mainstream GUIs for gaze users.

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Stereoscopic Eye Movement Tracking: Challenges and Opportunities in 3D

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We introduce a method for eye movement tracking of 3D stimuli and present results from a study where we have investigated differences in vergence eye movements when viewing scenes in 2D and 3D. Vergence is the simultaneous movement of both eyes in opposite directions to obtain or maintain binocular vision.

The basis of 3D vision, or stereopsis, is that each eyes sees a separate image of the same scene. To achieve depth, the two images have to be horizontally displaced with an increasing disparity in the depth plane. The two most common ways to achieve stereopsis with a computer involves either shutter glasses, which alternates the image from one source to the eyes, or polarized glasses, which separate the image from two sources to either eye. If you want to simultaneously track eye movements, the latter approach is more or less the one you have to use since shutter glasses by necessity occludes the eyes. For stereoscopic presentation, we have used a Planar like setup where polarized light from two LCD screens (1900x1200) is aligned by a half-silvered mirror. When wearing glasses with polarized lenses rotated to the appropriate angles, each eye sees a separate image from one of the two screens. For eye tracking, we have used the Chronos Eye Tracking Device (C-ETD); a head mounted binocular video system that can record eye movements in up to 400 Hz. In order to synchronize and calibrate the eye tracker with the display, we developed a custom application which also enables us to present stimuli in 2D and 3D.

The aim of the first study where we used the setup was to investigate how vergence movements are affected by the use of a 3D display in comparison to a 2D display. Furthermore, the study aimed to answer if any differences were dependent on the direction of gaze. 20 test subjects viewed a series of four images, all with different positions of gaze, in both 2D and 3D. Each subject was instructed to alternate viewing a near and far point in the image upon an audible cue. The results showed significant differences in the size of vergence movements between the conventional display and the stereoscopic display. The vergence movements were much larger in all 3D images, particularly when the near object was placed upwards in the image. It seems that the difference in disparity between near and far focus points had a larger impact on vergence than the actual disparity in each point. After the experiments were concluded it turned out that the images differed in disparity, something that we had overlooked from the start, for this reason we can not say too much about the impact of gaze direction. Yet, the results seem to indicate much larger differences in the vertical direction.

In our talk we will discuss 3D vision in general, the challenges we experienced with the experimental setup, and the opportunities stereoscopy offers in combination with eye tracking.

Sampling frequency – What speed do I need for my particular measure?

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Sampling frequency is perhaps the technical aspect that is the most highlighted by the manufacturers. Researchers, however, mostly discuss sampling frequency when striving to detect small or fast movements such as various saccades. However, what does it mean when a user of, e.g. a 50 Hz system, which samples every 20th ms, detect a difference between two conditions that is smaller than 20 ms. Is it possible to accurately detect such a small difference between sample? Is such a result, when significant, really significant?

We present a discusson on how limited frequencies give rise to a temporal measurement error and how this can be overcome. Furthermore, we present simulations that estimate the extent of this temporal measurement error and how these errors can be compensated for. We identify two distinct groups of eye-tracking measures that can suffer from a limited sampling frequency and how we can overcome these errors by recording more data and/or perform post-measurement adjustments.

Results show that measures that are qualified by one system event and one gaze event, typically under- or overestimate the results by half a sample worth of time. This is true for typical latency measures, such as saccadic latency and time to target. Measures that are qualified by two gaze events typically do not under- or overestimate given enough data, but the exact estimates may be unstable if not enough data is provided. Such measure are typically fixation durations and dwell time.

These results have implications especially for researchers using naturalistic set-ups with lower speeds and/or have limitations on the number of trials they can record, e.g. by using clinical groups, infants or primates, or researcher who want to aquire very exact estimates of gaze measures.

Effect of head-distance on raw gaze velocity

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Fixation identification methods rely mainly on raw gaze velocity to detect onsets of fixations and/or saccades. Thus, it is very important to know if and how this measure may be affected by experimental and/or physiological settings. We present recent work that explores the relationship between gaze velocity amplitude and head-distance when recording eye-movements using a remote, screen-based eye-tracker device (Tobii 1750). More specifically, we were interested in how the head distance affects the raw gaze velocity during fixations and during saccades.

With screen based eye-trackers working in pixel coordinates, the measured gaze velocity in pixels is obviously directly affected by the head distance. Indeed, a given gaze velocity expressed in visual angles will correspond to a greater pixel velocity if the head is far from the screen than if it is close. However, additional effects lead us to think that other phenomena, producing a different effect of head-distance on the measured gaze velocity, may exist.

We conducted an analysis on a dataset of 600 subjects recorded in six different experimental settings. The results show the existence of a U-shaped relationship between gaze velocity and head distance, which is clearly inconsistent with a simple unit conversion effect as described above. More specifically, raw gaze velocity during fixations is higher when the head is too close or too far from an optimal head position. The effect of head distance on raw gaze velocity during saccades seems to be different, resembling more to a simple linear relationship.

Moreover, a small very controlled experiment was conducted with two different subjects in order to verify the effects found in the meta-analysis described above. This second study confirmed our findings especially well as the head distance was tightly controlled.

The implications of this effect for eye-movements research, especially on the fixation identification process are very important. We briefly present an adaptive fixation identification algorithm which could overcome this problem. Last but not least, we also propose some possible explanations for this phenomenon and we discuss the potential existence of this phenomenon in other eye-tracking systems.

Quantifying and modeling factors that influence calibration and data quality

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A successful experimental setup and eye-tracking calibration procedure are prerequisites for collecting high quality data in terms of accuracy, precision, and data loss. While there are mostly anecdotal evidence on what (and how) factors affect these measures of data quality, we systematically investigate the impact of visual aids, eye physiology, eye color, eye dominance, eye lashes, mascara, operator skills, and the choice of calibration method.

In addition, we quantify how the operator's subjective judgment (by visual inspection of the calibration result) correlates with measured, objective quality. Statistical models of accuracy, precision, and data loss as a function of the variables above will be presented at the workshop.

Poster presentations

Thursday 6 May

How mindsets affect visual processing: Action control and anticipation in computer games

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Efficient visual search strategies are important for anticipation and decision-making in complex environments. Decision-making in computer games such as First-Person Shooter games (FPS games), however, is characterized by a dilemma of action control. In cognitive science this is referred to as the "Shielding-Interruption Dilemma" (Goschke, 1997): On the one hand, players should be capable of retrieving relevant information from a wide field of view. This strategy in the pre-decisional phase is associated with a deliberative mindset that allows players to process as much information as possible in order to make an accurate decision. On the other hand, action theories such as the Rubicon model of action phases (Gollwitzer & Bayer, 1999) demand to narrow the (visual) field for information retrieval at some stage of the decision-making process. This post- ecisional phase should start after players have made up their mind and subsequently focus on the actual realisation of the intended action in an implemental mindset. Furthermore, according to volition theories (Gollwitzer, 1996), volitional shielding processes should increase abruptly immediately after intention formation. This discontinuous course of the shielding function could allow us to determine the "cognitive Rubicon".

We evaluated these hypotheses in an eye-tracking study with 16 participants. They viewed (egocentric perspective) animated sequences of an FPS game where opponent game characters pursued characters from the participant's team. Participants had to decide which opponent characters to pursue in order to help their own team characters. After this "who"- decision, participants decided how to implement their action (choice of weapons). Each participant viewed 26 sequences. We recorded eye movements with an EyeLink II eye tracker at 500 Hz and computed statistical analyses for fixation duration, saccade amplitude and the ratio of deliberative saccades (> 5 degrees across centre of screen) vs. non- deliberative saccades, comparing means between pre- and post-decisional action phases.

Results show a clear distinction between the width of attention in pre- and post-decisional phases – a wide and narrow field of view, respectively. Deliberative and implemental mindsets apparently characterise decision-making in FPS games and thus support the Rubicon theory. When the goal intention has been formed (cognitive Rubicon), approximately 850 ms before response communication, the focus of visual attention rapidly narrows. Furthermore, the shielding-interruption dilemma exists in each action phase, pre- and post- decisional activities are not completely disjunctive. The considerable lag between the cognitive Rubicon and the manual response could be used by game programmers to improve the anticipatory abilities of FPS games. Data also indicates that players spend most time focused around the screen centre. This could be used to further compress video streams which only require high resolution gain within the eye-gaze window.

Ad-editorial congruency and side of ad presentation affect eye movements and memory for print advertisements

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Previous research on visual processing of advertisements has mainly focused on formal aspects such as graphics, size and location of the ads. Currently, little is known about how semantic relation between the ad and editorial contents affects processing of print advertisements. Eye movements were recorded from 45 participants in order to investigate whether ad processing differs when the ads were semantically related (congruent) versus unrelated (incongruent) with the editorial texts. Moreover, the side of ad presentation was varied (either on the left or on the right side of the editorial text) in order to test whether the side of the ad presentation affected attention and memory for the advertisement pictorials and brand-logos.

The stimuli were 40 newspaper pages consisting of 20 congruent and 20 incongruent ad-text pairs presented in a randomized order. In addition, the side of the ad presentation was varied randomly between participants. Eye-movements were recorded during a typical newspaper reading situation, where the eyes land on the ads as part of scanning on the page. Recognition of the ads and brand-logos was measured from all participants after a 24-hour delay from the initial viewing of the newspaper pages.

The results showed that the dwell times (the total time spent on the stimulus) on the congruent ads were longer when the ads were presented on the left side of the text. The dwell times on the ads during initial viewing significantly influenced ad recognition accuracy. The congruent ads were best recognized when they had been presented on the right side of the text during initial viewing. The number of entries and the number of fixations to logos were higher when the ads were presented on the right side of the page. Furthermore, the diversion times (the dwell times including the incoming and outgoing saccade durations) on logos were longer when the ads were congruent and presented on the right side of the text. The later recognition of logos, however, was more accurate for the congruent logos when the ads had initially been presented on left than on the right side of the page.

To summarize, semantic congruency systematically increased attention in terms of eye movements to both ad pictorials and logos. Moreover, later recognition of ads and logos was better when the ads were congruent with the texts. The results also demonstrated a relation between attention and memory for the ads, because the gaze durations on ads and logos during initial viewing affected later recognition. As regards the side of ad presentation, the results were less clear. It seems that logos presented on the right side of the text received more attention, but the recognition was, however, improved for the logos presented on the left side of the text. An opposite pattern was observed for the ad pictorials.

Sublexical effects of repeated reading among fluent and dysfluent readers in Finnish

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In this study, the dynamics of orthographic learning was studied among fluent adult and dysfluent children readers in orthographically transparent Finnish language during word and pseudoword reading tasks. Participants read aloud repeatedly lists of items, in which the number of letters (NoL) and number of syllables (NoS) were independently manipulated. It was hypothesized that repeated reading would rapidly evoke whole-word recognition among fluent readers whereas dysfluent readers may continue to rely on sublexical reading strategy irrespective of repetition. The eye tracking methodology will reveal whether the reduction in sublexical effects is actually due to increased whole-word processing as indexed by reduced number of fixations or increased efficiency in sublexical processing as indexed by reduction in average duration of fixations.

Fixation-based eye movement measures were log-transformed to attain equal variances between groups and to prevent proportionally equal effect sizes from producing significant interactions. Following item-based measures were analyzed: gaze duration, number of first-pass fixations and average duration of first-pass fixations, accompanied by corresponding second-pass measures (total fixation time, total number of fixations and overall average fixation duration). In fixation frequency measures there was three-level interaction of Lexicality x NoL x Group, $F(2,30)=10.72$, $p=.000$, for number of first-pass fixations, as only adults showed stronger pseudoword than word length effect. Repetition substantially reduced the NoL effect for adults, $F(2,15)=7.76$, $p=.005$, but not for children, $F = 1$. Children showed a reduction in word length effect in total fixation time measure. In respect to NoS manipulation, gaze duration showed a significant four-level interaction, Group x Block x Lexicality x NoS, $F(2,30)=4.039$, $p=.028$. In the first half of the repetitions, adults had longest gaze durations to the trisyllabic pseudowords, whereas children did not show a clear response to NoS manipulation. Repetition cancelled the adult NoS effect, as it was not present anymore in the latter half of the experiment.

The reduction in sublexical effects in fluent reading suggest rapid shift towards whole-word recognition, whereas dysfluent children continue to rely on letter-based sublexical reading strategy even when reading repeatedly familiar words. Parallel visual processing seems to be preserved in these children as indexed by generally decreased fixation frequency as a response to lexicality, $F(1,15)=107.74$, $p=.000$ for number of first-pass fixations in NoS inspection, and repetition, $F(1,15)=108.39$, $p=.000$, for number of first-pass fixations in NoL inspection. Repetition also supported the usage of lexical knowledge in these children as indexed by shortened average fixation durations to words but not to pseudowords, Block x Lexicality, $F(1,15)=11.10$, $p=.005$, for average fixation duration of first-pass fixations in NoL inspection. These findings suggest that the deficit may be at the orthographical or phonological level instead of visual or lexical processing stages.

Remember the News? What we focus on is what we forget

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The effectiveness of TV newscasts with regard to viewers' news information memorisation and recall has been an area of interest for researchers for some time. However, little effort has yet been made to examine how viewers integrate verbal information given by the news presenter and visual information provided by a photographic snapshots that is presented in the background of the TV news desk. Snapshots show, for example, a person or a venue that is verbally referred to in the news and are often complemented by text captions. As viewers are required to process all verbal and pictorial information rapidly before the programme proceeds, it is essential to optimise the visual structure of the newsroom setting as well as the verbal referencing so that relevant news contents are easy to understand and to remember.

In the present study, we investigated how positioning of newsroom elements and referencing consistency affect recall of semantic detail of TV news. More specifically, we varied the location of the photographic snapshot (left vs. right) and its coherence with the news presenter's verbalisation (consistent vs. inconsistent). The analysis of eye movements allowed us to understand how visual attention is guided by pictorial elements, verbal references and their interaction – and thus to understand how these factors affect information memorisation and recall. Oculomotor data and recall rates of 16 subjects were recorded while they viewed 18 dynamic scenes of different newsroom settings. After each scene, subjects recalled the semantic content of the news while looking at a black screen. We used an EyeLink II eye tracker to record subjects' eye movements during both news watching and recall phases. This allowed us to determine where, when and how long they attended to the presenter and the photographic screenshot, and to detect possible correspondences between the two phases. Eye-movement parameters such as fixation numbers and saccade amplitudes were also statistically analysed with respect to viewers' interests.

Results show, for example, that in all trials the presenter predominantly becomes the centre of attention, irrespective of the position. This contrasts findings from studies with static TV news settings, where a presenter on the left was always attended to significantly longer (Vasilj, Koesling, Ritter & Sichelschmidt, 2009). Interestingly, although photographic snapshots were generally attended to less than presenters, the recall and recognition test shows that subjects could remember the photographic snapshot better than the verbal information. Data also suggests that similar eye- ovement patterns in watching and recall phases coincide with better recall performance. Findings from our study can be used to optimise the visual structure of newsroom settings and may improve the processing and recall of essential news details. Not only broadcasters can benefit from the results, but also TV viewers. They can learn how to increase awareness of what they saw and heard in order to better remember news content.

Perception and effectiveness of commercials: An experimental study using eye-tracking

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Knowing what is in foveal vision of consumers when they look at commercials is central for advertising practitioners. Against the background of consumers' scarce attention which they consciously or unconsciously dedicate to marketing stimuli in gen-eral, the knowledge of factors which are able to boost a commercial's capability to concentrate consumers' attention becomes crucial in the competition of companies for loyal customers and in a world of thousands of different brands (Teixeira et al. 2008). Whereas eye tracking has already been used for a long time in scientific advertising research, the analysis of dynamic stimuli such as commercials has not been able until the vast developments in eye tracking techniques (hard- and software) a few years ago (see Wedel and Pieters 2008).

In the underlying study a theoretical model has been designed in order to explain the perception and effectiveness of TV commercials. The model centres on the influence of product in-volvement, familiarity with the commercial, attitude toward advertising in general (as factors which influence visual attention top-down), and brand position/position of the web address in the commercial (as a bottom-up factor) on eye movements of consumers. In the study each of the 140 test subjects (59% female, 41% male) was shown three different commercials, incorporated in an ad break of the popular German on-air program "Galileo" together with five other commercials. A Tobii T120 Eye Tracker was used for stimuli presentation. The three commercials varied in complexity and products/services promoted (fast moving consumer good versus services), but not in length (commercial length: 30 seconds). To allow for the effect of continuous versus late presentation of the brand (brand position), two different tapes were produced using the same TV program and filler ads but different test-commercials. The same commer-cial with continuous presentation of the brand or web address was shown to one half of the respondents and with late presentation of the brand or web address to the other half.

The study is the first to confirm the influence of top-down-factors such as product involvement and familiarity with the commercial on eye movements. Within commercials with moderate - compared to low or very high - complexity the position of the web address has a positive impact on the number of fixations on the address, if the address is shown all over the commercial instead of being shown only at the end. The model further focuses on the predictive power of eye tracking metrics. Eye movements in the underlying study predict the effectiveness of commercials in regard to the attitude toward the commercial (e.g. "relevance", "transparency") and the attitude toward the brand (e.g. "cognitive aspects"). The findings support that a commercial's power to concentrate consumers' attention (= fixation density which was assessed by the Voronoi method) predicts the respondent's attitude toward the commercial. The greater a respondent's fixation density is, the better the commercial is rated by the respondent concerning the "relevance" of the commercial.

Task-oriented text book reading strategies

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Combination of eye movement data and verbal protocols has been used to study attentional and cognitive processes in picture viewing and picture description (Holsanova 2001, 2008), netpaper reading (Holsanova & Holmqvist 2004), problem solving (van Gog, Paas, van Merriënboer & Witte 2005) and learning from animations (de Koning et al. 2009).

In our project, we use this methodology in order to investigate strategies employed by school children during task-oriented text book reading. The materials used come from text books in biology, physics and chemistry. The goal is to trace the underlying cognitive processes by means of eye-tracking in combination with cued retrospective protocols. Temporal and semantic analysis of the functional segments of eye movement data and verbal protocol data (Holsanova 2001) will enables us to investigate children's task-oriented text book reading strategies in detail. The extracted strategies will be correlated with the results from a multiple choice questionnaire. Examples of successful and less successful strategies will then be presented in schools as a pedagogical tool - in order to raise childrens' awareness about their reading strategies, contribute to a reflective learning and improve their metacognition.

Presently, a proposed experimental procedure has been piloted by using the SMI RED 5 remote eye-tracker. Materials consist of text book web pages shown on the monitor. Children are presented with a task and a text book page containing the solution to the task. All trials end with multiple choice questionnaire. Each participant does nine trials in total. Every third trial, the procedure is interrupted, and the participant can inspect his or her own eye movements from the last trial represented as a dynamic scanpath diagram. The participant is then instructed to reflect and comment on procedural and content aspects of their interaction with the materials (what they did, how they did it and why). The recording of participants' eye movements is either replayed at half the speed of the original speed or the participant is given opportunity to control the gaze replay him/ herself. This allows them to verbalize in as detailed a way as possible all thoughts they had at a specific moment while studying the text materials.

There are pedagogical benefits in obtaining a behavioral and cognitive record on how school children go about solving tasks while reading text books. School children can benefit from these findings in developing and improving their text book reading abilities and study techniques. Teachers can benefit from this when planning their course materials. And finally, text book publishers can benefit from this knowledge when designing text books.

Perceptual components in moral decision making

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This study explores the use of eye tracking as a method in moral psychology with the goal of discovering gaze cascades and other psychophysical correlates of moral decision making.

Gaze cascades (Shimojo et al. 2003) are rising probability fixation curves prior to a choice between visually presented alternatives towards the to-be-chosen alternative. As such they indicate perceptual feedback mechanisms guiding and influencing choice. Moral psychology has been dominated by developmental approaches and, more recently, brain imaging studies. Using the latter dual process models of moral decision making have been proposed consisting of emotional and deliberative components (Greene et al. 2008). Participants' eye movements and pupil dilation were studied when seated by a stationary 500 Hz monocular eye-tracking device. Moral dilemmas, presented in either text or pictorial form, based on the trolley problem were used. This created a two-alternative forced choice situation between a deontological and utilitarian alternative. Gaze cascades are demonstrated for both types of stimuli when making moral decisions. Pupil dilation was found to correlate with the onset of gaze cascades and thus with decision making. Together this indicates that the role of the perceptual system should be further investigated to better our understanding of our moral psychology and that a perceptual component needs to be taken into account when modelling moral decision making. The use of eye-tracking as a viable method in moral psychology is established.

Using Eye-Tracking and Event-Related Potentials to Monitor Skill Acquisition in Visual Processing

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The visual system is fundamental for our functioning in everyday life. However, attempts to improve visual skills through training for specific tasks have either met with limited success (e.g. Donovan et al., 2005; Fischer amp; Hartnegg, 2000) or have been of little practical benefit (e.g. Ahissar, amp; Hochstein, 2000; Braun, 1998).

I will present a project currently in its initial phase, which utilises Eye-Tracking (ET) methodology and Electroencephalography (EEG) to tackle unresolved issues in the visual training literature. The overall goal of the project is to understand how visual skills are acquired, and how this acquisition can be improved. Eye tracking is ideal for this purpose as it allows moment-to-moment recording of peoples' gaze, with high spatial accuracy. EEG is likewise ideal because it can identify the neural signatures of learning (Hajcak, 2008), and the processing of important visual stimuli for the observer (Carretie´, 2004). Used in conjunction then, ET and EEG will allow us to address unanswered questions about how we learn to interact with our surroundings. Can automatic processes guiding attention be overridden by visuomotor learning if they impede task performance? What is the profile and retention interval of such learning, both from the eye-movement and EEG record? How can we best combine object-based and location-based learning to develop optimal training principles?

The specific experimental paradigm I will present will tackle these important questions. Stimuli are to be shown in a visual search array. Half of the stimuli will be intrinsically attention capturing (i.e. have high valent associations), and half will be neutral in this respect. Under experimental conditions the design will be orthogonal and different types of high and low valency stimuli will correspond to the critical manipulation: half of the high valency stimuli and half of the low valency stimuli are to-be-ignored; and likewise half are to-be-attened. In a single trial one stimulus from the 'attend' cluster will always be presented along with a stimulus from the 'ignore' cluster, and the remaining items in the display will be distracters, which lead to no consequence if fixated. When fixated, the critical stimuli will transiently change in colour to a blue or red hue registering the trail as correct or incorrect, respectively, depending on whether the fixated stimulus is to-be-attended or to-be-ignored. The crucial measure is to determine the profile of learning the attend/ignore contingency over time, both in visuomotor terms – with ET– and in neural terms – with EEG. Variations of this paradigm will address the above questions, and the results will have important implications for a range of fields, including computer vision, hazard-perception in drivers, website usability, and training eye movements for the recovery of visual function following neurological damage.

Eye-tracking in Collaborative settings: Setup and Descriptive analysis

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One of the important skills in collaborative work and learning is the ability to attend to information of mutual interest. In fact, we are experts in coordination of our activities based on the information we get about the point of regard of our peers. Together with other social communication cues, such as facial expressions, gestures, or posture, we continuously monitor gaze direction of other collaborators, and we use these to contribute to our understanding of joint attention as we communicate and work with others. Because visual attention is an important skill in programming and in collaborative programming, we began investigating its aspects in collaborative program development. The objectives of this work are to be able to 1) record eye movements in collaborative settings in which a shared monitor screen is used 2) analyze recorded eye movements efficiently and cost effectively 3) find candidates for collaborative eye-tracking metrics. The goal is to be able to reliably and efficiently track and analyze eye movements in collaborative settings in order to infer different aspects of collaborations, such as efficiency, so that we could use this information to create new theories for eye movements' behavior in collaborative tasks and give tracked users feedback on their success. In short, the goal is to produce a framework for eye-tracking in collaborative settings.

We developed an eye-tracking setup for tracking (two) collaborators' eye movements simultaneously and then used this setup for recording eye movements during a two-month long empirical software project. We are constructing tools for eye-movement analysis and are currently able to superimpose two person's eye movements on to a recorded scene video. The setup can incorporate eye tracking of more than two persons eye movements.

Our current result is a descriptive analysis of the recorded eye movements, but we propose new metrics that could be used for inferring different aspects of collaboration, such as overlapping fixations and their average fixations lengths. The idea is to extend and validate the current eye tracking metrics used in eye tracking single persons' eye movements to collaborative settings. A setting that contains two or more persons working on a shared task. We are also considering the use of superimposed eye-movements as an additional communication medium, which might be useful especially in distributed settings, as claimed by other researchers.

The main outcome is to be able to track multiple persons' eye movements simultaneously, synchronize the recordings and produce a video representation of the combined data for descriptive analysis. In addition, we have experience on combining different manufacturers' eye-tracking devices for the purpose of investigating collaborative work and have knowledge on problems related to this kind of particular settings, though with some solutions also. The best current eye tracking setup for studying human collaboration varies depending on the purpose of use.

Spatio-temporal coupling of eye movements and the individual affective state

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Human's affective states have a clear relation to the stimulus that elicited them. It is widely accepted that picture content and intensity have a direct impact on the individual affect which can be measured by interpreting the corresponding pattern in physiological data. Following this, it exists a standardised image set (the International affective picture set (IAPS)) whose items are viewed to induce a specific affective state that can be measured by interpreting a subject's physiological data during picture presentation. In present studies using IAPS, physiological changes are investigated for six seconds during picture presentation (due to the fact that the normative rating refers to a 6-sec exposition) and not linked to eye movement data. As there is evidence that saccade amplitude and fixation duration change during the first couple of seconds of exploration, we want to investigate whether this potential change in exploration behaviour also results in a change in physiological reaction of cardiovascular activity, skin conductivity, respiratory rate and skin temperature.

As there is a latency between a stimulus and a response in physiology of up to 2 seconds, it might be that the impact of top-down affective judgements that occur later during exploration are not collected during the first six seconds. The latency between the affective stimulus presentation and the single physiological channels is determined using affective content during a short presentation time. An affective picture is presented for 150 ms seconds and physiological data is collected 2 seconds before, during and 4 seconds after presentation of the stimulus. As this time is enough to process the affective content, we expect a reaction on the four different physiological channels; each of them with a different latency.

After this, we present subjects different stimuli from the IAPS for 20 seconds and collect their eye movements and physiological data 2 seconds before, during and 4 seconds after presentation. Eye movement data is analysed with respect to saccade amplitude and fixation duration in order to investigate changes in exploration behaviour. Depending on fixation duration, the corresponding intervals in the physiological channel with respect to the individual latency are analysed with respect to distinguishable changes that can be interpreted as affective reactions in physiology. It results a spatio-temporal coupling of fixation duration and the individual affective state that can be extended by information about the corresponding saccade amplitudes before and after a fixation. By this, a shift in exploration behaviour that is illustrated in an increase of fixation duration and decrease of saccade amplitude can be investigated with respect to corresponding changes in physiology.

In addition, it is possible to investigate the physiological response during longer exploration on visual affective stimuli. At first, this investigation can help to identify stimulus characteristics that trigger reactions that contradict with the intended one; whether or not these result from pure bottom-up affective judgements or if they are the result of top-down processes remains to be investigated.

How to effectively communicate messages and claims on packaging

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Our previous study suggested that most consumers' eyes and minds process packaging information similarly and the actively consider only three or four design-elements on the packaging. It is not obvious to think that increasing the amount of information will increase the amount of time a consumer spends with a packaging.

More research was needed to analyse under which conditions, if at all, attention to the elements of packaging may positively influence final brand attitude and choice. This new research using ETS technology:

1. Examines the influence of different characteristics of packaging designs in order to determine the best way to communicate information on packs.

2. Investigates the influence of packaging design on attention to the brand.

3. Measures the impact of a given packaging design in a real-life competitive setting.

Uncompensatory eye movements and slippage of head mounted recording system during head tilt

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The purpose of the present study was to evaluate the dynamic changes in eye position during head tilt and to analyze the influence of slippage of the head mounted recording system due to the head acceleration. Twenty healthy subjects participated in a head tilt paradigm from head straight to 15, 30 and 45 degrees both to right and left shoulder. The eye position was evaluated using the head mounted binocular three-dimensional video-oculography (3D-VOG, SMI, Germany). A saccade-like transient torsional change in position was a consistent finding. This torsional movement was bi-directional with no intersaccadic interval. The direction of the first part was the same as the head tilt (i.e. non compensatory). The amplitude of this rapid movement varied between 3 and 10 degrees and the peak velocity approximated 80 degrees/sec. Head tilt induced vertical vergence with right over left eye in head tilt to the right shoulder.

Head movements will unavoidably cause a head mounted recording system to move due to gravity and inertia. Such movement changes the relative position between the eyes and the cameras and this will be interpreted as an eye movement (chimera movements). Since all findings described above theoretically could be induced by slippage of the head mounted camera system, a control experiment was carried out with three subjects. The subjects wore occulopad patches attached to the skin surrounding the eyes. These patches had manually drawn pictures of an eye (i.e. phantom eye). The phantom eye was positioned in front of the subject's eye. The VOG-mask was worn as in the experiments and the cameras were centred and focused on the phantom eye. In test 1 the left eye was occluded while in test 2 both eyes were occluded by phantom eyes.

The purpose of test 1 was to compare the eye movements with that of the left phantom eye, and in test 2 to quantify the presumed mask rotation. The control experiments verified that head tilts give rise to a small displacement of the VOG mask which can then be interpreted as eye movements. The amplitude of the chimera movements was always smaller than the amplitude of the eye movements. The chimera torsion due to the vertical movements of the VOG mask was found to be conjugate and range between ±0.1 degree in the maximum head tilted positions. The largest chimera horizontal displacement was found to be 0.7 degree. The chimera movements were found to be prompt and synchronous with the right eye movements that were induced by the head tilt. No drift of the chimera position was detected in the head tilted positions, thus no drift of VOG-camera position was seen. We presume that the rapid bidirectional torsional and vertical changes found during a head tilt paradigm are real and due to inertia of the inner ear otolith in response to head acceleration during a head tilt paradigm.

Investigating Visually Induced Ocular Torsion

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Ocular torsion is the eye rotation around the visual axis. The eye movement is regarded as non-voluntary and it can be induced by either the vestibular or the visual system. Ocular torsion in response to a static tilted visual stimulus has previously been demonstrated by a few research groups. Nevertheless, the findings have been doubted and the underlying mechanism are not well understood.

In two studies, we have investigated the nature of visually induced ocular torsion. Eye movements were recorded binocularly using three-dimensional video-oculography. In the first study we used an eye tracker from Sensomotoric Instruments (test 1; 3D-VOG: 15 test subjects), in the second we used an eye tracker from Chronos Vision (test 2; C-ETD: 19 test subjects). In both studies, the subject was seated in front of a LCD screen and was instructed to fixate a centre target during the tests. The viewing condition was binocular and the screen subtended a visual angle of approximately 50 degrees. In the first study, two stimuli were used, one displaying a photographic image of a city scene with spatial clues relevant for body posture, and the second displaying yellow rectangles on a black background with no natural spatial information. The scenes were tilted in 15-degree steps from 0º to 45º in counter clock wise and clock wise direction around the central fixation target, and each stimulus position was held static for 15 seconds. The purpose was to evaluate the effect of spatial clues on ocular torsion during tilting of a visual scene. In the second study, the same photographic image of a city scene was tilted 30 degrees and held static for 4 minutes and 40 seconds. The purpose was to evaluate if visually induced torsion is maintained over time or starts to drift back towards the initial reference position.

Tilting of a visual stimulus induced a compensatory, well conjugate, torsional response in all test subjects. The torsional response increased slightly with increased stimuli angle. The stimuli with the city scene induced more ocular torsion compared to the stimulus with yellow and black rectangles. The direction of stimuli tilt had no effect on the torsional amplitude. Following the initial compensatory ocular torsion response the torsional position started to drift back towards the reference position seen prior to the stimulus tilt. The drift started immediately when reaching the maximum ocular torsion amplitude or after a short time interval.

Our conclusions are that torsion can be visually induced by tilting a visual scene. The content is very important as spatial clues enhance the torsional response. The torsional position is not held static but starts to drift back after a period of time.

Further improvement of an offset correction method to overcome the inaccuracy of fixation data

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Even after calibration, eye trackers – in particular remote eye trackers – often maintain a systematic error, such that the recorded fixations exhibit a vertical and horizontal offset from the user's actual fixation point. The resulting inaccuracy of eye tracking data is particularly problematic when eye tracking is used to analyze individuals' gaze behavior in realistic task settings with small and closely spaced stimuli. Therefore, Kammerer and Gerjets (SWAET, 2009) developed and evaluated an offset correction algorithm which post-processes fixation data offline, based on the offset measured before the task. To calculate this offset, the to-be-recorded participants were instructed to successively fixate nine small black dots which were distributed over the screen. On the basis of this data, for each dot the average x-axis and y-axis offset between the captured fixations and the corresponding fixated dot can be extracted. The offset correction algorithm then uses a weighted function which interpolates the extracted values as estimation for the offset of all points on the screen. As weighting factors the inverted squared distances between a fixation and the nine dots are used.

Results of a first application of this correction method with the gaze data of 80 participants inspecting Web search results (recorded by a Tobii 1750 eye tracker with chinrest) showed a significant increase regarding the number of fixations within the AOIs (defined as polygons around the search results), with an average improvement of 7.0% per participant (Kammerer amp; Gerjets, SWAET 2009). However, the method used to measure the offset had two potential shortcomings: First, as the nine dots were presented simultaneously, even though participants were instructed to successively fixate each of the dots for 1 second in reading direction, participants might have deviated from this instruction. Second, even though participants were instructed to fixate on the dots, it cannot be ruled out that participants only roughly fixated in the area of these simple, small dots. Both of these shortcomings of the offset measurement might have resulted in an inaccuracy of the data used as basis for the correction. Therefore, the offset measurement method has been further improved: Instead of presenting all nine dots simultaneously, now the dots are presented sequentially, each for 2 seconds.

Furthermore, to reduce predictability of the appearance of the dots, the dots are not presented in reading direction, but in a more random order. To avoid strong search reactions, however, subsequent dots always appear in adjacent screen regions. To address the second shortcoming, in each of the nine dots now a small yellow letter is presented. Participants are instructed to fixate on the letters, which result in a word. The success of the further improved offset correction method was tested with the gaze data of 60 participants inspecting search engine result pages (again recorded by a Tobii 1750). The correction algorithm was the same as in the 2009 study. Results revealed a significant increase regarding the number of fixations within the AOIs, with an average improvement of 18.5% per participant. Although improvement rates in the two studies cannot be directly compared to each other, because the size of the search results was smaller in the second study, the offset correction algorithm with the offset measurement method used in the current study seems to be a successful way to correct the spatial inaccuracy of fixation data.

Exhibitors at SWAET 2010

Tobii
www.tobii.com

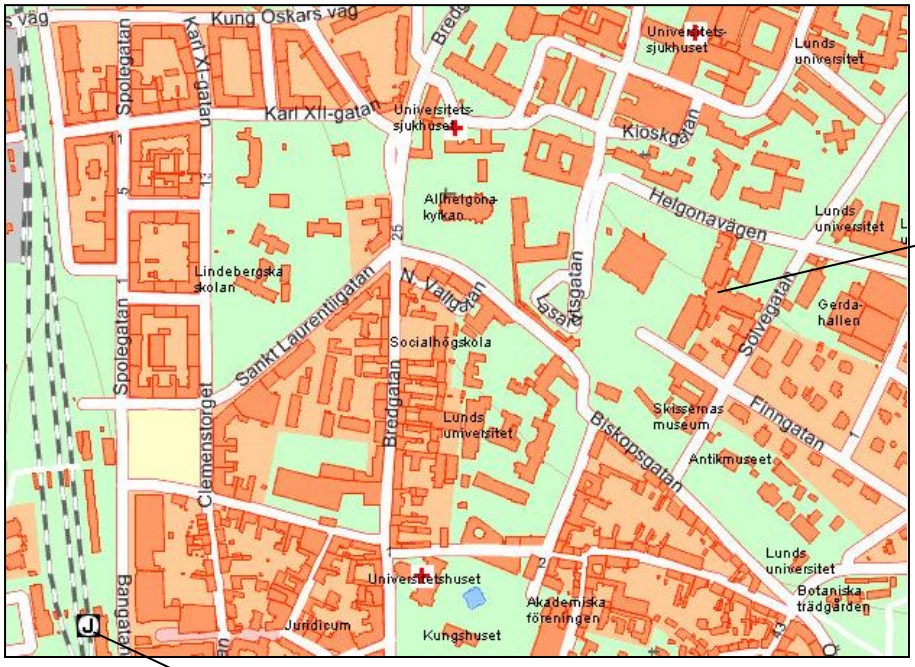
SensoMotoric Instruments
www.smi.de

Seeing Machines
www.seeingmachines.com

Smart Eye
www.smarteye.se

Practical information

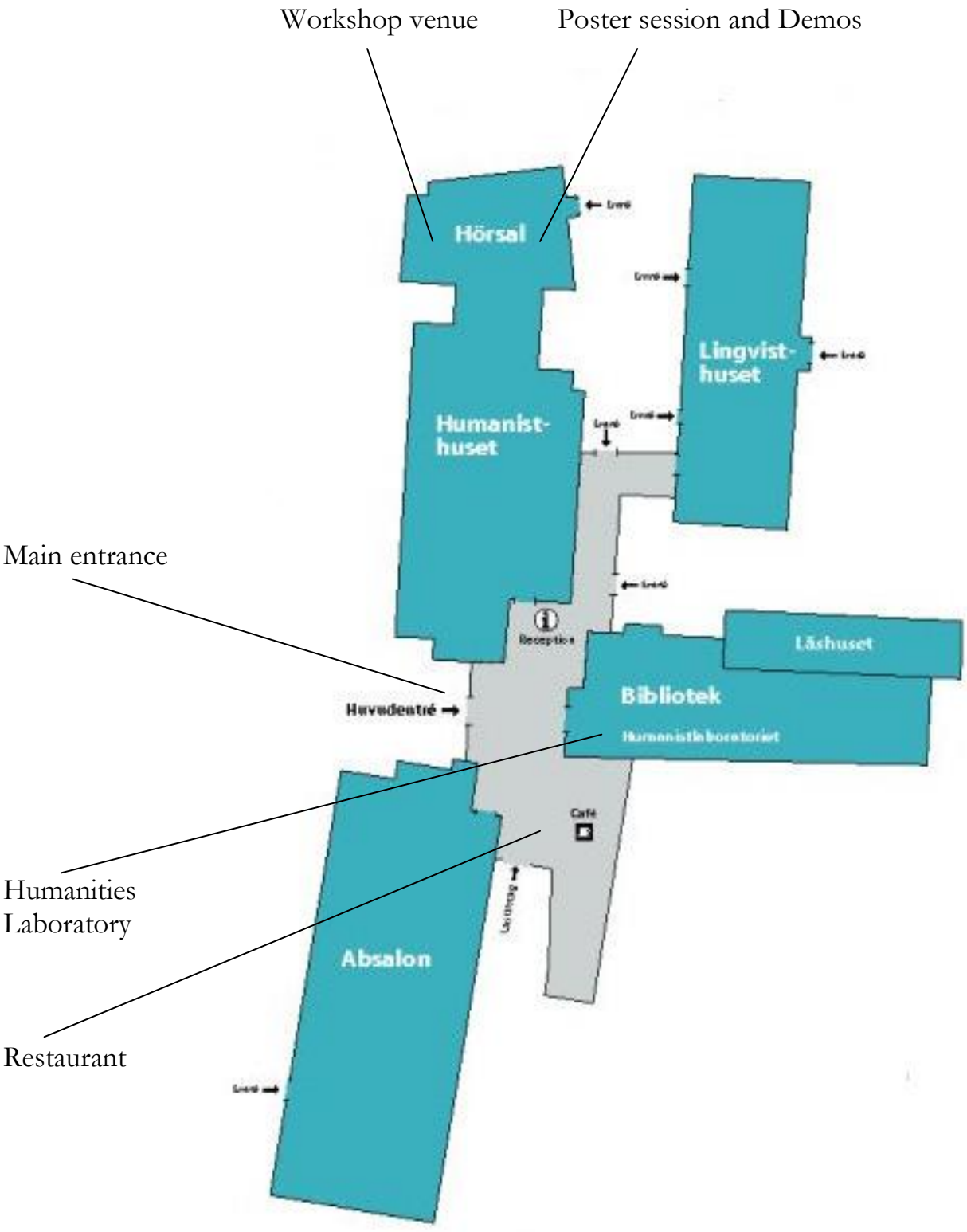
Important locations



SOL – centrum
Helgonabacken 12
Workshop venue

Train station

Språk- och litteraturcentrum (Centre for literature and language) (SOL – centrum)



Lunches

The lunches at the workshop will be sandwiches (Widerberg specials) and beverages.

Music and mingle

Before the workshop dinner (17:45-19:00) there will be mingle with snacks, wine and live music in the SOL-lobby.

Workshop dinner

The dinner will be a spring and summer buffet with dessert. It takes place on Thursday night (19:00) in the SOL-restaurant.

Lund Eye-Tracking Academy (LETA)

In collaboration with selected manufacturers

The LETA "eye-tracking academy" is designed to help students, researchers and labs who start with eye-tracking to get up and running, to give them a flying start. Although eye-tracking research can be both fascinating and extremely useful, doing good eye-tracking research requires a certain minimum knowledge. Without having a basic understanding of what can be done with an eye-tracker, how to design an experiment and how to analyze the data, the whole study runs the risk of just producing a lot data which cannot really answer any questions.

In Lund we offer an intensive 3 day course, open to all interested in eye-tracking, who want to get a flying start and acquire some basic understanding of how to run a scientifically sound eye-tracking experiment and get high quality data that they know how to analyze. This training course is open for all researchers and investigators just before or in the early phases of using eye-tracking, and for users wanting to refresh their knowledge of their system. It is open for attendees from universities as well as from industry. As part of the course, attendees will work hands-on with sample experiments, from experimental design to data analysis. Participants will train on state-of-the-art SMI eye-tracking systems and other eye-trackers, but the course is largely hardware independent and open to users of other systems.

Dates
22-24 September, 2010.
Starting at 09:00 in the morning and ending the last day at around 16:00.

Course contents
• Pro and cons of headmounted, remote and contact eye-trackers.
• High sampling speed and detailed precision – who needs it?
• Gaze-overlaid videos vs datafiles – what can you do with them?
• How to set up and calibrate on a variety of subjects on different eye-trackers?
• Glasses, lenses, mascara, and drooping eye-lids – what to do?
• How to work with stimulus programs, and synchronize them with eye-tracking recording?
• How to deal with the consent forms and ethical issues?
• Short introduction to experimental design: Potentials and pitfalls.
• Visualisation of data vs number crunching.
• Fast data analysis of multi-user experiments.
• Fixation durations, saccadic amplitudes, transition diagrams, group similarity measures, and all the other measures – what do they tell us? What are the pitfalls?

Teaching methods
Lectures on selected topics (8h). Hands-on work in our lab on prespecified experiments: Receiving and recording on a subject (9h). Hands-on initial data analysis (3h).

Eye-tracking systems available for this training
SMI HED 50/200 Hz with Polhemus Head-tracking
2*SMI HiSpeed 500/1250 Hz
SMI RED4 remote 50 Hz
SMI RED250 remote 60/120/250 Hz
SMI HED-mobile 50/200 Hz
+ other systems pending availability (A Tobii T160 Remote and a NAC EMR-9 were used in the last course in February, 2010)

Attendance fee
€940 incl course material, diploma, lunches and VAT if you register before Spetember 12, 2010. We will only run the course if we get enough participants.

The course content is equivalent to 1 ECTS credit at Master's level or above, although we cannot currently provide official registration at Lund University for this credit.

For further information and registration:
http://www.humlab.lu.se/en/education/leta

Organizers

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LUND UNIVERSITY

SWAET 2010