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Contents

Eye movements in reading and cognitive processing tasks: Data and models

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Earlier, I suggested that there have been three eras of eye movement research with respect to reading and information processing tasks (Rayner, 1978, 1998). It could be argued that we have now entered a fourth era in which sophisticated computational models have a major influence on the field. I will first review some basic data regarding eye movements in reading that any model must take into account. Then I will review current models, highlighting where they are similar/different, while also commenting on compromise positions that could be taken with respect to the differences. I will also comment on models of eye movements in scene perception and visual search.

On the agnosticism of spikes: Attention, intention, and salience in the monkey lateral intraparietal area and prestriate area v4

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In a search task in which a monkey is free to move its eyes, LIP exhibits three independent signals: a visual response to the abrupt of the search array, a saccadic signal predicting the goal and latency of the impending saccade, and a cognitive signal which distinguishing between distractor and target even when the monkey makes a saccade away from the target. LIP combines these signals in a predictable way. We suggest that LIP provides a salience map of the visual field which the visual system can use to determine the locus of attention, and the oculomotor system can use to drive saccades when they are appropriate. V4 distinguishes the saccade goal after LIP, but discriminates the target before LIP.

I3   **Perceptual and physiological effects of fixational eye movements**

Susana Martinez-Conde; *Barrow Neurological Institute, Phoenix, AZ, USA;* email: smart@neuralcorrelate.com

Most of our visual experience is driven by the eye movements we produce while we fixate our gaze. Our visual system thus has a built-in contradiction: when we direct our gaze at an object of interest, our eyes are never still. Therefore the perception and physiology of fixational eye movements are critical to our general understanding of vision. Moreover, because we are not aware of our fixational eye movements, they can also help us understand the underpinnings of visual awareness. I will present findings on the neural activity generated by fixational eye movements at different levels in the visual system, as well as their consequences for visual perception. Special attention will be given to microsaccades, the fastest and largest type of fixational eye movement.

I4   **Language-mediated eye movements: Why, when, and where**

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The 'visual world' paradigm involves monitoring eye movements as participants hear sentences referring to objects in a concurrent (or previously presented) scene. I shall focus on two phenomena associated with this paradigm: anticipatory eye movements, in which the eyes seemingly anticipate what will be referred to next, and eye movements towards objects which, although not referred to directly, are related to objects that are. I shall argue that these phenomena reflect sensitivity to objects' affordances, and I shall describe an account of the linkage between language processing and visual attention that can account not only for looks towards named objects, but also for those cases (including anticipatory eye movements) where attention is directed towards objects that are not being named.

Right hemisphere role in spatial attention

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Spatial orientation and exploration as well as vestibular processing at cortical level show a dominance in the right hemisphere and involve common brain areas. Intraoperative electrical stimulation in awake patients, lesion studies in human and monkey, transcranial magnetic stimulation, as well as functional imaging results have revealed the superior temporal cortex, insula, and the temporo-parietal junction to be substantial parts of the multisensory system involved in these processes. It is argued that these regions provide us with redundant information about the position and motion of our body in space. They seem to play an essential role in adjusting body position relative to external space and provide the matrix for attentional orienting in space.

R1-1

Lexical predictability exerts robust effects on fixation duration, but not on initial landing position during reading

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An eye movement experiment was conducted to examine effects of local lexical predictability on fixation durations and fixation locations during sentence reading. In the high-predictability condition, a verb strongly constrained the lexical identity of the following word, while in the low-predictability condition the target word could not be predicted on the basis of the verb. The results showed that the durations of first-pass and second-pass fixations on the target noun were reliably shorter in the high-predictability than in the low-predictability condition. However, initial fixation location was not affected by lexical predictability. As regards eye guidance in reading, the present study indicates that local lexical predictability influences when decisions but not where decisions.

R1-2

Factors influencing effects of implausibility on eye-movements during reading: Empirical results and implications for the EZ Reader model

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This talk will present experimental results elucidating the time course over which selectional restriction violations, world knowledge, and context contribute to or mitigate eye-movement disruption to plausibility violations during reading. The theoretical implications of this time course for reading comprehension will be discussed, as well as its implications for models of eye-movement control in reading. Finally, we will present modeling work attempting to capture these effects with the EZ Reader model.

Sentence wrap-up and parafoveal processing of sentence-initial words

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Previous studies have examined parafoveal processing of individual words in the middle of sentences. In the present study, parafoveal processing was investigated for sentence-initial vs. sentence-medial critical words. For example, "before" has correct or incorrect previews in "After dinner, Joe and Bob phoned. Before.../phoned before...". Standard sentence wrap-up effects appeared on the word prior to the critical word ("phoned"), such that fixations were longer when it was sentence-final. Importantly, although previous research suggests that foveal load can reduce parafoveal processing (Henderson & Ferreira, 1990), sentence wrap-up did not reduce preview benefit for the following sentence-initial word. Implications for the interpretation of the sentence wrap-up effect and the relationship between foveal load and parafoveal processing during reading will be discussed.

Building syntactic structure takes time: Experimental evidence and theoretical implications for models of eye movement control in reading

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It is well known that reading is disrupted when the reader's initial syntactic analysis of a sentence is revealed to be incorrect. However, it has been less clear whether processes of syntactic structure building affect reading time more generally. In this talk, we will describe several recent experiments demonstrating that reading time is inflated when attaching input words into the phrase marker requires the reader to build new syntactic structure, compared to when the reader is able to build the required structure in advance. We propose that the next generation of models of eye movement control in reading should account for syntactic structure-building time, and we offer a very preliminary sketch of how this might be done.

R1-5   **Effects of syntactic complexity and strategic control on
                            eye-movements during reading**

Matthew J. Traxler, Kristen M. Tooley; *UC Davis, Department of Psychology,
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Fixation times on syntactically complex sentences are shortened when a preceding sentence
has the same syntactic structure and the same critical verb as the target. These results
could reflect readers using the repeated verb to predict the upcoming structure. This
hypothesis was tested in a set of eye-tracking experiments. In the first, properties of the
filler items were manipulated to reduce or eliminate the strategic value of repeated verbs.
In the second, noun overlap, rather than verb overlap, created a valid strategic cue to the
upcoming sentence structure. Significant priming occurred in the absence of a valid cue
in the first experiment; and no structural priming occurred in the presence of a valid cue
in the second experiment.

R1-6   **Eye-movement behaviour during ambiguous pronoun resolution**

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We report a study that shows that after encountering an ambiguous pronoun, readers go
back to parts of the text that are most informative for resolving the ambiguity. Read-
ing times were longer following pronouns that were gender-consistent with two possible
antecedents than following gender-unambiguous pronouns, indicating that the two inter-
pretations of ambiguous pronouns compete. The effect occurred relatively late, during
sentence wrap-up, suggesting that ambiguous pronoun resolution is a rather slow process.

  Most interesting, we observed an ambiguity disadvantage effect in rereading: After
gender-ambiguous pronouns, readers reread parts of the sentence that might provide se-
mantically disambiguating information. They did not reread the two possible antecedents
with the same gender, presumably because they contained no disambiguating information.

Rapid detection of person information in a naturalistic scene A1-1

John M. Findlay, Sue Fletcher-Watson, Susan R. Leekam, Valerie Benson; *Durham University, Dept of Psychology, Durham, UK;* email: j.m.findlay@durham.ac.uk

When viewing scenes containing human figures, fixations fall preferentially on these figures. We investigated whether this was true for the first fixation made on the scene. Twelve students viewed displays containing two pictorial scenes side by side, one containing a human figure. In the first condition the participants were simply asked to look at the scene; in a second condition they performed a gender discrimination task. In both conditions, many more first fixations were made to the picture containing the person. The results are similar the finding of Kirchner and Thorpe (2006) who showed that rapid first saccades can be directed to animate figures. They extend this finding by showing that a human figure appears to attract attention automatically.

Ultra-rapid categorisation of natural sounds: Assessing auditory processing speed with saccadic eye movements A1-2

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Here we aimed at measuring the time it takes human listeners to make a saccade to a specific category of target sound. Two natural sounds were simultaneously presented using headphones, in both ears but lateralised with small interaural time (0.5 ms) and intensity (3 dB) differences. In half of the blocks the response was a saccade, in the other half of blocks we used a manual forced-choice response for comparison. Segregating between sounds, localising and identifying the target was easier and faster in case of human voices than in case of bowed string instruments as target sounds. Our results show that choice saccade responses provide a new experimental paradigm to study the speed of sound source categorisation.

A1-3   **Emotional content drives the saccade generation system**
                                    reflexively

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We assessed whether parafoveal perception of task-irrelevant emotional pictures influences saccade programming. In Experiment 1, paired emotional and neutral scenes were presented on the central horizontal axis. Participants performed reflexive saccades towards either of the pictures, signalled by an exogenous cue (a frame around the picture). Saccadic reaction times were faster when a saccade was made to a location occupied by the emotional picture. In Experiment 2 participants performed reflexive saccades orthogonal to the emotional/neutral picture locations. Saccade endpoints deviated away from the visual field in which the emotional scenes were presented. The results show that gist of emotional scenes can be grasped from the parafovea, and that saccade initiation and target selection are automatically influenced by emotional picture content.

A1-4   **Variable resolution images and their effect on eye-movements**
                                    during free-viewing

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Earlier studies indicate that while free-viewing images, people gaze at regions with a high local density of bottom-up features such as contrast and edge density. This tendency appears more emphasized during the first few fixations after image onset. In this paper, we present a new method to investigate how gaze locations are chosen by introducing varying image resolution, and measure how it affects eye-movement behaviour during free viewing. Results show that gaze density overall is shifted towards regions presented in high resolution over those degraded in resolution. However, certain image regions attract early fixations regardless of display resolution. These results suggest that top-down control of gaze guidance may be the dominant factor in early visual processing.

3D fixations in real and virtual scenarios A1-5

Thies Pfeiffer, Matthias Donner, Marc Erich Latoschik, Ipke Wachsmuth;
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Humans perceive and act within a visual world. This has become important even in disciplines which are prima facie not concerned with vision and eye tracking is now used in a broad range of domains. However, the world we are in is not two-dimensional, as many experiments may convince us to believe. It is convenient to use stimuli in 2D or 21/2D and in most cases absolutely appropriate; but it is often technically motivated and not scientifically.

To overcome these technical limitations we contribute results of an evaluation of different approaches to calculate the depth of a fixation based on the divergence of the eyes by testing them on different devices and within real and virtual scenarios.

The Processing of Flashbacks in Film A1-6

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In Experiment 1, a short narrative film was presented, either with flashbacks or in chronological/linear order. A recent movie, "Memento", deliberately used several types of flashbacks which were disentangled and studied separately in Experiment 2. Participants watched the movie while responding as quickly as possible to light flashes. In Experiment 3, pupil size of the viewers, as a measure of mental load, was registered on-line while watching the same movie as in Experiment 1. Flashbacks did not enhance aesthetic judgments (Experiment 1). Linearity emphasized the semantic features of the leading actors (Experiment 1), with less consumption of mental resources (shorter reaction times in Experiment 2; smaller pupil size in Experiment 3).

P1-1   **How to measure the horizontal main sequence from
             non-instructable children and infants**

Christopher M. Harris, Noreen Derbyshire, Faith Budge; *University of Plymouth, Centre for Theoretical & Computational Neuroscience, Plymouth, UK;* email: cmharris@plymouth.ac.uk

The saccadic main sequence is a useful quantitative measure of brainstem function, but it is very difficult to measure from non-instructable infants and children with developmental delay or cognitive regression using standard protocols. We describe a new procedure to measure calibrated horizontal saccades via quick-phases induced by physiological nystagmus. In 20 healthy children (3 months - 4 years) we report saccade speeds similar to adults. In 33 uncooperative children with moderate/severe developmental delay (11 months - 11 years), the technique succeeded in 88%, and we found normal and abnormal saccade speeds depending on the diagnosis. This demonstrates for the first time the possibility of quantifying eye movements in infants/children of all ages regardless of cooperation.

P1-2   **Anti-saccade task training in children with ADHD**

Izabela Krejtz[1], Anna Orylska[2], Maksymilian Bielecki[2], Malgorzata Matuszczak[2], Grzegorz Sedek[2], Tomasz Wolanczyk[3]; [1]*Polish Academy of Sciences, Institute of Psychology, Warsaw, Poland;* [2]*Warsaw School of Social Psychology;* [3]*Warsaw Medical Academy;* email: izolda@psychpan.waw.pl

The main goal of this study was to analyze the influence of controlled attention training on ADHD symptoms. The ADHD group (N=12) underwent the attention training. During 20 sessions they practiced Stroop and Anti-saccade task. Their performance was compared on pre and post tests with non-ADHD group (N=13).

The Anti-saccade task triggered the effect of learning. Furthermore, after the training, the accu-racy of the clinical group reached the performance level of non-ADHD participants. In the second study at pre and post tests, eye-movements were recorded while both groups performed the anti-saccade task. Overall, the training had a positive influence on ADHD children's ability to inhibit irrelevant reactions.

Primate prefrontal cortex sends cue, delay, saccade, and post-saccadic activity to the superior colliculus

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One of the most extensively studied functions of the prefrontal cortex (PFC) is working memory. Although theories of PFC function have suggested that this area participates in high-level functions by modulating the activity of target structures to which it is connected, no studies have investigated the output properties of PFC neurons during working memory tasks. Here, we used antidromic activation to identify PFC neurons sending a direct projection to the superior colliculus (SC), a midbrain oculomotor structure, and recorded the activity of these neurons while monkeys performed a memory-guided saccade task. Many neurons exhibited spatially-selective cue, delay, saccade, and post-saccadic activity. These data provide direct evidence that PFC neurons send task-related activity to oculomotor structures during visuospatial working memory tasks.

New concepts on the dominant eye

Yutaka Kitamura[1], Ken Horii[2], Kentaro Kotani[2], Géry d'Ydewalle[3]; [1]*Kansai University, Institute of Foreign Language Education & Research, Suita City, Osaka, Japan;* [2]*Kansai University, Engineering Department, Suita City, Osaka, Japan;* [3]*K.U. Leuven, Exp. Psychology;* email: kitamura@ipcku.kansai-u.ac.jp

It is pointed out regarding the dominance of the eye that there is no consistency of the results of the different tests and the functions of the dominant eye in the process of eye movement and perception is not clearly discussed.

We first classified two types of dominance: the passive dominant eye (PDE) and the active dominant eye in vision (ADEV). We propose the five visual spaces based on PDE and ADEV. These visual spaces can be represented by the five possible types of the dominance respectively. To verify this idea, the shifting amounts of the both eyes between two points different in depth and direction must be measured. The theoretical values and our experimental outcomes matched incredibly high.

P1-5   **Role of posterior parietal cortex in the alignment of the eyes**
                    during fixations and saccades: A human TMS study

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Human ocular saccades are not perfectly yoked; the origin of this disconjugacy (muscular vs. central) remains controversial. The purpose of this study was to test a cortical implication into the binocular coordination of saccades. We used a gap paradigm to elicit vertical or horizontal saccades; TMS was applied on PPC, 100 ms after the target onset. TMS of the left and right PPC increased the misalignment of the eyes during the pre-saccadic period and increased the size difference between the saccades of the eyes; this increase was significant for rightward and downward saccades (TMS of right PPC) and downward saccades (TMS of left PPC). These results will be discussed in the context of current models of saccade and vergence interaction.

P1-6   **Neuronal activity in the human parietal cortex during**
                    memory-guided pro- and anti-saccades: A MEG study

Cécile Beauvillain[1], Etienne Guillaud[1], Antoine Ducorps[2], Line Garnero[3],
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Despite advances in our understanding of how the parietal cortex processes spatial information, it remains unclear how it computes the sensorimotor transformation leading to an antisaccade. We used magnetoencephalography (MEG) to examine the time course of the activity for memory-delayed prosaccades and antisaccades. We showed that, just after the stimulus onset, the parietal cortex responded preferentially to the target presented in the contralateral visual field. During the memory delay, the activity shifted from one hemisphere to the other and sustained responses are observed to store the location of the remembered stimulus presented in the ipsilateral visual field. Then, an updating of the activity was shown for antisaccades that became indistinguishable from the activity prior to prosaccades in the same direction.

Dynamic receptive field effects predicted by a saccade target theory of visual perception

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M1-1

Theories of visual stability have emphasized the need to construct a continuously accurate, retinocentric representation of visual space. Evidence comes from the observation of the remapping of RFs and the mislocalization of flashed stimuli around saccade onset. Under some conditions, the perceived locations appear compressed around saccade target. We have developed a quantitative computational model that explains the compression of visual space by a spatially selective corollary discharge. Interestingly, the model predicts RF shifts similar to those of remapping but only for specific RF center positions.

We argue that remapping is not the cause for the appearance of compression and suggest testable experiments that allow to dissociate between our hypothesis and remapping.

Simulation of cerebellar Purkinje cell activity during saccadic adaptation

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M1-2

Activities of Purkinje cells and fastigial cells during saccades were shown first by Noda and his colleagues in 1980's and 90's and later by others. Feed-forward associative learning (FFAL) theory proposed by the author (2005) connects cerebellar cell activities with motor behaviors under cerebellar adaptive control. Computer simulation of saccadic adaptation following this theory shows the necessity of unknown cerebellar function to diversify Purkinje cell responses in order that the simulated saccades should bear the same movement features in acceleration and deceleration as real adapted saccades. Furthermore, an experiment (Kojima et al., 2004) showed facilitation phenomena of saccadic adaptation. Not LTP but de-LTD is required for the facilitation to take place from the viewpoint of the FFAL theory.

M1-3   **Saccadic procrastination: Predicting latencies from the visual
costs and benefits of movement**

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Once a target has been selected for a saccade, it is often assumed that one should execute
the movement immediately to take maximal advantage of foveating it. However, there
are visual costs as well as benefits to saccades due to the degraded vision during move-
ment. We hypothesised that these costs cause saccadic procrastination, accounting for
increased latencies to intra-foveal target movements (Wyman and Steinman, 1973), and
that balancing costs and benefits may be an important determinant of latencies of small
saccades.

We modelled the visual benefits of saccades based on human cone and ganglion cell
distributions, and estimated the visual costs from saccade durations in subjects respond-
ing to spot targets (0.04deg) moving by 0.1-9deg. The combined cost/benefit predicted
latencies accurately.

M1-4   **Multi-competence cybernetics of eye movements**

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Multi-Competence Cybernetics (MCC) is a non-traditional unified approach to adapta-
tion. It concerns the study of multi-objective artificial systems and multi-fitness natural
systems. MCC is based on accumulating evidence concerning the role of multi-criteria and
Pareto-optimality in natural evolution (Moshaiov 2007). This paper positions MCC ideas
with respect to the evolution of the control of eye movements. It concludes that MCC is
not only providing a novel framework of thinking for eye movement research but it may,
in return, benefit from eye movement studies.

Modeling gaze and decision making in realistic, dynamic sports situations

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We present empirical support of a model that relates athletes' performance strategies to self-generated options and subsequent choices in an ill-defined task. We formalize a mathematical model that predicts athletes' initial "intuitive" action in a realistic game situation based on the sequence of gaze fixations. Our conceptual model also incorporates experience- and context-based association strength in determining subsequently generated options.

Model predictions concerning the number and quality of these options, as well as choice from among them, were verified by empirical data. Differences based on athlete expertise (across three levels) were also revealed. We discuss the implications of these results and the advantages of understanding decision behavior by simultaneously considering human information search via eye-tracking, option generation, and choice.

A test of alternative models of fixation target selection

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Several alternative theories have been proposed to explain how successive features are selected for fixation. The predictions of these alternative theories were tested against eye movements recorded from 8 subjects during free viewing of a Marroquin pattern. We used this pattern because it is a multi-stable image which subjects can attend to for long durations and because it has known salient features. Fixations were centred on the salient features with errors consistent with a Gaussian distribution. The space constants of the fixation errors, distributions of saccade amplitudes and fixation durations were all gaze angle dependent. The decrease of the durations of fixation with increasing eccentricity implies a sensory involvement which is not accounted for by current models of fixation.

IS-1   **The Double Step revisited: Interactions between when and where**
in saccade control

Iain D. Gilchrist, Adam Ranson, Casimir J. H. Ludwig; *University of Bristol, Department of Experimental Psychology, Bristol, UK;* email: i.d.gilchrist@bristol.ac.uk

We use the double-step paradigm (e.g. Findlay & Harris, 1984) to investigate the interaction between when and where the eyes move (see Findlay and Walker 1999). Previously, we have demonstrated that the minimum time required to change the target of the next saccade, the dead time, is not influenced by a gap manipulation but is systematically influenced by the spatial separation between the first and the second target. We present a model which integrates the spatial and temporal components of saccade choice (Ludwig, Mildenhall & Gilchrist, 2007) to account for these data. As a further test of this model we have manipulated the luminance of the two targets; the effects of these manipulations are also accounted for by our model.

IS-2   **Binocular coordination during reading**

Simon P. Liversedge; *University of Southampton, School of Psychology, Southampton, UK;* email: s.p.liversedge@soton.ac.uk

During the last 10 years I have had the pleasure of working closely with John Findlay in the eye movement laboratory at Durham University. By way of marking John's retirement I will talk about some of the recent experiments that John, myself and other colleagues have conducted collaboratively to investigate how readers coordinate their eyes binocularly when they read. I will provide descriptive data from adults and children. I will also discuss work in which portions of a target word within a sentence were presented dichoptically to each eye. We consider our findings to be informative regarding the processes by which people perceive a single unified visual percept when they read.

The influence of distractors on saccade target selection

Robin Walker; *Royal Holloway, University of London, Psychology, Egham, UK;* email: robin.walker@rhul.ac.uk

The influence of distractors on saccadic eye movements depends on both the spatial and temporal relationship between the target and distractor. Distractors presented close to the target modulate saccade landing position ('global effect' Findlay, 1982) but not latenc; while more distant distractors modulate latency but not landing position ('remote distractor effect' Walker, Deubel, Schneider & Findlay, 1997). Recently, we have shown that the modulation of saccade trajectory, either towards or away from a distractor, depends on saccade latency. When latency is short saccade trajectories deviate towards distractors, while at longer latency deviation away is observed. These distractors effects can be related to facilitatory and inhibitory processes operating in the 'when' and 'where' channels involved in saccade generation.

Eye movements in a single case of visual neglect

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We will report data from experiments that examined oculomotor control in a single case of visual neglect (MB). Evidence of processing for stimuli presented in the neglected field, was not observed in the RDE paradigm, however a dissociation between oculomotor control and verbal report for briefly presented stimuli in the neglected field was observed. Specifically, in the RDE paradigm MB was able to move his eyes to left stimuli at a mean latency of 314ms, whereas, in a verbal detection task, MB was unable to report seeing such targets unless they were presented for 1s or more. It appears that in the RDE paradigm the saccadic orienting system can respond to stimuli for which MB has no conscious visual perception.

IS-5   **Inhibition of single and multiple distracters**

Trevor J. Crawford; *Lancaster University, Mental and Neural Systems Research Unit, Lancaster, UK;* email: t.crawford@lancaster.ac.uk

What is the effect of a single or multiple distracters on a future saccade? Two displays were presented in sequence. The first required a saccade to a target that was presented together with a singleton irrelevant distracter. In the second display, saccades were directed to a target that was presented either at the location of the recent target (T-T), the recent distracter (T-D) or a new location (T-N). Saccadic latencies were slowed by 10-20 msecs on T-D trials. This slowing was restricted to correct target-directed saccades, supporting the idea of inhibition at the location of the recent distracter (IRD). IRD was generally absent using a set of multiple homogenous distracters. However, IRD emerged when a salient distracter was introduced in the distracter set.

IS-6   **Saccadic gain adaptation does not modify the pre-saccadic attention focus**

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Collins and Dore-Mazars (Vision Research 2006) recently suggested that after saccade adaptation pre-saccadic attention is focused onto the actual landing position of the saccade, rather than on the saccade target. This implies that attention shifts are controlled by an efference copy of the actual saccade vector.

The present study attempted to replicate these stunning findings. The visual attention focus was determined with a discrimination task while participants prepared a saccade to an item within a string of characters (Deubel and Schneider, Vision Research, 1996). Saccadic gain adaptation was induced by systematic intrasaccadic target shifts. The results show that, for both reflexive and voluntary saccade adaptation, the attention focus remains on the visual target. The implications of these results are discussed.

Binocular coordination of saccades: Development, aging and cerebral substrate

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The origin of binocular coordination of saccades (central, peripheral) and the role of learning remain controversial (Hering vs Helmholtz). We will present evidence for learning: in young children (5 years) horizontal saccades are poorly yoked, coordination improves slowly with age particularly at near. In dyslexic teenagers coordination of horizontal saccades is poor relative to non-dyslexics, suggesting slower learning. On the other hand, in healthy elderly (73 years) coordination of vertical saccades is intact, an example of non ageing sub-system. To assess further central mechanisms, we apply TMS over the posterior parietal cortex of healthy adults, 100 ms after target onset. TMS impairs coordination particularly for rightward and downward saccades. Thus binocular coordination of saccades relies partially on cerebral function.

Investigation of the effect of remote and near distractors on saccadic eye movements

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Saccade accuracy is reduced by the presence of distracting stimuli. This can be attenuated by the presence of remote distractors (RD). To further investigate this effect we varied the number, location and similarity to target of RD. All stimuli were Gabor patches, differing in spatial frequency. Initially, distractors and RD were visually similar to target stimuli and appeared in potential target locations. In a second experiment, similarity between RD and target stimuli was reduced. In a third experiment, dissimilar RD were positioned in non-target locations. Finally, target side was constrained so that RD were no longer in an attended location. We found that the location, similarity of RD to target and the size of the RD effect modulated saccade accuracy.

IS-9

The global effect: About the limited influence of foveal distractor stimuli

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The global effect, discovered by John Findlay in 1982, refers to the general tendency for the eyes to move towards the centre of gravity of the visual configuration formed by target and distractor stimuli. We recently showed that this phenomenon fails to occur when the distractor does not extend outside of a central foveal region. The present experiments further investigated the existence and properties of such a foveal dead zone; singleton targets were displayed either in isolation or simultaneously with foveal vs. peripheral distractors. Preliminary data confirm that averaging responses occur mainly with peripheral distractors. Implications for eye guidance in natural perceptual tasks are discussed.

Findlay, J. M. (1982). Global visual processing for saccadic eye movements. Vision Research, 22, 1033-1045.

The effects of word length on english compound word recognition: Evidence from eye movements during reading

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Three eye-tracking experiments will be reported which investigate the role of word length on English compound word processing. Past research (Bertram & Hyona, 2003) has demonstrated that only long Finnish compound words are decomposed into their component lexemes during recognition. In the present experiments, long (e.g. heavyweight) and short (e.g. suntan) English compound words were embedded into sentences. In addition to word length, Experiments 1 and 2 manipulated the frequency of the beginning lexeme and Experiment 3 manipulated compound word familiarity. While word length had a clear effect on reading time measures, compound length was not found to modulate lexical decomposition in English. These results will be interpreted within a new framework for English compound word recognition.

The role of hyphens in compound word processing

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Bertram and Hyönä (2003) showed that the way a compound word is processed depends on its length. Long compounds are segmented and accessed via their constituents, while short compounds are processed holistically. Two new reading experiments showed that long Finnish compounds where spelling rules require hyphenation (vaihto-ohjelma 'exchange program') are processed faster than long concatenated compounds (vaniljakastike 'vanilla sauce'), whereas short hyphenated compounds (ilta-asu 'evening gown') are processed slower than their counterparts (kesäsää 'summer weather'). This suggests that hyphens are functional segmentation cues, beneficial when word processing relies on morphological decomposition but detrimental for normally holistically processed short compounds. Experiment 3 explored the role of hyphens inserted illegally at major constituent boundaries of tri-constituent Dutch compounds (vliegveld-taxi 'airport taxi').

R2-3   **Effects of morphological structure on the processing of**
                  trimorphemic Finnish compounds

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Recent morphological research stresses the role of affixal salience in the processing of complex words. Salient affixes are claimed to enhance morphological decomposition. In our eye-tracking study of Finnish compounds, we explored whether this effect holds for a suffix embedded in the first constituent of a compound (e.g., kirjastokortti, "library card"). If so, we expect to detect the effects of first constituent base frequency (kirja "book") only for those compounds that contain a salient suffix (sto).

We show that indeed first constituent base frequency only affected processing of compounds containing salient affixes. Thus, even with deeply embedded morphemes, affixal salience enhances decomposition. We also report effects of compound frequency and constituent frequencies and morphological families on reading times.

R2-4   **Lexical access reflected in the eye movement record**

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Most studies considering evidence for lexical access in the eye movement record have looked for the presence of word frequency effects, rather than their form. The presence tells us when lexical access begins, but it is not always clear when it is completed – a critical issue in current controversies concerning serial-sequential vs. parallel models of eye movement control during reading.

Recently, Murray and Forster (2004) argued for a particular 'Rank' form of frequency effect during word recognition. This paper considers evidence for Rank effects and how these are distributed over fixations in two experimental studies and in corpus data. The results suggest some variability in the link between where the eye is fixated and what is actually being processed.

Child and adult frequency effects during reading: Frequency effects exist independently of Age-of-Acquisition effects in children

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While word frequency effects are extremely robust in adult readers, less attention has been given to frequency effects in children in the eye movement literature. In two experiments, children's and adults' eye movements were monitored as they read sentences containing high and low frequency words taken from either child or adult corpora. Words from the child corpus were also controlled for Age-of-Acquisition (AoA).

Results showed that adults exhibited strong frequency effects using adult norms but not using child norms, while children showed very strong effects using child norms. These results show that while adult frequency counts offer a good index of processing difficulty in adult readers, child frequency counts, independently of AoA, provide an excellent index of children's processing difficulty.

Binocular fixations on different words: Are words skipped as often as we thought?

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Previous studies have reported that many words are skipped during reading (15% of content words and as much as 65% of function words (Carpenter & Just, 1983; Rayner & Duffy, 1988). We report binocular data from a large corpus of eye-movements in the reading of English multi-line text. On a surprisingly large proportion of fixations, the two eyes are fixating different, but typically adjacent words. We describe the variation in this phenomenon, both within and between readers. We discuss the implications for previous reports of word-skipping, which have been based on monocular tracking of eye-movements. We address some of the implications for models of word recognition in reading.

C1-1   **Dyslexic and control eye-movement differences in the RAN task**

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We obtained eye-movement and voice data for adult dyslexic and control participants in a Rapid Automatized Naming (RAN) paradigm. Three types of letter sets (visual, onset and rime) were ordered according to confusable or non-confusable sequences within the 24 RAN trials. Critically, dyslexics obtained longer naming latencies on both confusable onset (g/j and k/q) and visual confusable letters (p/q and b/d), compared with non-confusable equivalent items (g/k and j/q, and P/Q and B/D respectively). Furthermore, dyslexics made more initial fixations to the left of the targets, as well as making more fixations per target. Our findings suggest disengagement and parafoveal processing differences, as well as hemispheric differences between groups.

C1-2   **Dyslexics' eye movements during reading words of different
length and linguistic complexity**

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We assessed the eye movements and vocal reaction times of 50 dyslexics (7 - 11 years) and 41 age-adequate readers (7 - 10 years) in third, fourth and fifth grade during reading single words of different length and consonant cluster density. Both length and cluster density affected gaze duration, mean fixation duration, number of fixations and vocal reaction times. Effects were stronger for dyslexic readers. A clear developmental trend towards shorter fixation durations and fewer fixations was observed for the unimpaired readers, whereas the dyslexic readers seem to apply a serial reading strategy as suggested by their persistently high number of fixations across all Grades.

Memory-guided saccade abnormalities in schizophrenic patients and their healthy, full biological siblings

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Ocular-motor inhibition errors have been associated with familial risk for schizophrenia. In the memory-guided saccade (MS) paradigm, temporal decoupling of saccade inhibition and initiation allows separate within-task analyses of vulnerability factors. We compared the performance of 16 families with one case of schizophrenia (16 patients, 19 siblings) with 18 controls. Patients and siblings similarly showed an elevated MS error rate that consisted mostly of 'reflexive' errors independent of target amplitude. In contrast to controls, patients and siblings did not benefit from errors to improve MS accuracy. Taking into account specific characteristics of MS errors might yield more precise information about disinhibition deficits in spatial working memory and motor learning processes and their role as possible vulnerability markers in schizophrenia.

Endogenous control of oculomotor reflexes in Parkinson disease

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The reduction in saccade latency when the fixation-point is removed (fixation offset effect – FOE) reflects the degree to which collicular fixation neurons are under external control by a stimulus at fixation. Although it is a subcortical reflex, the size of the FOE is influenced by the oculomotor cortex: e.g. it is significantly smaller in an antisaccade task requiring an oculomotor-set to inhibit the visual grasp reflex. We tested patients with Parkinson's disease to determine whether the endogenous control of the FOE is disturbed. So far, we have tested 7 patients, and found that the size of the FOE during antisaccades, does not significantly differ from the FOE during pro-saccades, suggesting a decreased endogenous control of oculomotor-reflexes

C1-5

Eye Movement analysis in glaucoma when viewing a Driving Hazards Perception Test

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Little work has been done on eye movements in glaucoma patients when viewing an 'everyday' scene. Fifteen patients with bilateral glaucoma and 25 age-matched control subjects were shown 26 randomised UK Hazard Perception Test (HPT) video clips. Eye movements were monitored during the HPT with an SMI iView X High-Speed System (240Hz). Computer software was purpose written to process the data and included novel tools of analysis (e.g. dynamic bivariate contour ellipse analysis). The results consisted of the various types of eye movements performed by the subjects. The software revealed differences between the subject groups, the most important being a difference in saccade numbers ($p<0.001$). The software may be useful for interpreting eye movement data on viewing general moving images.

C1-6*

Length perception in hemispatial neglect: Having a Look at the Brentano illusion

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In the Brentano version of the Müller-Lyer (ML) Illusion, one half of the line looks longer than the other. Recently, it has been shown that different versions of the ML-Illusion do not only affect manual bisection performance, but also eye movements. Patients suffering from visuo-spatial neglect after brain injuries show systematic spatial asymmetries in eye movements as well as in bisection of simple lines.

The present study was aimed at investigating illusion effects in neglect patients by comparing the relationship between eye movements and manual bisection performance in different versions of the Brentano Illusion. Results suggest that illusion effects in both oculomotor and manual behaviour are modulated (e.g. left-right asymmetries, position effects) by hemispatial neglect.

Bottom-up and top-down visual attention in humans and monkeys

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Many tasks require that we direct attention to the most "relevant" entities in our visual environment. While much progress has been made in investigating experimentally how humans may operate such goal-based attentional selection, very little is understood of the general mathematical principles and neuro-computational architectures that subserve the observed behavior. I will describe recent computational work which attacks the problem of developing models of visual attentional selection that are more flexible and can be strongly modulated by the task at hand. I will back the proposed architectures up by comparing their predictions to behavioral recordings from humans and monkeys. I will show examples of applications of these models to real-world vision challenges, using complex stimuli from television programs or modern immersive video games.

Scanpaths and saliency in scene perception

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Do sequences of fixations (scanpaths or scan patterns) persist from one viewing of a scene to a second viewing, and are these sequences influenced by the low-level saliency distribution across the scene? Two experiments presented images of real-world scenes, asking viewers to inspect them in preparation for a recognition test. Scanpaths on the two viewings were found to be more similar than would be expected by chance, but saliency did not predict fixation patterns. In the second experiment viewers looked at pictures that were sometimes within their specialist domain of knowledge. Scanpaths were again similar on repeated viewings, and although saliency predicted fixation locations this was moderated by the viewer's knowledge of the domain depicted.

N-3   **Is attention drawn to changes in familiar scenes?**

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What mechanisms control attention in natural scenes? Does familiarity with the environment make subjects more sensitive to changes or novel events in the scene? Previous investigation has been based on viewing 2D images, a situation which does not reflect the challenges of natural vision. We found that familiarity with the environment significantly increased the the time spent fixating regions in the scene where a change had occurred. Our results suggest that we learn the structure of scenes over time, and that attention is attracted by deviations from the stored scene representation. Such a mechanism would allow attention to objects or events that were not explicitly on the current cognitive agenda.

N-4   **Image features, behavioural task and systematic tendencies in scene viewing**

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When we observe human behaviour, what we record is a combination of at least three factors: (1) extrinsic influences (e.g., image features), (2) intrinsic influences (e.g., task) and (3) systematic tendencies of the behavioural system. Systematic tendencies can be thought of as regularities that are common across all instances of and manipulations to the behaviour; thus providing a baseline for assessing the influence of extrinsic or intrinsic factors upon the behaviour. We show that non-systematic factors (image features and task) dominate oculomotor behaviour in exocentric co-ordinates, but in retinocentric co-ordinates oculomotor behaviour is dominated by systematic tendencies to move the eyes in particular ways. We consider potential underlying causes of the observed systematic tendencies.

Fixation durations during scene viewing

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A good deal of recent research has focused on accounting for where observers look during active scene viewing. Little emphasis has been placed on how long observers look at a particular location. I will present new data from a scene-onset-delay paradigm suggesting that average fixation duration during scene viewing reflects a combination of two fixation populations. One population is relatively constant regardless of the current visual input, whereas the second population is under the direct and immediate control of the current visual stimulus. These results suggest that gaze control for active vision is finely tuned to the immediate needs of the visuo-cognitive system. Implications for theories of attention and gaze control in active scene viewing will be discussed.

Eye movements are agenda-driven

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Graphics models that simulate extensive human capabilities can be used as synthetic models of behavior. These behaviors consist of complete visuo-motor subsystems described at a significant level of detail. Such behaviors greatly simplify the specification of the abstract control protocols that guide them. The net result is that, essentially, one is faced with a tractable embodied "operating system" (OS) model for picking the right small set of active behaviors at each instant. A centerpiece of the OS uses eye movements to aid the active behavior that has the most to gain from taking environmental measurements. Preliminary tests of the model against human performance in realistic VR environments show that main features of the model show up in human behavior.

R3-1   **Can mislocated fixations explain parafoveal-on-foveal effects?**

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Properties of an unfixated parafoveal word affect foveal inspection time, a form of parallel processing not predicted by strictly serial processing models. Proponents of such models now generally accept that such effects are reliable, but claim they result from measurement errors associated with mislocated fixations. These generate data consistent with parallel cross-talk, but the outcome is, it is claimed, wholly artifactual. This presentation will show that the "mislocated fixation" hypothesis itself may be flawed. In its simplest form it generates the erroneous prediction that parafoveal-on-foveal effects should not occur in cases where words are processed in a single fixation. A more complex version of the hypothesis deals with this problem, but raises further difficulties in turn.

R3-2   **Backward contextual influences during normal reading revisited:**
A multiple-regression analysis

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The mechanisms underlying predictability effects (e.g., whether more or less parafoveal information is obtained from constrained words than from unconstrained words) are still unclear. In a series of multiple-regression analyses conducted on a large-scale corpus of eye movement data, the predictability of a given word, as assessed via Latent Semantic Analysis (LSA), was found to modulate the time spent inspecting the prior word. In line with McDonald and Shillcock's results (Vision Research, 2003, 43, 1735-1751), but in contrast to Kliegl, Nuthmann, and Engbert's (Journal of Experimental Psychology: General, 2006, 135, 12-35.), a decrease in prior-word gaze duration was observed as contextual constraint increased. The nature this effect, as well as the nature of the contextual constraints LSA is likely to capture, will be discussed.

The Edinburgh Five Language corpus: A cross linguistic perspective on eye-movements in reading

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We describe the Edinburgh Five-Language Corpus, a corpus of binocular eye-movement data collected during reading of multi-line texts in five languages with divergent phonological, syntactic and orthographic characteristics: English, Chinese, Hebrew, Spanish and Arabic. Comparing diverse languages allows us to contrast psychological universals in reading behaviour with language specific factors, as one step towards determining on the degree of cognitive and linguistic penetration of eye-movement control. We present initial analyses of the similarities and differences between the five languages of the Edinburgh Corpus. Our analyses follow Kleigl et al (2006), allowing comparison with the Potsdam Sentence Corpus.

On the eye-voice lag during oral reading

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Whereas a plethora of data and sophisticated models exist on eye movements during silent reading, comparatively little is known about the coordination of eye and voice during oral reading. Obviously the eye-voice lag (time between fixation and pronunciation onset) is positive, but it is less clear how it is affected by local processing demands. How does the reader cope with the voice being much slower than the eyes: Do fixation durations increase, or do the eyes run ahead of the voice and stop to re-synchronize? How do textual variables like word length, frequency, or predictability influence the eye-voice lag? We will present results of an ongoing study of oral reading, using a combined analysis of eye movements and voice protocols.

R3-5

Word length and frequency effects on eye movements in dyslexic readers

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We assessed the eye movements of adolescent and adult developmental dyslexic readers and unimpaired controls (N = 30 each) during reading of the Potsdam Sentence Corpus and found substantually shorter forward eye movements and prolonged fixation durations of the dyslexics. The proportion of regressions was equal in both groups. Controls frequently skipped words of up to 7 letters, whereas the dyslexics fixated almost all words from a length of 4 letters upward. Analyses of a subset of 144 words - uncorrelated in length and frequency - revealed reliable word length and frequency effects.The effects were significantly more pronounced for dyslexics than for controls with a steep increase in fixation probability and inspection time with decreasing word frequency and increasing word length.

R3-6

Proofreading: A case of mind-delayed reading

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Eye movements were recorded as subjects either read isolated sentences for comprehension or proofread the identical material. Reading instruction had a significant impact on first-pass reading behavior. In contrast to reading for comprehension, there were no immediacy effects of word length, frequency, or predictability on single fixation duration. In proofreading, strong effects of the word to the left of fixation were found on fixation duration, indicating that lexical processing lags behind the eyes. Fixation position revealed a tendency towards an OVP effect for single fixation duration in proofreading, further supporting the idea that subjects applied a superficial, word form based reading strategy as observed in isolated word recognition. Implications for models of eye movement control in reading will be discussed.

High sampling rate and low latency mobile binocular video eye tracking system enables realtime control applications

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To control devices in realtime dependent on gaze direction, we developed a mobile eye tracking system, setting value on low latency and high sampling rate. The system was especially designed to control a pivotable head camera.

It is based on inexpensive standard components, can be operated with standard laptops and measures binocular eye movements with sampling rates up to 500Hz. Fast and efficient algorithms detect eye positions within 1.5ms at a resolution of 0.04°. The system's lightweight (170g) and anti-slip assembly and robust pupil detection algorithms with slippage compensation facilitate a mobile operation. The system is also appropriate for clinical measuring vestibular eye movements (Halmagyi-test) and all dynamical aspects of saccades.

Real-time gaze-tracking for freely-moving observers

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We have developed a real-time mobile gaze-tracker, by combining a high-speed eye-tracker (Eyelink II, 500Hz) with head- and body-tracking (VICON, 200Hz). The position of the observer's gaze on the screen can be measured continuously with an accuracy of <1.0 deg as they walk around and make head movements in a natural way. The system is modular, i.e. individual components can be easily replaced (e.g., different eye and head tracking systems can be used).

The system is primarily developed for interaction in front of wall-sized displays. For validation, the system has been tested with displays of different sizes (from 2.2x1.8m to 5.2x2.5m), and several applications, including psychophysical experiments and a multi-resolution gaze-contingent display.

E1-3   **Eye-tracking joint action: New technologies**

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We report the development of innovative eye-tracking software used to study the multimodal aspects of joint action. Illustrated using the Edinburgh Joint Construction Task Corpora (an experimental paradigm involving the cooperative assembly of two-dimensional models) we will primarily demonstrate two unique methodological facilities. First, the parallel linking of eye-trackers that enable two participants to interact in a shared virtual environment where both can manipulate objects and see live traces of each other's mouse and eye positions; and second, how to automatically record eye movements against participant-controlled Dynamic Areas of Interest. The resulting output comprises synchronised data streams of transcribed speech, eye and mouse movements, and on-screen object manipulations. The presentation and analysis software will be released under General Public License.

E1-4   **"Here's looking at you, kid" - Forms and functions of gaze contact in dialogue**

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Against the background of the 'interactive alignment' approach to dialogue (Pickering & Garrod, 2004), we have investigated the functions of mutual gaze contact in a simultaneous eye tracking study (LC EyeGaze system, full-duplex). In a face-to-face situation, participants had to find the only difference between their respective displays (which were almost identical). For the analysis (ongoing), alignment-related parameters of the participants' verbal behavior (such as the taking up of lexical, syntactic, or semantic structures) are linked to gaze behavior parameters (such as fixation number, position, and duration) in order to empirically distinguish between two basic backchanneling functions which can roughly be described as 'alignment acknowledging' and 'misalignment alert'.

Impact of cognitive state on gaze patterns during face-to-face interaction

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For the analysis of gaze during realistic face-to-face interaction, we developed an experimental setup of coupled cameras and screens equipped with eye trackers to monitor video, audio and eye-gaze during dialogs via the monitors. In order to elicit mutual attention and ease the determination of cognitive states (speaking, listening, prephonation etc.), one interlocutor was asked to repeat Semantically Unpredictable Sentences uttered by the other. The role (prompting vs. repeating) was exchanged in each dyad to identify its impact on turn-taking and attention management. The data confirm the predominance of the eyes and the mouth as targets of fixations and show significant influence of cognitive state and role on fixations. Recordings with superimposed fixation data will be presented.

Visual attention dynamics - Personality and social determinants

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Dynamical perspective on self-esteem suggests that people tend to persevere and fixate on information confirming their self-evaluation. We claim that this process is reflected in dynamics of visual attention. In the time course we should observe different patterns of eye movements and fixations depending on one's level of self-esteem.

The empirical support of the above hypothesis was found. Participants were exposed to experimental trails consisting of two simultaneously presented, schematic faces which expressed opposite emotions. Participants were to memorize the place where the faces appeared. During memorization phase their eye movements were recorded. Results are discussed in the theoretical framework of complex systems explaining the relation between global self-characteristics and dynamical patterns of visual attention.

P2-1*

Fixation disparity and asymmetry in convergent and divergent disparity step responses: Relation between individual differences

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We estimated vergence step responses to 1 deg disparity step stimuli in 16 subjects with dichoptic nonius lines, flashed for 100 ms with various amounts of delay after stimulus-onset (0-1000 ms). Previously, we showed that this subjective method provides similar results as objective recordings.

Fixation disparity, the vergence error during fixation of a static fusion stimulus, was correlated with the asymmetry between convergent and divergent step responses indicated by the difference in final response level (r=0.76, p<0.001) and the difference in vergence velocity (r=0.63, p<0.01). All subjects with exo fixation disparity (i.e. static under-convergence) had weaker responses for convergent than for divergent step stimuli. This relation may have implications for the understanding of fixation disparity.

P2-2

Spontaneous vergence oscillations induced by delayed visual feedback

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By introducing artificial delays in visual feedback ("transient stabilization"), we have induced spontaneous oscillations of the eyes, with the period of oscillation varying linearly with the artificial delay. Extrapolating the period-vs-delay function to its x-intercept allows estimation of the internal delay. By applying feedback to vergence only, we are able to isolate the response of vergence system. In this case we observe internal delays of 300-350 milliseconds, more than double those observed for version, and slightly higher than estimates obtained from correlogram analysis of tracking of random motion. The slope of the period-vs-delay functions is higher for vergence (1.8) than version (1.5), suggesting different control laws.

Different aging effects for voluntary and express vergence

P2-3

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Vergence eye movements are frequent in every day life and important for depth perception. Yet, studies of vergence in elderly are rare. We examine convergence and divergence between targets at 20, 40 and 150cm placed along median line. 11 elderly (75 ± 7years) and 10 young (24 ± 4years) subjects participated in the study. Eye movements were recorded with the Chronos video eye tracker. Latency of convergence and divergence increased with age in the overlap condition (voluntary movements). In the gap condition, express latencies (80-120ms) were frequent for divergence only but at similar rates for young (23%) and elderly (21%). These results are in line with prior study of saccades and indicate differential aging effects for reflexive versus voluntary movements in 3D space.

Orientation of Listing's plane is affected by sustained centrifugation

P2-4

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Adaptation to a novel gravitational state involves adaptation of the vestibular system, in particular the otolith subsystem. We investigated whether the orientation of Listing's Plane (OLP), which is under otolith control, is also affected by sustained exposure to hypergravity. Subjects were adapted to four different G-loads (2 and 3Gx for 45 and 90 min) and OLP was measured during re-adapting to 1G again (i.e., after centrifugation) with the head erect and tilted in pitch. The transition to a reduced gravity level induced a backward tilt of Listing's Plane and a decrease of the head tilt dependency. These results confirm that the otolith subsystem adapts to new gravitational environments and this adapted otolith response does affect the orientation of Listing's Plane.

P2-5

Measurement of Listings plane with galvanic vestibular stimulation (GVS) using 3D video-oculography (VOG)

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Saccadic eye movements are constrained to Listings plane, the displacement and orientation of which is determined by otolith input. In contrast, vestibular eye movements do not show this restriction. Subjects were instructed to make saccades to the luminous dots of a laser diffraction pattern that was flashed every 2.5s in darkness. The eye positions following these saccades were analyzed with GVS and control condition without stimulus. Markers were applied to determine the ocular torsion.

In the GVS condition Listings plane was shifted torsionally by 0.8deg for 2.8mA as compared to control condition. This was probably due to stimulation of otolith pathways. This experimental setup will serve as a new examination for vestibular patients in the future.

P2-6

How do concurrently performed manual movements influence oculomotor performance?

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Earlier studies on the coordination of eye and hand movements have mainly focussed on grasping movements towards a target. In the present study, we analyse on a more general level to what extent concurrently performed eye and hand movements interact. For this purpose, subjects had to respond to an auditory stimulus with either a button press (manual response), a saccade to a visual target (oculomotor response), or both. In follow-up studies, subjects had to cross hands and respond to the auditory stimulus with either the spatially corresponding hand or button. The results indicate that both, manual and oculomotor responses, suffer from dual task conditions, and that oculomotor response times are severely prolonged with increasing difficulty of the simultaneous manual task.

The target is absent but the memory is present: Distractor processing in repeated visual search

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Körner and Gilchrist (in press) investigated memory processes when participants searched the same display twice for different targets. A distractor which became a target in the second search could be found faster when it had been fixated more recently in the first search. This suggests that the identity of distractors was remembered. Here we determined the number of fixations necessary to refixate a particular distractor in the second search while participants searched for an absent target. We varied the recency of this distractor experimentally by on-line analysis of the scanpath of the first search. The number of fixations necessary to refixate the distractor depended systematically on its recency. This supports the notion of an identity-based memory for distractors.

Mismatch detection strategies in collaborative visual search

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Rather than sending out engineers to inspect faulty appliances, many manufacturers offer customer support over the telephone. To detect a fault, engineers and customers accomplish a verbally guided, collaborative visual search task: they discuss their respective appliances and attempt to identify a mismatch between them. We are currently investigating the effects of typical mismatch dimensions such as colour, completeness or typicality on visual processing patterns and task completion while simultaneously tracking the interlocutors' eye movements. We should be able to identify individual differences in search strategies, e.g. single-pass (sequential detailed processing in one pass) vs. multi-pass visual scanning approaches (increasingly detailed analysis over several passes) and expect to find efficient strategies for rapid mismatch detection in collaborative visual search.

A2-3

Cognitive workload as a means to distract top-down visual search in dynamically changing interfaces?

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In visual search bottom-up signals are largely ignored if top-down knowledge is available (Chen and Zelinsky, 2006). Investigating patterns of initial fixations in a search task Myers, Gray and Schoelles (2004) found that imposed cognitive workload made it difficult for subjects to follow conscious strategies and lead to data-driven behavior. We present the results of a study where the visual search of task-relevant information in a dynamically changing process control system microworld was distracted by cognitive workload induced through an acoustic secondary task. The results indicate that visual search strategies are indeed affected when workload is increased and that this effect is sensitive to interferences of interface elements. We discuss our findings and further steps of the research.

A2-4

Comparison of the effect of dynamic visual events on saccade target selection

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The saccadic eye movement system is highly sensitive to changes in luminance, but not all such changes in the visual world are equally important. Using an oculomotor capture paradigm we systematically compared 4 types of dynamic events: object onset, object offset, motion onset, and flicker. We develop a signal detection theoretical model that enables comparison of these different events on a common scale. Our results show that any local luminance change is important to the system, but the strongest response is elicited by object onset. We account for these findings in terms of the response of early visual areas to these dynamic signals. This account is further tested by examining the temporal tuning of the interference effects.

The spatial coding of the inhibition evoked by distractors

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It is generally agreed that saccade deviations away from a distractor location represent inhibition in the oculomotor system. By systematically manipulating the location of a distractor we tested whether the inhibition of the distractor is coded coarsely or fine-grained. Results showed that the location of a distractor had an effect on the saccade trajectories, suggesting that the amount of inhibition observed depends on the location of the distractor. More specifically, the vertical distance of the distractor from fixation seems to be a determining factor. These findings have implications for models that account for inhibition in the target selection process and the areas that could underlie inhibitory influences on the superior colliculus, like the frontal eye fields and dorsolateral prefrontal cortex.

Integration of task dependent information of different image patches during scanning eye movements

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In many daily life situations different parts of a visual stimulus contribute to the overall assessment. Here we investigate how such distributed information is integrated during scanning eye movements. We measure gaze movements of human subjects viewing segments (bubbles) of natural visual stimuli (faces, landscapes) in the context of four classification tasks (gender, mood, openness, man-made influence, respectively). Presenting varying combinations we can attribute task relevant information content to each individual bubble.

Comparing three competing hypotheses of integration a probabilistic model performs best. Surprisingly, geometrical rearrangements of bubbles do not lead to a change in task performance. In summary, task relevant information viewed in temporal sequence is integrated near optimally for several of our classification tasks, without considering detailed spatial relationships.

G-1   Different patterns of contralateral preference for spatial orienting and visual search

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In recent attention research, there is a controversy regarding hemispheric asymmetries in visual attention processes. Some groups find support for Mesulam's model. Here the left hemisphere shows a contralateral preference whereas the right shows bilateral processing of visuospatial information. Others found a contralateral preference for both hemispheres, which has implications for alternative models of spatial neglect.

We now introduce a fMRI paradigm trying to separat spatial orienting from visual search. Results reveal highly different patterns of contralateral preference for these sub-processes. While spatial orienting shows results in accordance with Mesulam's model, during visual search, the right hemisphere presents more contralateral preference than the left. Thus the findings elucidate the opposing results on contralateral preference in recent attention research.

G-2   Velocity coding cortical activation during retinal and extraretinal smooth pursuit revealed by event related fMRI

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Smooth pursuit eye movements (SPEM) were registered during event related functional magnetic resonance imaging. A factorial design comprising different target velocities with continuous target presentation and intervals of target blanking were applied. Main effect velocity of the ANOVA revealed the angular gyrus, basal ganglia and cerebellar regions. Main effect condition revealed the occipital cortex, the angular gyrus, the dorsolateral prefrontal cortex and the parahippocampal gyrus. Interaction yielded activation of the inferior parietal lobe. Regression analysis of the BOLD and the target velocity during target blanking revealed more regions compared to the condition with contiuous target presentation including the superior temporal gyrus, the V5 and IPS bilaterally.

Our results suggest specific cortical regions related to retinal and extraretinal target velocity processing during SPEM.

Saccadic behavior during the response to pure vergence stimuli G-3

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If two targets are carefully aligned so that they fall along the midline, the required eye movements will be symmetrical with the two eyes turning in equal and opposite directions. Only a "pure vergence" movement is needed, yet in most cases saccades are found. Such saccades must either produce errors in the desired symmetrical response or correct errors due resulting from vergence asymmetries. Saccades occurring in the early response were most common. The associated errors must be corrected for the eyes to achieve accurate bi-fixation. Correction is accomplished by either a compensatory asymmetrical vergence, or oppositely directed saccades, or both. The compensatory mechanism is subject dependent with some subjects favoring one of the three strategies in most responses.

Gaze-based models of human diagrammatic problem solving G-4

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Eye movements which humans make during diagrammatic problem solving often reflect shifts of attention as well as organizational and procedural aspects of the current mental representation that corresponds to the problem which is being solved. With regard to problems of spatial configurations, this contribution suggests different modeling approaches that relate captured eye movements to functions in an ongoing problem solving process as well as to the eventual outcome of the process. Implications for a better understanding and gentle shaping of human-computer interaction in diagrammatic problem solving will be discussed.

G-5

Determinants of scanpaths : Theoretical and methodological considerations

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The notion of fixational scanpaths, as introduced by Noton & Stark, has been conceived as purely top-down strategy of visual information encoding and retrieval. A revision of the scanpath theory proposed by Groner et al. (1984, 1985, 1989, 2000) introduced an extension of the model to an interaction between top-down and bottom-up processing.

We discuss possible reformulations of the extended model with respect to (1) the temporal course of the underlying processes, (2) the allocation of attentional values to the spatial saliency map, and (3) empirical predictions of the model.

G-6

How do we differentiate ART from NON-ART pictures: Statistical eye movement analyses of Scanpath locations and sequences

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Eye movements-EM during active looking are controlled by an internal cognitive, top-down representation, with informativeness, top-down, and conspicuity, bottom-up, being intimately interconnected. Using string editing, similarity coefficients can be calculated for the two measures Sp [Similarity-positions] and Ss [Similarity-sequences]. Using high resolution infrared EM recordings we compared art with non-art pictures of similar size and scene in 7 art-naïve subjects. Sp Repetitive showed the highest SimIndex, i.e. there was no basic difference between viewing artful vs. non-artful pictures. Ss Global showed significantly higher SimIndices than normally found: Probably because of a tendency to view artful pictures more globally, i.e. to "read" them skillfully, similar as in reading-text as a global-invariant EM control.

Learning algebra by exploration

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A major component of learning a skill like algebra is knowing which operators are appropriate for what situations. This study investigated learning to solve algebra-isomorphic problems either by exploration or by a step-by-step instruction. Instructed participants performed better for instructed problems while participants learning by exploration excelled in solving related problems later on. Exploring problems on their own enhanced participants' capabilities for debugging and acquiring new operators. More important, exploration also changed the way they perceived new situations: Although these situations were new to all participants, the probability to focus on task relevant aspects was higher for students learning by explorations than for students learning by instructions. Therefore, the right operators became more likely to be chosen by explorers.

Making multiple representations more useful: Instruction on the intended cognitive functions of representations affects gaze behavior and learning

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Learners often use multiple external representations (e.g. text in combination with diagrams and equations) in less than optimal ways. The present learning experiment tested the prediction that informing learners of the intended cognitive function of external representations should affect information intake as well as the quality of learning. Forty students of psychology studied a set of so called worked-out examples (i.e. a problem formulation, an equation, and a tree diagram) from the theory of probability in one of two conditions while their eye movements were recorded. Preliminary results showed substantial influences of the instruction on gaze behavior (e.g. distribution of fixation durations, transition frequencies between representations, scan paths). Effects on learning outcomes and instructional design implications will be discussed.

E2-3

Eye-movement behavior and cognitive processes of science learning

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Although scientific concepts have often been presented in a multimodal (i.e. audio-visual) format, the effects of multimodal information on science learning still need to be examined. In this study, we employed eye-tracking technique to investigate how learners with different levels of expertise process a multimodal learning material elucidating a process of chemical reaction. A 2 (science major versus non-science major) by 2 (audio-visual versus visual-only format) factorial design was adopted for the two main factors: learners' major and presentation mode. Both quantitative and qualitative eye-movement analyses and learners' interviews about the chemical reaction were carried out in attempt to tackle the cognitive processes underlying the learning of the chemical reaction.

E2-4

Investigating the effects of background knowledge on Chinese word recognition: Evidence from eye movements

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Two experiments determined the effects of background knowledge on Chinese word recognition. In Experiment 1, both higher- and lower-knowledge graduate students read physics texts that contained unfamiliar physics and common words. Results showed whether physics or common words, higher- knowledge readers had lower regression rate than lower-knowledge readers. Besides, both groups had longer fixation durations and higher regression rate on physics words than common words. In Experiment 2, low-knowledge readers read both physics and non-physical texts that contained the same common words. It is surprisingly to find recognizing physics words had influence on common words. In order to construct the meaning of physics words, readers had higher regression rate on common words even though they are high frequent words.

Looking in our mind: Can eye movement registration be used as a tool to objectively measure motor imagery?

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Motor imagery is a well known training technique among athletes. Recent studies show that imagery can also be useful within neuromotor rehabilitation. Unlike healthy persons, not all patients with brain damage are able to accurately use this technique. Therefore, in the present study, an objective approach was used to measure subjects' imagery ability by means of eye movement registration. 89% of the subjects made eye movements during imagery of goal-directed hand movements with the eyes open, 84% did so during imagery with the eyes closed. In most cases, the number and amplitude of the eye movements were similar to those during physical execution of the task. This implies that eye movement recording can be useful to objectively assess motor imagery.

Age-related changes in eye movement control from early childhood to adulthood using prosaccade and antisaccade tasks

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To investigate developmental changes in the ability to generate automatic and voluntary saccades, or to inhibit unwanted saccades, we asked 244 healthy participants 5-40 years-old to perform prosaccade and antisaccade tasks. We compared saccadic reaction time, coefficient of variation, express saccades, direction errors, gain, duration and peak saccadic velocity across ages. Saccade performances gradually improved until early adulthood. Furthermore the different components of saccade control follow specific developmental courses, the inhibitory control maturing the latest. After 30 years of age, all aspects of saccade performances begin to decline. Thus while the basic sensorimotor processes are functional early, those that underlie voluntary control develop later. Specific brain developmental processes may support these behaviour developmental changes in normal individuals.

F-1   Fixational eye movements and Op-Art

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Visual images consisting of repetitive patterns (often used in Op-Art) can elicit striking illusory motion percepts. For almost 200 years, artists, psychologists and neuroscientists have debated whether this type of illusion originates in the eye or in the brain. Here we investigate the role of fixational eye movements in the generation of this phenomenon and rule out the hypothesis that the origin of the illusion is purely cortical. The results may have wide implications for a range of illusory motion effects arising from static images.

F-2   Modeling retinal activity during natural visual fixation

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Previous studies suggest that fixational eye movements are an integral part of the neural code in the early visual system. To test this hypothesis, we modeled spatiotemporal receptive fields of retinal ganglion cells and simulated their responses while they scanned natural images in the presence of fixational eye movements previously recorded in human subjects with a Dual-Purkinje-Image eyetracker.

At the onset of visual fixation, cell activities were correlated over several degrees of visual angle due to broad spatial correlations present in natural images. Thereafter, if fixational eye movements were present, the cells continued to respond while quickly becoming uncorrelated, suggesting that fixational eye movements may contribute to a more efficient neural code in the information transfer to the visual cortex.

In-between fixation and movement: Towards a common-field model of microsaccade and saccade generation

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As the interest in microsaccades and their function for perception and oculomotor control increases, it becomes important to understand their implementation in the circuitry of saccade generation. However, this issue has not yet been discussed in great detail. The present work aimed to fill this gap from a behavioral perspective. We make a case for a model according to which microsaccades and saccades result from mutually dependent motor plans, competing for expression. In detail, activity at fixation-related sites of an activation field coding for saccades of different amplitudes occasionally results in microsaccade generation. In a series of ocumolotor tasks we tested implications of this common-field model of microsaccade and saccade generation. Their results yielded strong support for the model.

F-3

Microsaccades distinguish between different attention modes

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It is still an open question whether the visual system can perform some visual analysis using a distributed rather than focused attention mode. Some authors have argued that singleton detection can be performed in distributed attention, whilst others suggest that even such a simple visual operation involves focused attention. We showed that during a feature search task microsaccades were spatially biased during singleton discrimination but not during singleton detection. The results provide support to the hypothesis that some coarse visual analysis can be performed using distributed attention (Nakayama, 1990); in addition, they show that microsaccades can be used as a window into the distribution of attention.

F-4

F-5

Covert orienting modulates microsaccade metrics in non-human primates

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In previous human studies, covert orienting of visual attention has been shown to modulate the frequency and orientation of microsaccades. The aim of this study is to establish consistent behaviour in non-human primates so that we can then investigate the neural correlates of microsaccades. Cue-target tasks were used in which a cue appeared at the same position as a horizontal target or at a mirror position across the horizontal axis. We observed a reduction in microsaccades 150 ms following cue presentation. Following this inhibition, microsaccades preferentially oriented towards the cued location for a period of 200 ms. Target predictability had no influence on microsaccade metrics. These results are consistent with those found in human studies.

F-6

Characterisation of the tremor component of fixational eye movements

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Ocular microtremor (OMT) is the smallest in amplitude of the fixational eye movements, and has known diagnostic potential in a number of clinical conditions. This study aimed to quantitatively characterise OMT frequency parameters in normals. OMT records were obtained in 22 normal subjects using a piezoelectric strain-gauge system. Test-retest reproducibility was calculated from measurements on five separate occasions. A novel wavelet denoising technique (alKalbani et al submitted IEEE) was used to recover the ocular microtremor signal from recordings, which faithfully removes microsaccades and artefacts, leaving the OMT signal intact. The mean frequency of OMT oscillation was 88Hz (SD 4.5Hz). Frequency was independent of time of day, background illumination and common stimulant effects. Spectral parameters of OMT are also presented.

Cortical and subcortical involvement in the anti-saccade task

AS-1

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The anti-saccade task provides an elegant means to investigate the flexible control over behaviour. Animals can be trained to either look toward an eccentric visual stimulus (pro-saccade) or suppress this automatic response and instead generate a voluntary saccade in the opposite direction (anti-saccade). This presentation will describe the discharge characteristics of neurons in the frontal eye fields, substantia nigra pars reticulata and superior colliculus in monkeys performing an interleaved pro-/anti-saccade task. Neurons in these structures modulate their activities in these tasks and show dramatic differences prior to the execution of pro- and anti-saccades. The talk will highlight how these neurophysiological data can be used to interpret abnormal behaviour in clinical populations and functional brain imaging data.

Contribution of the dorsolateral prefrontal cortex to antisaccade task performance

AS-2

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Cognitive control requires the suppression of automatic responses in favour of voluntary, goal-directed behaviour. Several current models have suggested that the dorsolateral prefrontal cortex (DLPFC) has an important role in cognitive control, but the neural mechanisms are poorly understood. In the first study, we used antidromic activation to identify DLPFC neurons sending a direct projection to the superior colliculus while monkeys performed blocks of pro- and antisaccade trials. The activity of these corticotectal DLPFC neurons suggested that they have a role in saccade inhibition. In the second study, we applied electrical microstimulation to the DLPFC while monkeys performed randomly interleaved pro- and antisaccade trials. The results confirm a role of the DLPFC in saccade suppression.

AS-3 **Neuromuscular correlates of covert orienting in an anti-saccade task**

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Cue presentation in an anti-saccade task transiently captures attention. Because the eyes remain stable, attention is thought to be oriented covertly. Here, we ask whether such covert orienting remains divorced from motor output. We recorded EMG signals from multiple neck muscles while a head-restrained monkey generated either pro- or anti-saccades. On both types of trials, cue presentation lead to a time-locked, short-latency (55-90 ms) recruitment of a muscular synergy that would turn the head toward the flashed cue. Such recruitment was slightly weaker and more delayed on anti- vs. pro-saccade trials. These results demonstrate that covert orienting of attention during an anti-saccade task influences motor output at the head, despite the stability of the visual axis.

AS-4 **The development of state and task related processes during antisaccade performance: A mixed block/event-related fMRI study**

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We characterized developmental changes in brain function supporting the ability to voluntarily inhibit a response as a single event and the ability to maintain an inhibitory set using the antisaccade task in 54 participants (18 8-12 year olds, 18 13-17 year olds, and 18 18-27 year olds) using a mixed block/event-related design. Decreases in frontal and subcortical regions supported the maturation of trial-related brain function supporting correct inhibitory responses. Age related changes in brain function supporting an inhibitory response state was characterized by a transition from executive and premotor regions to more posterior regions. These results suggest that with maturation there is a reorganization of brain function that allows for more efficient voluntary control of behavior.

Transient neuromagnetic and hemodynamic activity in human parietal cortex during memory-guided antisaccades

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We performed fMRI and MEG neuroimaging experiments in human subjects to analyze the time-varying aspects of sensorimotor processing during antisaccades. The fMRI results show that the stored memory activity in human parietal cortex shifts to the opposite cortical hemisphere when a memorized spatial location of a visual stimulus must be reversed in order to establish a goal for an antisaccade. Similarly, the MEG experiments identified oscillatory activity in parietal cortex showing spatially-selective power changes in alpha (8-12 Hz) and gamma (60-100 Hz) frequency bands during delayed antisaccades. The power in these frequency bands also indicates that the representation of the saccade goal becomes increasingly more prevalent prior to the initiation of the saccade.

Inhibiting unwanted saccades

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The dynamic interplay between automatic and controlled determinants of behavior is one of the most general organizing principles of brain function. A powerful analogue of this interplay is seen in the antisaccade task, which pits reflexive and willed saccadic mechanisms against one another. Control processes can override an unwanted saccade if a cancellation signal can be generated in time. Preparatory processes prior to the choice and performance monitoring processes following the choice are key components that influence the success of response cancellation. I will present data from humans performing oculomotor tasks, focusing on neural activity linked to saccade preparation and performance monitoring.

R4-1   Does saccade targeting determine the acquisition of parafoveal word information?

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According to recent findings (McDonald, 2006), the target of a forward-directed saccade during reading coincides with its selection for linguistic processing. Using McDonald's sentences with relatively long pre-target words and mid-length target words, we manipulated the visibility of the target during the first and second of two pre-target fixations. The results revealed shorter viewing durations for the target when it was visible during the first and second pre-target fixation than when it was visible only during the second of two fixations. Readers therefore obtained useful information from the parafoveally visible word before it became the target of a saccade.

R4-2   Exploring the limits of spatially distributed word processing in normal reading: A new look at N-2 preview effects

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We re-examined the claim that, while fixating word N-2, no parafoveal information can be extracted from word N (Rayner et al, 2007), using conditions that should be most amenable to this kind of spatially distributed processing. Participants read sentences in which high frequency target nouns were preceded either by a high frequency three letter word or the word "the". Using N-2 boundary locations, the target word, word N-1 or both were masked until crossing the boundary. Although no significant N-2 preview benefit was found on word N, evidence for distributed processing materialized in terms of parafovea-on-fovea effects, supporting and extending Kliegl et al. (in press). Implications for current theories and models of eye movement control in reading will be discussed.

Mislocated fixations and parafoveal-on-foveal effects in eye movements during reading

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Predictions of serial and parallel views on the processing of foveal and parafoveal information during reading were tested. A high-frequency adjective (young) was followed by either a high-frequency (child) or low-frequency word n (tenor), which in turn was followed either by a correct (performing) or an orthographic illegal word n+1 (pxvforming) as a parafoveal preview. A limited parafoveal-on-foveal effect was observed: there were inflated fixation times on word n when the preview of word n+1 was orthographically illegal. However, compatible with a mislocated fixation account, this effect was independent of the frequency of word n, restricted to instances when the eyes were very close to word n+1, and associated with relatively long prior saccades.

Do Chinese readers obtain preview benefit from character n+2? Evidence from eye movements

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The boundary paradigm (Rayner, 1975) was used to determine if Chinese readers obtain preview information from word n+2 as well as from word n+1 during reading. The boundary location was set either at the end of word n-1 (the word just to the left of the target word) or at the end of word n-2. In Experiment 1, single-character words were used as targets; in Experiment 2, two-character target words were used. Robust preview effects were obtained in both experiments for word n+1. However, the results also suggest that Chinese readers obtain information from the second word to the right of fixation. Implications of these results for models of eye movement control will be discussed.

R4-5

Reading spaced and unspaced Chinese text: Evidence from eye movements

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Native Chinese readers' eye movements were monitored as they read spaced and unspaced text. Sentences contained four types of spacing information: normal unspaced text, text with spaces between words, text with spaces between characters that yielded nonwords, and text with spaces between every character. We examined (1) whether the introduction of spaces into unspaced Chinese text facilitated reading, and (2) whether the word or character is of primary importance in Chinese reading. Global and local measures indicated that unfamiliar word spaced sentences were as easy to read as familiar unspaced sentences. By contrast, nonword spacing and every character spacing produced longer reading times. The data indicate that words, not individual characters are the unit of primary importance in Chinese reading.

R4-6

Reading Chinese script - The Beijing Sentence Corpus

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Thirty native Chinese readers were instructed to read 150 sentences while their eye movements were monitored. Although Chinese is written without orthographical word boundaries (i.e., spaces), results strongly suggest word-based eye-movement control. Readers exhibit a stronger tendency to fixate at the word center in single-fixation cases and at the word beginning in first of multiple-fixation cases than one would expect from mere random saccades. We also report the relation between fixation duration and its position in the word in comparison with previous studies of Chinese reading. We conclude that it is the word, not the character, which serves as the saccade target. We propose a two-stage hypothesis about language-independent reading.

Better Apple Behaviour (BAB) - a 'consumer' gaze pattern found to be common across different creative media

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Better Apple Behaviour (BAB) is presented as a commonly occurring eye gaze pattern found across different media during eyetracking market research. BAB was originally observed whilst consumers were engaged in selecting items from a grocery store shelf - before making a final selection a consumer makes one last look around the shelf to see if they have missed a better product. Our current research investigates this behaviour whilst people inspect different types of marketing creative, namely newspaper advertisements, e-mail marketing and website landing pages. We show that the BAB gaze pattern is found across all these media and how the behaviour immediately following BAB provides us with insight into both the viewer's experience and the success of the creative.

Eye tracking for objective usability evaluation

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The ISO 9241-11 standard defines usability and includes guidance on how the usability of a product can be specified and evaluated. Disadvantage of this method is that it costs high effort and provides only results based on subjective data. Therefore the aim of this study was to examine if it is possible to derive objective design decisions using measures from eye movement data – obtained by an eye tracking system. An empirical study with 26 participants was conducted on the example of a calibration dialogue for a marker based tracking system developed at the Fraunhofer IITB.

The experimental results showed that effectiveness and efficiency measurements, as proposed in ISO 9241-11, can be obtained in an objective way using eye tracking.

E3-3   **Which features of gerontechnology products interest elderly users?**

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In order to clarify what is important to elderly users in gerontechnology products, subjects' eye movements were recorded while looking a brochure on a new type of blood pressure monitor. The results showed individual differences: some subjects were interested in ease of use, others in legibility of the display. Subjects' eye movements and behavior were then observed while trying to use the device. Most subjects were confused by the novel design and required a long time to measure their blood pressure. As a result, subjects looked mainly for ease of use and accuracy, but not additional features. It is concluded that gerontechnology products should be designed so that use of their basic functions is intuitive to elderly users.

E3-4   **Individual pilot performance incidents in a flight simulator task addressing situation awareness**

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The information processing approach of situation awareness by Endsley (1988) represents a powerful and compelling means for the evaluation of human performance. Situation awareness and eye movements of fifty pilots using advanced pilot assistance systems in flight simulator tasks were measured in DLR project MOSES (cf. contribution by M. Biella to 13th European Conference on Eye Movements).

Only very few flights resulted in crash after a loss of situation awareness. Most of the 'near-crash' situations were terminated by the pilot himself announcing the necessity to perform a go-around. However, it could be observed that a loss of situation awareness can originate from different pilot performances and eye movements. Therefore, in this presentation different case studies will be presented.

SimTrA: A tool for analyzing and comparing simulated eye movement data of cognitive models and empirical data

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Different cognitive architectures enable the modeling of eye movement at a detailed level. Data at this level is seldom used to analyze human performance models to compare them to empirical findings or to evaluate for example visual search, information processing or the spatial design of interfaces. To remedy the main obstacles we developed SimTrA (Simulation Trace Analyzer), a method and tool to process simulated and empirical eye movement data and to compare the outcomes in an effective and efficient manner. We show the applicability and benefits of SimTrA by presenting the results of a HMI-study. We successfully used eye movement data to discriminate different cognitive models of internal/external control and human performance data in a dynamic control task.

Eye tracking of maritime watch-keepers: What's a safe navigation pattern?

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There is a common belief that experienced ship's officers look out more through the window than novices who are said to believe more in instruments. There is a large overlap of information between instruments and looking out, however this overlap is not complete. This pilot study aimed at looking at how the visual attention of a bridge watch-keeper is shared between the window and the instruments. A pilot study where eye movements were recorded was performed in a bridge simulator with five subjects performing different navigation tasks. We propose to describe the visual behaviour of navigators to improve safety and bridge design and also to provide knowledge to improve training programs.

M2-1   **SARL: A computational reinforcement learning model with**
                                  selective attention

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The eye-tracking data show that players selectively attend the information presented to them while playing iterated Prisoner's Dilemma game. A reinforcement learning model with selective attention is developed that tries to model both the playing and the information acquisition patterns of the players. The model selectively attends the information about the payoffs on the basis of two mechanisms: more important payoffs (determined on the basis of the previous games outcomes) and the more uncertain payoffs (payoffs that are often changing) are attended. Next the model uses a reinforcement mechanism to make a choice of a move. The model data are compared to the experimental data with respect to the choices made in the game and to the eye-movement patterns.

M2-2   **Using Latent Semantic Analysis for computing semantic**
                 relatedness to predict Chinese readers' eye movements

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The present study was conducted to determine whether the semantic relatedness measuring with Latent Semantic Analysis (LSA) predicts Chinese readers' eye movements. Twelve college students read 16 expository texts. We used a 49021-term corpus and LSA to measure the coherence of the text and the semantic relatedness of each sentence to the whole text. We found that the numbers of character per minute was higher for highly coherence text, $F_{(1, 14)} = 5.66$, $p <. 05$. In addition, the average return gaze was longer for important sentences, $F_{(1, 218)} = 6.41$, $p <. 05$. Both results indicate that the LSA-based analyses of coherence can be a good predictor of Chinese readers' eye movements.

Calculating fluid regions of interest in textual stimuli

M2-3

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Latent Semantic Analysis – Semantic Fields (LSA-SF) is used to assess the utility of textual elements in comparison to users' goals in complex visual environments such as web pages. This textual utility or 'heat' is then used to automatically define eye-tracking regions of interest (ROI). Using LSA-SF, the unit of measure becomes more precise, moving ROI from a nominal to a continuous scale of measurement. Finally, the LSA-SF algorithm buffers error, because an eye-point which is out by several degrees will still gauge 'heat' generated from the textual elements beside it.

The LSA-SF method was used to estimate the visual saliency of the semantic content contained on 1842 web pages. Semantic Field values were found to predict 49 participants' eye-tracking data.

Estimating word's predictability on lexical processing using latent semantic analysis – verification from eye movement data

M2-4*

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Word's Predictability influences the lexical processing time in both early and late stages of word identification in EZ Reader Model. This study estimates the word's predictability by calculating the semantic similarity between the target word and its precedent information using Latent Semantic Analysis (LSA). Considering frequency effect in content words from eye movement data of 16 expository texts from twelve college students, the higher semantic similarity shows less first fixation duration, gaze duration, and total time (F = 13.818, 30.762, and 37.679 respectively). The result suggests that LSA could estimate word's predictability and reflect eye movement measures more on late stages (phonological / semantic form) of word identification than on early stages (orthographic form).

M2-5   **Control principles underlying the generation of fixational eye movements**

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We investigated the role of retinal input for the control of fixational eye movements. Participants were required to maintain a fixation for 20 seconds in complete darkness on a prespecified position. We analyzed statistical measures of microsaccades and drift using surrogate data from random sampling of Monte-Carlo type.

We found that the rate of microsaccades is inverse proportional to the box counting dimension. Further that, in darkness emerges a second group of microsaccades with an amplitude centerd around 1 deg of visual angle. In comparison to microsaccades during fixations on a fixation spot the microsaccades are less curved.

M2-6   **Reading with a dynamic processing span**

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Henderson and Ferreira (1990) suggested that the perceptual span might be modulated by the foveal load during reading. Using the SWIFT model of saccade generation during reading (Engbert, Nuthmann, Richter, & Kliegl, 2005), we explore the consequences of such a dynamic processing span on various measure of eye-movement control. First, the impact on distributed processing, i.e. lag and successor effects (Kliegl, Nuthmann, & Engbert, 2006), is small. Second, we found that the dynamic processing span can explain decreased fixation duration before skipped words (Kliegl & Engbert, 2005)—a finding, which is incompatible with a framework based on serial attention shifts.

The frequency of noun phrases and memory interference during complex sentence processing

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Durations from eye-tracking data in English show that sentences with object-extracted relative clauses (RCs) are more difficult to process when they contain a high frequency noun phrase (NP) in the subject position and a low frequency NP in the embedded position than when the ordering of these NP types is reversed. In contrast, such a difference between NP frequency ordering does not exist for sentences containing subject-extracted RCs. In addition, this interaction between RC type and NP frequency ordering disappears when both NPs are either high or low frequency, though main effects of frequency and RC-type persist. Such findings support the similarity-based memory interference hypothesis, while suggesting that NP frequency ordering may be a relevant factor in complex sentence processing.

Eye tracking parallelism in coordinate constructions: The effects of syntax, semantics and coordinating conjunction

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Reading times for the second conjunct of "and"-coordinated constructions are faster when that conjunct is parallel to the first conjunct than when it has a different structure. The scope of the mechanism underlying such parallelism effects, however, is unclear.

Three eye-tracking studies on German addressed this issue. Findings from these studies reveal: (1) The type of parallelism (syntactic vs. semantic parallel structure) does not interact with parallelism effects in comprehension. (2) The semantics of the conjunction, however, modulates parallelism effects in processing, with contrastive conjunctions (e.g., "but") eliminating parallel structure faciliation. Together our findings suggest that the semantic relationship (alike vs. contrastive) that the conjunction establishes between the two conjuncts plays a fundamental role in parallel structure processing.

L-3   **The time course of lexical ambiguity resolution in children**

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Ambiguous words, words with more than meaning, occur very frequently in the English language. Yet, comprehension is seldom disrupted because the contexts in which ambiguous words are embedded usually suggest the correct interpretation. The purpose of current study was to examine fourth graders initial encounter with balanced and biased ambiguous words and the integration of these words into the sentence representation. Context that did not rule out a particular interpretation of ambiguous word preceded the mention of each ambiguous target word and context that biased the interpretation of the ambiguous word followed its mention. Analysis of early and late processing of the target word region indicated that children demonstrated processing effects that are comparable to those demonstrated by adults.

L-4   **Local syntactic coherence interpretation: Evidence from**
                       visual-world experiments

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Are local coherences, as in "The coach chided the player tossed the frisbee by the opposing team." (Tabor et al. 2004) processed despite their prohibiting sentential context? Sentences with and without an embedded local sentence were presented auditively.Local coherences were constructed with lexically ambiguous words, controls with unambiguous synonym, and/or an inserted adverb. Three depicted events with the same pair of actors were presented simultaneously, representing: (A) the global content; (B) the local content; (C) an unrelated scene. We found significantly increased fixation probabilities on (B) when the sentence contained a local coherence, compared to its unambiguous counterparts. The results support the dynamical systems hypothesis of sentence processing.

Looking for the road most traveled by: A Clustering Approach for the Analysis of Saccades in on-line scene descriptions

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Scan paths in saccadic eye movements are known to be related to spatial and temporal features of cognitive processes in sentence production. In order to time-lock underlying cognitive processes to the argument-time structure of the verb (Klein 1999), instead of only its arguments (Griffin 2000), we need a method to compare different scanpaths.

We will present a transformation of saccades into an n-dimensional space that will allow us to compute the distance between two scanpaths. This yields a measure of similarity between fixation sequences of sets of utterances in a scene description task. With this distance metric a density-based algorithm is to return clusters of similar scanpaths, whose time course will be made visible using heatmaps.

Identifying relevant news in open corpora: Backtracking highlighted text regions

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Which piece of information is relevant for the user? This is the most important issue for adaptive information systems. For many information sharing systems, the answer comes from users' text annotations. Unfortunately, users tend to avoid processing costs associated with that task. This study investigated what is relevant to twenty users reading the news in a web-based system with different processing goals. Based on their eye movement patterns, we tried to predict what participants eventually would annotate in a second run for a text segment. Finally, we are one step closer to an intelligent information sharing system that reads from the users' eyes what is new, relevant and interesting to them.

U-1

On eye tracking and usability research: Introduction to the symposium

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Recent achievements in eye tracking increasingly allow the eye movement analysis in applied areas such as usability research. The long history of eye movement studies has produced a large body of empirical evidence together with profound knowledge about the mechanisms of visual perception, cognition and communication. Future developments in research and application will include the design of attention sensitive interfaces. Eye tracking seems to be a promising candidate providing solutions for this challenge. In the designing new generation of interfaces, we see at least the following major applications for eye tracking technologies: They can be used as (i) a source of information about mode of processing, (ii) a component of advanced assistant systems and (iii) means for communicative interaction.

U-2

Learning when to grasp

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Semi-autonomous robotic artifacts can be used to flexibly interact with a human being in various fields, among which assistance for the disabled. In this framework, eye movement can be effectively used to understand what the user wants to do and to therefore improve the timeliness and precision of the action performed by the robot.

To this end we envision the use of machine learning, an approach potentially able to understand userís commands it has not been programmed for. We show a machine learning system trained on arm/eye movement data gathered from several human subjects while trying to grasp objects. The system fully understands the userís intention to grasp, regardless of their visual impairedness, and it is usable in real time.

New usability metrics for the evaluation of eye typing systems   U-3

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Gaze interaction systems are powerful communication tools for people who are not able to control their hands. Freware systems for gaze typing and gaze interaction experiments may be found at http://www.cogain.org/downloads

The paper will present some of the design issues involved in interface design for eye typing, and it will present some resent empirical results that shows how people learn to master gaze interaction. We discuss gaze related metrics that would make remote monitoring of learning progress and usability evaluations possible. For instance, the number of keys that are attended for each typed character turns out to be particularly well correlated to the actual numbers of errors committed.

Eye tracking analysis in reading on-line newspaper   U-4

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Studying subjects' behaviour during reading on-line newspaper is important for the optimization of page layout. Which is the first part of the page that draws subjects' attention? Is the advertisement observed or ignored? Does the subject actually read the texts? Is there any influence of page size on subjects' exploration strategies? Are the navigation tools useful to the subjects?

All these questions can be answered by measuring subjects' eye movement during reading on-line newspaper and by computing quantitative parameters from the recorded signals: permanence time, number of fixations, sequence of accesses among different regions of the page. We have compared the on-line edition of two of the most important newspapers in Italy to investigate the effects of different layouts on subjects' behaviour.

U-5

How users adapt to new web applications: Evidence from eye-tracking studies

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In our recent research, we have studied how people adapt to and learn to use a new university web-site (replacing the existing site) and a new e-learning system developed in the framework of the WELKOM project. For each system, we performed eye-tracking supported user testing during the first days of the system's launch and several months later and compared the users' actions and eye-movement patterns during the execution of selected important tasks with the systems. The results allowed us to investigate the way novices and experts interact with an interface while solving a task. Another dimension is the evaluation of the additional information that can be gathered by eye-tracking studies compared to the one gathered via traditional user testing.

U-6

"Stop adding non sense!" Google's advertisement strategy on the eye-tracking test-bench

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Google's main revenues come from its online marketing called ad words: short textual based messages positioned on the right or the upper side of main page. They are separated in a graphical form from the page to avoid confusion between content and marketing. We present a study with three versions of the Google site, where we compared syntactical and semantically homologous and emotional cues versions with a base-line condition of unrelated ad words. Visual attention was assessed with a remote eye tracker. The data showed that the experimental variations caused a higher initial attention on Google's ad words than the base-line condition. This indicates that automatic bottom up processes play a significant role in the perception of textual stimuli on websites.

Dealing with the sensory consequences of smooth pursuit eye movements

SP-1

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We are unaware of retinal image motion resulting from smooth pursuit eye movements (SPEMs). This is because the brain self-attributes such image motion to our own agency by predicting this motion based on extra-retinal signals about the SPEM. Since schizophrenia patients, suffering from certain delusions and hallucinations, have an impaired ability to ascribe self-agency to the sensory consequences of their behavior, we speculated that they might be likewise impaired in dealing with retinal motion resulting from their own SPEMs. In fact, we found a correlation between the strength of delusions and the inability of schizophrenia patients to cancel out SPEM-induced retinal information in motion perception. This highlights the role of extra-retinal predictions for the formation of an intact self-awareness.

Contrast and assimilation in motion perception and smooth pursuit eye movements

SP-2

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The perception of visual motion and the oculomotor tracking of a moving object are known to be closely related. We compared perceived velocity and velocity of smooth pursuit eye movements in humans in a paradigm which required the segmentation of target motion from context motion. In each trial, target and visual context were perturbed to briefly increase or decrease in speed. Observers had to accurately track the target and estimate target speed. Results show that the same motion signals are processed in fundamentally different ways for perception and pursuit. For the computation of perceived velocity, motion of the context is subtracted from target motion (contrast), whereas pursuit velocity is determined by the motion average (assimilation).

SP-3 **Cortical processing underlying the execution of smooth pursuit eye movements**

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The execution of pursuit is tightly connected to the processing of visual motion signals. We recorded activities from areas MT, MST and FEF while our monkeys performed various pursuit tasks. Our data show that the processing within MT is restricted to the handling of retinal image motion characterized by a strong selectivity for direction and speed. But the cortical machinery underlying pursuit is not restricted to retinal image motion. Pursuit responses in MST and FEF contain visual motion and extra-retinal signals such as eye and head movements. In addition, FEF contributes specifically to the generation of anticipatory pursuit in case of predictive target appearances. These areas are not exclusively used to generate pursuit; MST contributes also to goal-directed hand movements.

SP-4 **Evidence that links anticipatory smooth pursuit and the extra-retinal component of sustained pursuit**

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Ocular pursuit is controlled by a combination of visual feedback and extra-retinal mechanisms. Although the extra-retinal component is evident in the form of response continuation during a brief target disappearance, its expression is dependent on expectancy of target reappearance. We presented randomised step-ramp stimuli for brief (50-200ms) periods followed by target extinction for 400-600ms and instructed subjects to track motion during extinction. By comparing responses in which the target regularly reappeared with those in which it didn't, we have been able to unmask the hitherto concealed temporal development of the extra-retinal component. Furthermore, we present evidence that this extra-retinal component bears a strong resemblance to anticipatory smooth pursuit, suggesting these two forms of response are created by a common mechanism.

Velocity scaling of cue-induced smooth pursuit acceleration obeys constraints of natural motion

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SP-5

This study investigates how predictive pursuit to a curved target trajectory (indicated by a low contrast static band) depends on target velocity. The results show that predictive eye acceleration increased quadratically with target velocity.

This quadratic increase of eye acceleration with target velocity results from time-scaling of a motion. This movement constraint is a feature of a many natural movements and is also implied by the two-thirds power law, which characterizes biologically controlled movements. We show that a velocity servo that is able to pursue such movements, must increase its feed-forward gain linearly with target velocity. We therefore suggest that gain control mechanisms of target-induced pursuit act similarly on predictive pursuit.

Probing prepursuit: active fixation inverts the effect of stationary cues

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SP-6

Smooth pursuit (SP) initiation is altered by factors which modify fixation (eg gaps and distractors). In these experiments, stationary cues were flashed for 100ms ipsilateral or contralateral to the position of appearance of the SP target in a step-ramp paradigm, during either a 1s gap or active fixation of a central fixation target. When cues appeared 500ms pre-SP target, SP latency was reduced by approximately 10% independent of fixation state or cue position. However when the cues appeared 250ms pre-SP target, contralateral cues increased while ipsilateral cues decreased latency when presented during a gap, but the opposite effect was observed when they were presented during active fixation. Fixation state appears to alter the processing of cue information in unexpected ways.

A3-1

Oculomotor capture by salient distractors: Effects of target similarity

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In a visual search task, a salient visual distractor captures attention and enlarges RTs even when it is task-irrelevant. However, these distraction costs seem to be larger when the irrelevant distractor is similar rather than dissimilar to the target. There are two different explanations for this similarity effect: According to the contingent capture hypothesis, attention initially selects similar distractors more frequently than dissimilar ones. According to saliency-based explanations, similarity only later modulates post-selectional processes, like distractor rejection or deallocation of attention from the selected distractors. The results of our eye tracking study indicate that both selectional and post-selectional processes contribute to the similarity effect. We discuss these results in terms of top-down and bottom-up controlled processes in visual selective attention.

A3-2

Is visuo-spatial perception related to visual or motor selection processes during eye movement preparation? Investigations with saccadic adaptation

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During the 90s, behavioural studies provided evidence in favour of an obligatory link between attention and eye movements, as perceptual enhancement was found to be tied to saccade preparation. However, whether the attentional shifts are driven by target or motor selection in the sensory-motor transformation that leads to saccades remains under debate. To dissociate visual from motor selection, we used the remarkable plasticity of the saccadic system, saccadic adaptation, obtained after systematic intrasaccadic target shifts. The postsaccadic error is progressively compensated for by the saccadic system, resulting in a spatial dissociation between the visual target and the actual saccade endpoint. We present a series of studies where modifications of perceptual capabilities were found to be driven by the adaptive saccade modifications.

Simple task, complex demands: Saccades interrupt visual imagery of motion

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We studied how attentional demands of a secondary task interact with the mental imagery of motion. Firstly we demonstrated that during a motion extrapolation task subjects spontaneously made sequences of saccades that indexed the trajectory of ongoing imagery surprisingly well. Introducing additional tasks such as making a goal-directed saccade or anti-saccade, or attending to a visual stimulus, interrupted this eye movement pattern and produced a persistent delay in motion imagery. Furthermore, the instruction to make saccades to a visual stimulus ahead of the trajectory of imagery displaced the focus of imagery. These findings suggest that interruption of motion imagery as mirrored in the saccade behaviour is due to the competition of the involved tasks for attentional resources.

Audio-visual integration during visual overt attention

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How do different sources of information arising from different modalities interact to control where we look? To answer this question with respect to real-world operational conditions we presented natural images and spatially localized sounds in (V)isual, Audiovisual (AV) and (A)uditory conditions and measured eye-movements.

Our results demonstrate that eye-movements in AV conditions are spatially biased towards the part of the image corresponding to the sound source. Interestingly, this spatial bias is dependent on the probability of a given image region to be fixated (saliency) in V condition. This indicates that fixation behaviour during AV conditions is the result of an integration process. Regression analysis indicates this integration is best accounted by a linear combination of unimodal saliencies.

A3-5   **Is selective attention at the target location necessary for smooth pursuit initiation ?**

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Allocation of attention to the goal of voluntary saccades is important if not mandatory for saccade initiation. We assessed the dynamics of the coupling between attention and smooth pursuit initiation by summoning attention - endogenously or exogenously - towards a peripheral discrimination target at variable times before pursuit target onset. The discrimination target was stationary and the pursuit target was the only moving object on the screen. The effects of attention shifts upon pursuit latency were negligible. However, pursuit gain was progressively reduced as the eye approached the closed-loop phase. While previous results suggested that attention is necessary to select the pursuit target among two moving objects (Ferrera & Lisberger, 1995), our results show that the absence of attention does not compromise pursuit initiation.

A3-6   **Eye movements in foveal and parafoveal search tasks**

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We compare attention allocation and eye-movement control in two sequential search tasks. In the first experiment, eye-movement control was driven by foveal information, i.e., fixated symbols provided information about the next target location. In the second experiment, parafoveal symbols specified the next saccade target. Results: First, we obtained both an increased number of immediate refixations and an increased error rate in parafoveal search, while fixation durations remained the same across experiments. These findings lend support to a broader attentional span in the parafoveal task compared to the foveal task. Second, effects of skipping provided evidence against serial processing. Third, we compare our experimental data with model simulations of a variant of the SWIFT model (Engbert et al., 2005, Psychol. Rev.).

Parallel object processing in a naming task   L-7

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Morgan and Meyer (2005, JEP:LMC) showed that speakers naming object triplets retrieved the name of the second object before fixating upon it. This means that they either processed the first and second object in parallel, or that they processed them sequentially, but that the processing of the second object began prior to fixation.

We describe two experiments aiming to distinguish between these options. Experiment 1 showed that the second object was processed more efficiently before fixation when the first object was easy than when it was difficult to name. Experiment 2 showed that the difficulty of the second object affected the gaze duration for that and the preceding object. These results support the parallel rather than the sequential processing hypothesis.

Eye movements and text understanding: New evidence for the   L-8
role of the parts of speech and the regressive fixations

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The questions regarding to the experimental examinations were carried out with regard to the function and meaning of the parts of speech. By means of Eye movement analysis 141 subjects got both a jumbled and a regular German and English text.

Regarding the two jumbled texts the analysis of those parts of speech (I. noun, II. verb, III. adjective and IV. side parts of speech) was of central interest, which will be used for the improvement of text comprehension. For this the analysis of the difficult understandable words was carried out based on three evaluation steps. The results show new evidence for the causes of regressive fixations and for the importance of the noun for the improvement of text understanding.

L-9

What is the animacy effect?

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Images of animate objects are processed differently to inanimate objects. What can subjects' looking behaviour tell us about this animacy effect? Three studies investigate how people process visual objects, when briefly presented sequentially. Pictures were preceded by a label, or no-label, and were controlled for orientation, typicality and within-category visual similarity, as well as animacy as a within/between subject factor.

Animate objects received significantly longer total looking time, longest looks and number of fixations than inanimates. Furthermore, cluster analyses demonstrated that looking was evenly distributed across inanimates, whereas clustered around particular features for animates. Crucially, naming condition had no effect on looking patterns, demonstrating that animacy, but not labeling, directs looking behaviour in this paradigm. Theoretical implications are discussed.

Gaze Communication: The case of object selection   U-7

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Gaze-based computer control is a challenging subject in many ways. One important topic is object selection. Whereas in keyboard-mouse control, an object is selected by pressing a key, a comparable solution within gaze control seems hard to imagine. The reason for this lies mainly in the implicit control of the eye movement, which has fast and efficient deictic functionality, but can hardly be used to voluntarily control actions. We have suggested anti-saccades as a tool for object selection by gaze since anti-saccades are known as eye movements which have to be explicitly controlled. In a first attempt, however, anti-saccade selection was prone to errors. New developments of the anti-saccade selection as well as further user studies are to be presented.

Quality of verbal data: Concurrent thinking sloud vs.   U-8
retrospective thinking aloud

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Many users find thinking aloud difficult and uncomfortable. An obligation to verbalize the performed processes may also slow down or even change the user's normal behavior with the product. We compared the quality of the verbal data received in a usability test in two conditions: (1) when the data was gathered from concurrent (traditional) thinking aloud and (2) when the participants gave verbal comments retrospectively while watching a playback of the session augmented with an overlaid gaze path animation. The retrospective think-aloud produced distinctively more verbal data than concurrent think-aloud. Analyzing the quality of the given comments revealed that in the retrospective condition the comments reflected more cognitive operations whereas in traditional thinking aloud the emphasis was on manipulative comments.

U-9   **From gaze mouse to attentive interfaces: three selected problems**

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In gaze controlled computer interfaces the dwell time is often used as selection criterion. But this solution comes along with several problems in the temporal domain: (1) Eye movement studies on scene perception could demonstrate that fixations are serving different purposes and should therefore be differentiated. (2) The Midas touch problem, the question of how to discriminate intentional selections from other perceptual processes. (3) The temporal relationship of eye position and the corresponding visual feedback to the user is tightly bound to the ongoing task.

We present research on the usability of a simple eye typing set up. Our results indicate that smoothing raw eye position and temporal delays in visual feedback enhance the system's functionality and usability.

Saccades and binocular coordination in reading: Effects of viewing distance and font size

R5-1

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Participants read sentences with retinal image size manipulated by varying viewing distance (62, 83, 124 cm at 12 pixels letter width) or font size (8, 12, 16 pixels letter width at 83 cm distance). Replicating prior research, we found that saccade amplitudes remain nearly constant across all conditions when measured in letter units. However, fixation durations were larger for smaller retinal image sizes, leading to a substantial increase in viewing times per word. Binocular disparity was predominantly uncrossed and depended quite strongly on retinal image size. During most fixations the eyes converged, with convergence velocity also mediated by retinal image size. Our results provide a comprehensive and consistent account of font size and viewing distance effects on eye movements during normal reading.

Reading someone else's finished text versus reading your own emerging text

R5-2

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By combining eye-tracking technology with keystroke logging we investigated how the reading of your own emerging text differ from the reading of a text written by someone else. Analyses of reading activity show that it sometimes consists of both regular forward reading and something that appears to be "backward reading".

The results show that backward reading is significantly more common when reading one's own emerging text than when reading someone else's text. Comparing forward reading during the reading of someone's own emerging text with the text written by someone else reveals that fixation durations are significantly longer when reading the own text. This indicates that more cognitive processing is involved during the forward reading of one's own emerging text.

R5-3   **Reading under the influence: Effects of alcohol intoxication on**
                          oculomotor control and linguistic processing

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Reading offers an intriguing context in which to explore effects of alcohol on information processing, as it involves coordinating oculomotor control and cognitive processing in a highly controlled perceptual setting. Participants read sentences with high/low frequency target words in two sessions (alcohol vs. no alcohol). Analyses revealed that under alcohol there was a substantial increase in fixation durations combined with a decrease in the number of fixations, pointing to a tradeoff between temporal and spatial aspects of oculomotor control. However, there was no interaction between alcohol condition and word frequency for any oculomotor parameter. These results suggest that alterations of eye movements in reading induced by moderate alcohol intoxication are largely due to visuomotor slowing, rather than lexical processing difficulties.

Fusion and saccadic targeting to dichoptically presented words in adults and children

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Both adults and children exhibit disparity between the fixation positions of the two eyes when reading, and disparate retinal inputs are fused to form a unified percept (Liversedge et al. 2006). We monitored children's and adults' binocular saccades onto dichoptically presented words or nonwords, varying the relative horizontal positions of the stimulus presented to each eye. Participants made a lexical decision. We measured binocular landing positions, fixation durations, vergence movements, refixations and response accuracy. We will discuss our results in relation to three theoretical issues (1) the size of Panum's fusional area for linguistic stimuli, (2) whether this changes with age and (3) whether saccades for each eye are targeted independently during binocular saccades to dichoptically presented stimuli.

A contralateral hemifoveal advantage in isolated word recognition

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A new stereoscopic methodology was used to present words to normal readers such that each eye only received half of the word, in the relevant hemifovea. The critical manipulation involved presenting half-words to the temporal or the nasal hemifoveas. In each case, participants saw a brief presentation of the stimulus and were aware of only a single coherent word. There was a significant advantage for the temporal condition, i.e., for the contralateral projection of letter information between eye and cortex, in perceptual recognition. This contralateral advantage is consonant with data from fMRI exploration of the binocular projection to V1 (Toosy et al., 2001). The data are only interpretable on the assumption that the human fovea is precisely vertically split.

B-3   **Understanding fixation disparity in reading**

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There is pervasive disparity between the fixation points of the two eyes in reading. On any one non-conjoint fixation, the left eye can be left of the right eye ("uncrossed") or right of the right eye ("crossed"). Current data on the distribution of these two types of disparities vary considerably. I will review what is known about fixation disparity from binocular eye-tracking studies of reading, and will argue that it is adaptive and may be understood in terms of the main evolutionary advantage of binocularity – depth perception. This analysis of fixation disparity has technological and methodological implications for eye-tracking studies.

The analysis of reading strategies as a tool for understanding and training eye movements in patients with central field loss

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Reading inability is a leading complaint of patients with macular degeneration. High spatial discrimination and global viewing of words are essential to reading. In patients both are spontaneously infrequently achieved, but can be fulfilled by combining different eccentric fixation points. We trained eye movements in 5 patients with long-standing reading disorders. We conducted ten sessions using scanning laser ophthalmoscopy. Patients must read isolated words combining complementary eccentric retinal locations. Before, immediately and three months after training, ETDRS acuity, threshold character size for words and texts and oculomotor strategies were assessed. All subjects benefited from the training procedure. However, gains were retained differently as a function of word lengths. Analysis of oculomotor strategies supported these observations.

Parkinson's disease: How does saccadic performance relate to arm movement measures and to clinical ratings?

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In Parkinson's disease (PD), the clinical examination of eye movements is seldom abnormal. Despite its apparent lack of clinical utility, quantitative saccadic measures have been an active area of research in PD, as they reveal subtle but consistent deficits.

What relevance do these laboratory findings have to the wider clinical presentation? We examined 19 people with PD and matched control subjects. They performed analogous saccade and arm movement tasks, the latter quantified by 3D magnetic trackers. There was little relationship between movement data and clinical scales. The relationships between the eye and arm data were complex. People with PD adopted markedly different strategies to compensate for impairments of arm control vs inherently ballistic saccades, particularly in rhythmic tasks.

C2-3   Downbeatnystagmus: Interaction with otolithic signals and therapeutical aspects

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Spontaneous ocular drift in cerebellar downbeat nystagmus (DBN) typically contains both a gravity-independent and a gravity-dependent component, which is probably mediated by otolith-ocular reflexes.

We specifically examined the effect of the potassium channel blocker 3,4-diaminopyridine (DAP) on the gravity-dependent vertical drift component of patients with idiopathic cerebellar ataxia. DAP could change exclusively the gravity-dependent or gravity-independent components or both. The gravity-dependent modulation of SPV was correlated with the efficacy of DAP, i.e. the larger the modulation the stronger SPV was reduced.

C2-4   The relation between antisaccade errors, fixation stability and prosaccade errors in schizophrenia

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We investigated whether antisaccade errors were related to saccadic inhibition during fixation. In 15 schizophrenic and 16 healthy subjects, we assessed fixation during the preparatory period in saccade trials, and during fixation trials interspersed among saccade trials.

1. Schizophrenia patients had more fixation losses than controls. 2. Antisaccade error rate was correlated with fixation losses during the preparatory period but not during fixation trials. 3. Antisaccade errors were more likely on trials with unstable than stable fixation. 4. Antisaccade and prosaccade error rate were correlated. Conclusion: antisaccade errors are related to difficulties implementing inhibitory control. However, the correlation between antisaccade and prosaccade errors suggests not a specific problem inhibiting prosaccades, but a more general deficit implementing goal-oriented behaviour.

When left becomes right and vice versa: Mirrored vision after cerebral hypoxia

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The combination of acquired mirror writing and reading is an extremely rare neurological disorder, characterised by a preference for horizontally mirrored over normal script in writing and reading. Here we report the experimental investigation of PR, a patient who developed pronounced mirror writing and reading following septic shock that caused hypoxic brain damage. Several oculomotor experiments revealed striking scanpath abnormalities that cannot be explained by previous theories. Considered together with mirror phenomena in neuropsychological tasks and everyday activities, our findings suggest a horizontal reversal of visual information on a perceptual level. When confronted with moving, flickering, or briefly presented stimuli, PR showed hardly any left-right reversals. These findings allow the interpretation of her pathology in terms of a dissociation between visual subsystems.

A4-1   **Contextually modulated viewpoint effects on object recognition
                                    in scenes**

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In research on object recognition in scenes, object fixation times have frequently been
used as indications of ease of object identification. Yet, there still is considerable debate
as to which processes are actually being reflected in object fixation times. To advance
this debate we first established a stimulus pool of objects for which we could demonstrate
a viewpoint effect on naming latencies: certain object viewpoints yielded faster object
naming than others. Subsequently, all objects were inserted in scenes and object fixation
times were analysed. We observed that object fixation times also show a viewpoint effect
and that this effect is modulated by scene semantics, corroborating previous claims that
object perception in real-world scenes is a prime example of re-entrant processing.

A4-2   **Extracting relevant visual properties of made-man object with
                monadic and paire-wise evaluation: Mixture modeling and parzen
                                    kernels infer attention**

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This work deals about visual perception of object's design. While participants are assess-
ing object's visual properties, eye movements are recorded in the aim to extract atten-
tion's grabbers and task's relevant visual features. Pictures are viewed under monadic
and paired-wise presentation. An exhaustive panel of eye movement's data treatments
is employed for spatial and temporal analysis, among which density estimation with two
complementary tools: Gaussian mixture modelling for global behavior and clustering, and
Parzen kernels for density temporal dynamic. Effects of experimental factors (task, scene,
and subjects properties) are observed. For this category of cluttered scene with an as-
sessing task, results show that visual attention is strongly drawn by object's perceptual
representation without respect of task's relevant visual properties.

Looking for continuity: The relationship between natural attentional shifts and perceived continuity across film cuts

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Whole field visual scene disruptions typically inhibit saccades and are highly salient. In film such disruptions occur with every cut but we are rarely aware of the disruption. Film editors create this impression of continuity by cutting during changes in motion or an actor's gaze direction. The effect of these events on attention and awareness was tested by eyetracking viewers whilst they detected cuts. Awareness of editing decreased when the shots either side of the cut depicted the same scene or action. All cuts resulted in delayed saccade initiation except when preceded by a gaze cue, resulting in saccade initiation before the cut. This evidence suggests that our awareness of editing is limited by coinciding cuts with natural attention shifts.

Towards automated mapping of semantic content from mobile eye tracking in urban environments

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Mobile eye tracking as a methodology is getting increasingly important for psychological research (usability, media, and psychophysics); recently it has been considered for visual memory augmentation (Roy, ISWC 2004). We currently work on a solution to prevent from manual coding of eye tracking video streams for analyses beyond the individual level. Computer based mapping of visual content will provide the bases for an accurate and cost efficient data aggregation and exploration of attention in natural environments like urban space, or supermarkets. We applied state-of-the-art computer vision methodology for the detection of objects of interest (brands, information signs) on fixated regions of interest within video frames and mapped the geo-referenced content onto digital city maps.

A4-5

Mobile visualization of natural scenes using a head-mounted wide-angle camera and a gaze-driven tele-lens camera

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Eye-tracking systems with head-mounted cameras are well known. In these systems the area of interest is emphasized in the scene by using markers, brightness, or other highlights. While these systems allow a quick and intuitive visualization of the spotted areas, they lack in spatial resolution of the interesting area. A gaze-driven camera was recently proposed, making it possible to capture exactly the area of interest within the whole field of gaze.

The combination of a traditional eye-tracking system containing a wide-angle head-mounted camera with the proposed gaze-driven camera emphasizes the scene using the high resolution picture of the gaze-camera. We developed a wearable system to capture and display these videos in realtime.

A4-6

Centering gaze behavior in audiovisual speech perception under noisy conditions

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The human face communicates visual information of particular significance for social interactions. To understand better the process of gathering facial information, we examined the spatial distribution of gaze fixations displayed by subjects performing an audiovisual speech perception task, in which we diminished the intelligibility of the speech by introducing either visual (low-pass spatial frequency filtering) or acoustic noise (multi-talker masking). Gaze fixations were significantly and similarly altered under these noisy conditions: subjects generally minimized their gaze fixation distributions around the center of the talker?s face, looking away from the mouth and the eyes. We suggest that this adaptive behavior provides an ideal vantage point to optimize visual/attentional processing of facial information.

Approaching normal reading: SOA, frequency, and predictability effects on event-related potentials

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To avoid overlapping components elicited by consecutive words, event-related potentials (ERPs) during reading are usually recorded while sentences are presented word-by-word with unnaturally long stimulus onset asynchronies (SOAs). Because artificial presentation rates make data difficult to compare with normal reading, we examined the influence of SOA on ERPs using standard (700 ms) and quasi-normal (280 ms) intervals between sequentially displayed words of 144 sentences. In addition, frequency as bottom-up and predictability as top-down variables were experimentally manipulated on target words. Apart from influences of frequency and predictability on the time-course of word recognition, we expected SOA to affect early and late ERP components. Furthermore, relations to fixation durations from an independent eye-movement study utilizing the same stimulus material were explored.

Co-registration of eye movements and event-related brain potentials: A new tool to investigate eye movement control in reading

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Simultaneous recordings of eye movements (EMs) and event-related brain potentials (ERPs) can provide new insights into the time course of visual, lexical and oculomotor processing during reading fixations. In two experiments (N=54), EM and ERPs were co-registered during natural sentence reading. Experiment 1 demonstrated that despite methodological challenges (e.g. ocular artifacts) reliable ERPs can be measured during left-to-right reading. Fixation-locked ERPs were modulated by the predictability of the currently fixated word (N400 effect). In Experiment 2, the word frequency and predictability of target words was experimentally varied, allowing direct comparisons between fixation-locked brain activity and the corresponding EM behavior. All results were compared to traditional ERP data recorded during passive, word-by-word presentation of the same sentences.

EE-3

The time course of visual distractor processing: Evidence from simultaneous recordings of eye movements and EEG/ERP

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Co-registration of EEG and eye movements can enhance our understanding of visual information processing and its time course. Such co-registration was used in our investigation of saccadic inhibition due to sudden visual events. Distractors were presented gaze contingent during a free viewing of pictures. In the past, such saccadic inhibition has been explained either as an oculomotor reflex or as manifestation of the orienting reflex. Our data support both hypotheses, indicating two stages of inhibition, one reflex-like with a latency of 110 ms and a second at 180 ms, reflecting the novelty of a distractor. Since saccadic inhibition preceded the earliest changes in cortical ERPs, we propose that a subcortical pathway for fast processing of visual information is involved.

EE-4

Fixation related brain potentials: A validation

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Exploration of the real world usually expresses itself through a perceptual behaviour that is complex and adaptive - an interplay between external visual and internal cognitive states. However, up to now, the measurement of electrophysiological correlates of cognitive processes has been limited to situations, in which the experimental setting confined visual exploration to the mere reception of a strict, serial order of events. Here we show - exemplified by the well known old/new effect in the domain of visual word recognition - that an alternative approach that utilizes brain potentials corresponding to eye fixations during free exploration reveals effects as reliable as conventional event-related brain potentials.

Microsaccadic inhibition and P300 enhancement in a visual oddball task

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Recent works have demonstrated that in a visual oddball task rare targets (oddballs) induce a prolonged microsaccadic inhibition compared to more frequent nontargets (standards). Under the same experimental conditions, an enhanced P300 potential is commonly observed. In the present study, we co-recorded eye-movements and ERPs in a visual oddball task. We demonstrated that both measures are influenced by the overall frequency of the stimuli and by the sequence-based subjective expectancy of the upcoming stimulus; in addition, for both measures this modulation is stronger for targets than for non-targets. However, the P300 amplitude is not predictive of the microsaccadic response on a given trial, indicating that they constitute two independent measures of the brain's response to novel task-relevant stimuli.

M3-1 **Simulating Chinese reading with SWIFT: Do word or character based rules apply?**

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Chinese script does not employ character spaces between words, since the concept of the 'word' is not as clear-cut as in western script. Chinese speakers do not always agree on where word boundaries are. A corpus of 150 sentences with words that linguistically trained speakers of Chinese agreed upon was presented to 30 participants (Yan et al, submitted). The present study aims at modeling the resulting data with SWIFT (Engbert et al, 2005).

The model needed to be supplemented with a mechanism enabling it to parse character strings into words, since Chinese script lacks inherent information regarding word boundaries. We compare SWIFT with a complete random saccade model and present variants of SWIFT incorporating word based and character based mechanisms.

M3-2 **Higher-level language processing during reading: Using the e-z reader model to examine post-lexical integration**

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Current models of eye-movement control in reading are incomplete: Although they explain how many visual and lexical variables affect eye movements, they largely ignore the effects of higher-level language processing. In this talk, we will attempt to "sketch" what a more complete model might look like, using a modified version of the E-Z Reader model (Reichle et al., 2007) to simulate the results of three eye-tracking experiments that factorially manipulated the lengths and frequencies of adjectives in sentences containing adjective-noun pairs (Pollatsek et al., 2007). The simulations provide insights into how post-lexical processing might operate in the "background" of on-going lexical processing, occasionally interrupting the normal progression of eye movements during reading.

A grammar extension to the Glenmore model of eye-movement control in reading

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M3-3

This paper describes an extension to the Glenmore model of Eye-Movement Control in reading that permits the application of syntactic and lexical semantic constraints in a natural way within the interactive activation modelling framework. The constraints are derived from an analysis of a corpus of written English. The paper presents some preliminary results on eye movement behaviour particularly in the context of syntactically anomalous sentences.

Eye movement planning as stochastic optimization: Reinforcement learning in SHARE

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M3-4

Since no-one is taught oculomotor strategies in reading, optimal eye movement planning must be a result of unsupervised learning. This paper presents a Reinforcement Learning (RL) model based on the Stochastic Hierarchical Architecture of Reading Eye-movement (SHARE).

The central hypothesis is that proficient reading entails optimal coordination of component processes. Word Recognition (WR) speed is limited by the availability of foveal and parafoveal information as well as predictions from the Language Processing (LP) module. Optimal Saccade Planning (SP) strategies are learned to maximize reading speed and minimize costs associated with WR and LP errors. The RL-based model accounts for a range of reading eye movement phenomena. Implications on reading, reading development, and reading different orthographies will be discussed.

M3-5   **Serial or parallel? Using reinforcement learning to examine
                      attention allocation during reading**

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Reinforcement learning has been previously used to examine the eye-movement behaviors
that emerged from artificial "agents" that learned to read efficiently (Reichle & Laurent,
2006). This technique was used to examine how two attention-allocation policies (serial
attention vs. attention gradient) affected the simulated eye movements of such agents.
The resulting simulations indicate that, although the attention-gradient reading agents
learned to move their eyes in a manner that promoted very rapid reading, the simu-
lated eye movements of the serial-attention agents more closely resembled those of human
readers. These results suggest that models that incorporate attention gradients may be
parameterized sub-optimally for efficient reading. The implications of these results for
models of eye-movement control will be discussed.

M3-6   **Evaluation of the SWIFT model using z-string scanning as an
                    oculomotor control condition to normal reading**

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One sustained controversy in research on eye-movement control in reading has been
whether low-level oculomotor or moment-to-moment cognitive processes predominantly
control the decisions about when and where to move the eyes. Here, we validate the
SWIFT model of saccade generation using data from a z-string scanning experiment as
an oculomotor control condition to normal reading. Key results like globally prolonged
fixation durations in z-string scanning and the effect of string length on fixation durations
were qualitatively reproduced by the model, yielding strong support for the model's as-
sumptions on visual processing and saccade generation. Furthermore, simulation results
for patterns of regressive saccades in z-string scanning lend support to SWIFT's concept
of an evolving field of activations of words and/or z-strings.

Searching for something unknown

PA-01

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What if you're looking for something, but don't know what it looks like? Participants searched for an object when shown either the target's picture or name (basic-level category). Targets were either a typical or an atypical category member. There was no typicality effect when searching for a picture target. For named targets, there was a modest gain in the latency to fixate the target for typical items. However, the bulk of the typicality effect for named targets was in "verification time": after initially fixating the target, there were more fixations to distractors and longer gaze durations on target items. Thus, most of the effect of object typicality on the search is in verifying that the target matches the category label.

Repeated visual search: Influence of memory and target proximity

PA-02

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In a repeated search task, Körner and Gilchrist (2005) found a recency effect: A target in the second search could be found faster when it had been fixated more recently in the first search. Here we investigated the extent to which this effect depends on target proximity. In a static search condition the display remained constant throughout. In a switch condition the letters exchanged their positions between searches which made the deployment of memory impossible. In the latter condition, performance in the second search benefited from target proximity. However, this effect cannot entirely account for the strong recency effect observed in the static condition. This is further evidence for memory in visual search.

PA-03

Measuring expectations: An application of eye movement tracking

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An important function of cognition is to detect connections between events and to form expectations. Such connections may relate to physical causality, e.g., an apple is falling from the tree; subsequently it is expected to hit the ground, and to social situations, in which the outcome of an action has to be predicted. In the present study, we measured in how far eye movements mirror the connections that are made between events and people and expectations regarding future events. Paired sketch drawings were displayed that contained the same visual contents, but the degree to which expectations about future events were raised was manipulated. Regardless of individual differences, scanpaths reflected the connections made between current events, people and expected future events.

PA-04

Natural scene statistics at monkeys' center of gaze

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Overt visual attention is studied both in humans and monkeys, yet for generalizing results there is need for more comparative studies on monkeys. Here, we looked at gaze movements of monkeys viewing natural stimuli. We investigated the contribution of stimulus features like luminance, contrast, and spatial correlation of luminance to guidance of gaze movements. The highly significant increase of luminance contrast and decrease of spatial correlation we found at monkeys' fixation points exceeded results other studies reported for humans. However, luminance contrast alone cannot explain the observed data, indicating that more complex bottom-up cues like texture contrast and top-down cues are involved. Summarizing, we found that low-level features have stronger effects on guiding overt attention in monkeys than in humans.

Visual search in real-world scenes: Effects of target cue specificity and cue lead time on component search processes

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Visual search studies typically report unitary search times. Using eyetracking, we divided visual search in naturalistic scenes into three epochs: initiation, scanning, and decision. We manipulated the nature of the target cue (picture or word) and cue lead time, and examined their effects on search time as a whole, and on the three search epochs. Results indicated that scanning and decision times are influenced by the nature of the cue, whereas the time to initiate the search is influenced by cue lead time. The results suggest that a pictorial template facilitates search by allowing faster rejection of non-targets and acceptance of the target. The results indicate that eyetracking can be used to better understand the processes underlying visual search.

A time-sensitive similarity measure for scanpaths

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Similarity measures for eye-movement patterns provide a powerful tool for analyzing empirical data and the evaluation of computational models of oculomotor control. However, measures based on edit-distances either disregard fixation durations or become computationally impracticable when repetitions of symbols for regions of interest (ROIs) represent time spans. As reading studies, among others, rely heavily on temporal information, this property renders analyses based on edit-distances inadequate in many situations. In response to this problem, we propose a modification of the Levenshtein algorithm that operates on sequences of fixated ROIs where each fixation in the scanpath is labeled with its respective fixation duration. The algorithm penalizes differences of eye-movement patterns dependent on their temporal extent and the degree of the spatial divergence.

PA-07 **Investigating levels of processing in eye movements: A stimulus driven approach**

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This study investigated the efficacy of inferring levels of visual processing from proposed parameters of fixation duration and saccade amplitude. Eye movement behaviours during free viewing of three types of static stimuli were analysed. The first study investigates the proposed parameters while subjects' viewed possible and impossible objects, which are known to differ in terms of representation. The second study examines eye movements on abstract stimuli according to whether they were judged based on local or global attributes, and finally the third study analyses eye movement behaviour while comparing natural scenes for 'what' versus 'where' differences. Results are discussed in terms of finding indices of levels of visual cognition through the analysis of eye movement behaviours.

PA-08 **Influence of task dependent information and saliency on overt attention**

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The contribution of bottom-up and top-down signals to overt attention is in the center of intense debates. Here we measure gaze movements of human subjects viewing segments (bubbles) of natural visual stimuli (faces, landscapes) in the context of classification tasks (gender, mood, openness, man-made influence, respectively). Local image contrast within each bubble is taken as a measure of bottom-up information, task performance attributable to a bubble as a measure for top-down information. We find that allocation of attention is affected by both, feature-based saliency and task dependent information content. Surprisingly, preliminary analysis indicates that, depending on the image-task combination, even in these well-defined tasks local image properties relayed bottom-up have a higher influence.

Context Dependency of Overt Attention in Natural Scenes

PA-09

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When viewing natural environments humans direct their gaze to relevant parts of the scene. It is known that this process of overt attention is guided by low-level stimulus features as well as by goal-directed volitional processes. Here we investigate selection of fixation points in relation to luminance contrast in four different task conditions. 'Free Viewing' and 'Study Carefully' re-vealed similar correlations of fixations points and luminance contrast. Surprisingly, a search task for 'Man-Made' objects showed a correlation of nearly identical magnitude. In contrast, the global task of 'Subjective Appraisal' induced a much lower correlation of fixation points and luminance contrast. These results demonstrate that the correlation of low-level features with overt attention can be modulated by the context.

Bottom-up vs. top-down control of eye movements during scene perception

PA-10

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During viewing of static natural scene images, observers exhibit a consistent pattern of eye movement measures over time: Fixation durations continually increase over time, saccade amplitudes initially increase and slowly decrease afterwards, and between-subject similarity of spatial fixation distribution is highest during the first one or two seconds. Moreover, during early viewing time, more targets with higher visual saliency are fixated.

These results suggest that during the first one or two seconds, fixation locations (and thus visual attention) are predominantly controlled by bottom-up mechanisms, which are less idiosyncratic and thus lead to the observed higher between-subject similarity of fixated locations. Top-down mechanisms, which are thought to differ more between subjects, start to exert their influence only later during viewing.

PA-11 **Comparison of the eye movement in observing polysemous pictures with a guided point**

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We recorded eye movements by use of eye mark recorder NAC8, subjects were nine males and three females aged from 21 to 23 and they watched pictures on the CRT. Pictures were composed of sixteen gray scale polysemous pictures, each picture was divided in three types; Type1: a default picture, Type2: a picture with a guided point which emphasizes the main content of Type1, and Type3: a picture with a guide point which emphasizes a hidden content of Type1.

Comparison with Type1 and Type3, difference were observed at significance level of 5% both in the horizontal and the vertical movements, however in comparison with Type2 and Type3, no statistical difference was observed both in the horizontal and the vertical movements.

PA-12 **Task impact on cognitive processing of narrative fiction film**

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The study investigates a segment of the process by which a spectator extracts information from moving images and treats it cognitively to generate an integral experience of a film. A comparison is attempted between eye movement data and the participants' own reports of their impressions of a film sequence under three different task conditions.

The results show that the cognitive processing of film information is influenced not simply by the presence or absence of a task, but by a combination of task specificity and the ways in which information is presented in the film. These findings are tentatively related to theories of frugal heuristics in everyday decision-making and their relevance to the cognitive processing of film information.

Saccade dynamics before, during and after saccadic adaptation

PA-13

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When saccade amplitude is systematically inadequate relative to target position, it is adaptively modified. Saccade duration and velocity have stereotypical relationships to amplitude ("main sequence"). If saccadic adaptation modified the function of brain areas controlling dynamics, these relationships might be modified. We investigated saccade dynamics before adaptation, during amplitude reduction induced by a systematic intra-saccadic backward target step, and during maintenance of adaptation. All saccades conformed to the main sequence relationships. A slight modification of the acceleration/deceleration ratio was observed during the maintenance of adaptation. These preliminary results suggest that the initial modification of amplitude is not sub-tended by a change in the function of brain areas controlling dynamics but that the maintenance of adaptation might involve such areas.

Changes in the spectral main sequence of human saccades during saccade adaptation

PA-14

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The saccadic system is capable of rapidly adapting to conditions that otherwise would lead to movement inaccuratenesses - an effect usually refered to as saccade adaptation. Up to now, it is still an open question, whether and how such gain adaptation also changes the dynamics of the saccades. In our present study we sought to address this issue by an examination of both the "classical" and the spectral main sequence of human saccades during saccade adaptation.

Comparisons between the control and the adaptation conditions revealed significant differences for the classical measures as well as for the spectral data. Hence, our results suggest an involement of the pulse-step generator in the process of saccade adaptation.

PA-15   **Movement target selection: Prelude activity expressed by fixational eye movements during a direction-discrimination task**

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Using random dot kinematograms (RDKs), we investigated the sensitivity of fixational eye movements (FEM) as measures of ongoing activity in the oculomotor system. Horwitz & Newsome (2001) have show that activity in the superior colliculus predicts target choices well before execution of the saccadic eye movement, and the strength of the motion signal in the display influences the intensity of this "predictive" prelude activity. We expected to find correlates of this activity in FEM. We measured FEM in a delayed-response direction discrimination task during and after presentation of RDKs varying in motion strength, comparing manual and saccadic responses. Microsaccades were predictive of the response, and the onset time and strength of this effect was correlated with motion signal strength.

PA-17   **The elderly's eye movements duaring stair walking**

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We focus on the relation between stair walking activity and stair walking environment from perspective on visual information. Spatial-temporal gaze behaviour patterns were analysed as participants, the elderly and the young, wearing a mobile eye tracker were required to walk on 13 steps. In the result, in the point where gait pattern from flat to stairs changes, the participants fixated on average two step ahead. In the point where gait pattern stays constant, the participants fixated on far step ahead. In addition, the elderly fixate on more near step ahead than the young. The results suggest that the elderly has crash risk in the point where gait pattern from flat to stairs changes.

Manipulating visual information in complex actions - Similarities and differences in gaze behavior between experts and novices

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Athletes may use different gaze behavior strategies in order to asure a steady performance if visual information gets manipulated (variability of vision in action - hypothesis; Davlin, Sands & Shultz, 2001). 16 subjects were to perform a front handspring in two experimental conditions (binocular & monocular view). An Eye-Tracker was used in combination with a movement analysis of the handsprings. We found no significant differences between binocular and monocular conditions regarding mean fixation duration or other parameters between experts and novices. Novices have their eyes longer closed concerning monocular view during the over head flight (F $[1,12] = 5.8$; p $<. 05$). The results support the tested hypothesis with some major restrictions. Future research is necessary to examine visual perception in complex movements.

OGAMA (OpenGazeAndMouseAnalyzer): An open source software designed to analyze eye and mouse movements in slideshow study designs

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A new software is introduced that allows analyzing eye- and mouse-tracking data in parallel. OGAMA is written in C#.NET and released as an open source project. Its main features include database-driven pre-processing and filtering of gaze and mouse data, the creation of attention maps, areas of interest definition and replay (with. avi recording). Any eyetracking and/or presentation soft- and hardware recordings in ASCII format can be imported. Data output is provided that can directly be used with different statistical software packages (like SPSS or SAS).

Because it is open source you can easily adapt it to suit your needs. Share your experience with us and give it a try: http://didaktik.physik.fu-berlin.de/ogama

PA-20   **Comparison of two process tracing methods in iterated Prisoner's Dilemma game**

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Information acquisition during iterated Prisoner's dilemma game was studied using two methods: eye-tracking and a computerized process tracing tool. In the latter, a mouse was used to access hidden information. The aim was to compare these two methods and to explore the influence of the particular method used on the decisions made during the game. The results show that there is no significant difference in the mean number of fixations produced by both methods. There is a difference however in the transition patterns between zones. The analysis also shows similar playing behaviour and use of similar decision strategies no matter which process tracing method is used.

PA-21   **Age-induced reductions in inhibitory control modulate antisaccade performance**

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Older adults make more directional errors on the antisaccade task than younger adults, although the cognitive source of this is contentious. This study manipulated the demands on inhibitory control and spatial working memory using three eye movement tasks that tapped executive function. Whilst old (Mean age = 58 yrs) and young (Mean age = 24 yrs) participants exhibited comparable error rates on a spatial working memory-loading task, marked impairments with old age were observed on a task requiring high inhibitory control and also on a standard antisaccade task. Thus, antisaccadic proficiency is apparently selectively impaired with old age, primarily due to a decline in inhibitory control over any decline in spatial working memory capacity.

Correlates of cued antisaccade performance in healthy participants

PA-22

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In the antisaccade task, pre-cueing the location of a correct response has the paradoxical effect of increasing errors and decreasing correct latencies. It has been suggested that this effect occurs because participants adopt an "antisaccade task set" and treat the cue as if was a target - directing attention away from the precue and towards the location of the impending target. This hypothesis was tested using a mixed pro-anti task. Reducing the amount of preparation time for each trial led an increased effect of cueing on antisaccade errors. In addition, the effect of cueing was reduced in participants with low working memory spans. The strongest predictor of cued and uncued antisaccade error rate was correct prosaccade latency.

Antisaccades as a developmental marker in the developing world: Antisaccade directional error rate in Malawian children

PA-23

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Prior to investigating the consequences of cerebral malaria (CM), we investigated whether antisaccades (AS) could be recorded using a laptop and digital video camera from a population in which most children had never seen such technology. AS data was recorded from eleven children (ages 5-14y), three of whom had previously had CM. All performed adequately; across the group we observed the familiar decrease in AS directional error rate with age (non-CM: $r2=0.52$; $p<0.05$). A subgoup case-control analysis between the Malawian group and UK children (mean age 10.3y) revealed no significant difference in directional error rate (M:44±17%; UK:49±16%; t=0.42, p=0.68). These results suggest that AS are a useful tool for assessing the developmental impact of CM in diverse populations.

PA-24

Inhibitory control of the human dorsolateral prefrontal cortex during the antisaccade paradigm - a TMS study

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The critical time interval was studied at which the DLPFC exerts its inhibitory control during the antisaccade paradigm. Single pulse TMS was applied over the right DLPFC in 15 healthy subjects either 100ms before the onset of the visual target, at target onset or 100ms after target onset. Stimulation 100ms before target onset significantly increased the percentage of antisaccade errors to both sides while stimulation at, or after target onset had no significant effect. All three stimulation conditions had no significant influence on saccade latency of correct or erroneous antisaccades. These findings suggest that the critical time interval at which the DLPFC controls the suppression of a reflexive saccade in the antisaccade paradigm is before target onset.

PA-25

Neural correlates of saccade initiation and inhibition in an event-related FMRI study

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The preparation of antisaccades is associated with neural activity in the frontal eye fields (FEFs), the supplementary eye fields (SEFs), and the dorsolateral prefrontal cortex. It is unclear, whether these areas are also involved in the execution of antisaccades, which implies suppressing a reflexive saccade and initiating a volitional saccade. To disentangle these two response components, we used FMRI to measure BOLD signal changes in tasks requiring either saccade initiation or inhibition or both.

Data from 19 healthy participants show that saccade initiation activated FEFs and SEFs bilaterally. Inhibition related brain activity did not include FEFs and SEFs, but rather involved other frontal and parietal brain areas. The results suggest that saccade initiation and inhibition recruit dissociable neural networks.

Incentive and the antisaccade task: A rewarding influence

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In order to be successful on the antisaccade task, participants must suppress the tendency to look at a sudden onset target and direct their eye gaze instead to an equidistant position in the opposite direction. It has been argued that errors occur when participants fail to sufficiently activate the relevant task goal within working memory. We explored the effects of motivational and monetary incentives on antisaccade performance in 88 healthy participants. We found that providing an incentive reduced error rate and decreased correct latencies. Interestingly, participants in financial groups made more errors than those in motivational groups. The results imply that incentives can increase goal activation in the antisaccade task.

How do sequences of anti-saccades differ from sequences of pro-saccades ?

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The anti-saccade task, i.e. performing a saccade to the opposite direction of the visual target, is used to understand the cognitive processes linked to reflexive saccadic inhibition but only a few studies examine the characteristics of such saccades. Here, we examined sequences of two anti-saccades made in response to two small separated targets, two objects or one long object. We characterized latencies and amplitudes of the first and second anti-saccades. The influence of the sequence preparation time was also examined by contrasting a gap-0 and an overlap paradigm. Finally, we looked at whether some well-established effects such as the "global effect" or the specific planning of between and within-object pro-saccades can also be found with anti-saccades.

PA-28 **Post-error slowing in the eyes, hands and feet: A generative role of conscious awareness**

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It has long been held as a psychological axiom that following an error humans slow down (Rabbitt, 1966). Why humans slow down, and whether they always slow down, remain open questions. Using variations of the antisaccade task and/or Simon task, we show post-error effects are varied across the different effectors. Post-error consequences are dependent particularly on awareness of the error. While following conscious eye-movement errors, participants slow down; after unconscious eye-movement errors, they speed up. Moreover, the well-known post-error slowing phenomenon may not provide any benefit to accurate performance, but may merely be a cost of being conscious of the previous error. Reasons for speeding up or slowing down after an error and the consequences of both are examined.

PA-29 **Antisaccade costs with an auditory target**

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We compared prosaccades and antisaccades using a peripherally-presented auditory target. In 'standard' conditions, participants were required to saccade towards or away from the target, depending on instructions. In a 'unidirectional' condition, participants executed a saccade in one direction only (e.g., to the left) on detection of the target, thereby minimising the involvement of working memory and eliminating uncertainty of saccade direction. Findings revealed significantly faster saccadic latencies on prosaccade trials in both standard and unidirectional conditions. In standard conditions only there was a higher rate of direction errors on antisaccade trials. We conclude that neither a visual target stimulus, the involvement of working memory, or uncertainty of saccade direction on antisaccade trials are necessary to elicit antisaccade costs.

Is the vector inversion visual or motor in anti-saccades? A behavioural study using saccadic adaptation

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To correctly execute an anti-saccade, the pro-saccade to the visual target must be suppressed and a saccade to the opposite location executed. How is the motor vector of such anti-saccades computed? Does it depend on the inversion of the target vector or on that of the motor vector of the non-executed pro-saccade? We dissociate these vectors with saccadic adaptation: the systematic backward shift of the visual target during the saccade induces a progressive decrease of the amplitude. Therefore, the motor vector of the adapted saccade differs from its visual vector. Preliminary results show that the adaptation of rightward pro-saccades transfers to rightward anti-saccades but not to leftward anti-saccades, suggesting that anti-saccade computation relies on the inversion of the visual vector.

The way we look at art

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Art theory suggests that observers' viewing behaviour will be affected by interpretation suggested by the title, whether it is original or a reproduction, and the observer's expertise.

When viewing art, observers' saccades were of greater amplitude and shorter fixation duration in the first half of the viewing time in comparison to the second half of the viewing time. This suggests a general scan of art works before a more detailed scrutiny. However, there were no systematic differences in saccades when paintings were randomly assigned to different categories; when observers viewed original paintings compared with photographic or on-screen reproductions; or as a function of observers' expertise. Results will be discussed in terms of general scene viewing and art theory.

PA-32

Measuring and shaping peripheral responsiveness in a virtual navigation task

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When viewers engage in a task with a high foveal workload, there is a decrease in the size of their functional visual field for peripheral events. To evaluate the extent of this decrease, we developed a 3D virtual navigation task and systematically varied the foveal workload of the task. In addition to measuring navigation performance in central vision, we also measured responsiveness to peripheral events: explicitly through change detection performance and implicitly through a scanpath analysis in the interval surrounding designated peripheral events. Compared to measures of foveal performance, measures of peripheral performance were more sensitive to variations in foveal workload. In addition, the task allowed us to explore the relative efficiency of various types of peripheral gaze capturing events.

PA-33

What can a moving dot tell us about language

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This eye-tracking study investigated whether words whose meanings imply directionality would affect smooth pursuit eye movements. Participants tracked a dot moving smoothly across a computer screen in one of four directions: Up, down, left or right. Motion verbs (e.g. rise and sink) were presented auditorily during the movement. Tracking performance (velocity and positional errors) was influenced by the directional properties of the verbs; thus, the congruency of the direction implied by the verb and the direction of the moving dot influenced participants' ability to track the dot. The results provide support for the perceptual theory of cognition and lend insight into the nature of the perceptual symbols activated during language comprehension.

Effects of workload on dynamic properties of saccades

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It is known that different patterns of eye movements are elicited by different tasks. However, the quantitative relationship between the pattern of saccades and psychological states is still debatable. In this study we examined dynamic properties of saccades and psychological states during a task classifying visual objects into categories with different levels of workload.

We manipulated workload of the task by varying stimulus interval. The results showed that the difference in the workload had effects on saccade velocity, but had little or no effect on the latency and amplitude. The difference in the workload also had effects on subjective responses of "activity", "time pressure" and "anxiety". These results indicate that there is a correlation between saccade velocity and psychological states.

Task set guides eye movements: Evidence from the Stroop effect

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Tasks containing conflicting information require cognitive control. Participants completed a numerical version of the Stroop task. On congruent trials the value of numbers on the side with more items was higher (e.g., 22 and 5555); on incongruent trials the value was lower (e.g., 55 and 2222). In Experiment 1 participants judged by manual response on which side more numbers were shown. Participants directed first saccades more frequently towards numbers with a higher value and to the side with more stimuli. To determine whether first saccades were guided by task set or centre of gravity, in Experiment 2 the task was to judge on which side fewer stimuli were shown. Task set was identified as the most influential factor.

PA-36

Working memory and express saccades

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Individuals with low working memory (WM) perform more poorly than high WM individuals on antisaccade tasks, producing more errors and longer latencies. This study examined individual differences in WM in 15 students, and their relationship with the maintenance of active fixation in two types of antisaccade and prosaccade tasks: a gap condition and an overlap condition. High WM participants produced more express saccades (with latencies of 85-135msec) than low WM participants in the antisaccade gap task, suggesting that they had a temporarily reduced ability to fixate. These findings are discussed in relation to the involvement of the superior colliculus. High and low WM individuals may adopt different strategies to allocate attention depending on the conditions and demands of a task.

PA-37

Homing accuracy and landmark saliency

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We measured eye movements of human subjects in a virtual environment. So far 4 subjects were trained to find back to 5 locations defined by surrounding landmarks. As dependant variable we measured the homing accuracy to the former trained locations. In the last trial we removed one landmark in the vicinity of the goal. Further we determine the saliency of each landmark in two ways: (i) by the recall rate in a memory test and (ii) by the number of fixations in the training phase. So far we found a tendency for higher homing errors if the saliency of the absent landmark was high.

Doing to things at once: Temporal coordination of motor actions

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In response to sensory signals, the human brain has to generate motor actions via sensory-to-motor transformation processes constantly controlling their spatio-temporal accuracy. This can be challenging when movement pattern comprises concurrent oculo-motor and manual responses, for example. The temporal relations between these two motor (re)actions in a dual task paradigm were investigated. In a continuation phase of tapping task, subjects continued tapping at a rate given in the preceding synchronization phase. As a concurrent task, in different experiments, single manual or biphasic ocular movements were given in response to a go-signal. As analysis in terms of "phase resetting" revealed, for manual actions, mutual influences of single and periodic tasks was evident, however, for the saccades, this was not a case.

Visual attention in multiple-choice tasks: Influences of image characteristics with and without a verbal stimulus in individuals with aphasia

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Image characteristics in multiple-choice displays may interfere with valid language comprehension assessment. Such influences may be problematic for individuals with aphasia, given the visual and attention deficits commonly co-occurring with aphasia. Eye movements of 41 adults with aphasia were recorded as they looked at 40 image arrays. One image characteristic (size, color, luminance, or orientation) was manipulated in each display. Within each set, three images shared the same image characteristics and one image differed in terms of that characteristic. All characteristics significantly influenced visual attention in verbal and nonverbal conditions. Verbal stimuli did not override effects of image characteristics in distracting attention from target images. Results suggest that careful design of multiple-choice images is essential to valid assessment.

PA-40   **Eye movements in an emotional Stroop task**

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Eye movements of 41 participants were recorded while an emotional Stroop task was performed. They were instructed to verbally report the color of the ink in which the words of a list were printed. Three categories of words with diverse semantic content were used: neutral, emotional and arousing (anorexic specific). The EAT-40 scale was used to evaluate the risk of developing eating disorders. Sample was split between high- and low-risk subjects. Results showed that emotional words required more time to be processed when compared to neutral and arousing ones. No differences were observed in the number of fixations among the three conditions, but bigger fixation durations were obtained in the neutral word compared to the other two categories.

PA-41   **Effects of L-dopa on the saccadic system in Parkinson's disease -
a pilot study**

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Characteristic features of voluntary saccadic eye movements in PD include hypometria, increased saccade count ('stair-case' pattern), increased prediction and longer latencies. Some studies investigating reflexive saccades in PD report shorter mean latencies or increased proportions of express saccades. It is not clear if or how any of these characteristic features are affected by L-dopa.

This pilot study measured eye movements of a group of PD patients performing a reflexive and a voluntary saccadic task in two conditions: 'on' and 'off' L-dopa. The effect of medication on saccadic parameters was dependent on individual performance level and task.

Prediction as a mechanism for compensation of smooth pursuit deficits in schizophrenic patients

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The mechanisms of smooth pursuit eye movement (SPEM) deficits in schizophrenic patients are still under debate. Unable to perform closed loop pursuit, velocity storage and prediction of target movement might be used. We studied a group of 25 patients and age matched controls in a pursuit blanking task. Deceleration of the eye movement after target blanking was significantly higher in control subjects compared to patients while residual gain was marginally, i.e. insignificant, lower for the patient's group. We conclude that schizophrenic patients use prediction of target movement for generation of SPEM, that is effective for a short period after blanking onset but cannot perform self generated SPEM just as the healthy controls.

Is there a contribution of impaired visuomotor control to aphasic reading disabilities?

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We compared oral reading of single words in six aphasics (two cases of deep, surface and residual dyslexia) with age matched controls. Participants read lines of target words differing in length, frequency, morphological complexity and concreteness. Influences of linguistic variables were most pronounced for word frequency. Especially the patients with deep dyslexia showed hugely inflated gaze durations and total reading times for low frequency words.

Interestingly, three patients (two surface, one residual dyslexic) showed nearly random distributions of initial fixation positions within words despite average amplitudes of interword saccades. This pattern corresponded to neuro-radiological findings, pointing to the possibility of compromised frontal eye fields. In conclusion, it appears that in some aphasics impaired visuomotor control may contribute to reading disabilities.

PA-44   **Response switching on saccade tasks in schizophrenia**

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To specify deficits of action control in schizophrenia we studied the effects of switching between rightward and leftward prosaccades and antisaccades. In a first study, we investigated task switching (between pro- and antisaccades) and response switching (between leftward and rightward saccades) in 20 schizophrenia patients and 20 control subjects. Groups did not differ concerning task switch effects. In contrast, response switching entailed a stronger enhancement of error rates in patients, suggesting a specific action control deficit on the level of response selection in schizophrenia. A second study is being conducted to investigate the effects of different inter-response intervals on response switching both in schizophrenia patients and in healthy subjects.

PA-45   **Simultaneous EEG recording and eye-tracking during active viewing**

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To date, methodological constraints have meant that EEG studies of human vision do not allow for natural eye movements. We use a highspeed eyetracker synchronized with a 128-channel EEG system. Eye-movement artifacts are removed using regression-based EOG artifact reduction. The peri-saccadic to peri-fixation variance ratio of EEG signals before and after removal drops from 2.65 to 1.11, showing that most artifacts have been removed. The eyetracking accuracy remains between 0.2-0.4 degrees during the experiment. Applying this method to simple active vision tasks, we report differences between event-related and saccade-related potentials. These results are strong proof of concept that EEG recordings with eye movements are possible.

Effects of rTMS on performance in an angle discrimination task

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PA-46

Repetitive transcranial magnetic stimulation (rTMS) provides the possibility to transiently interfere with brain activity and lead to a modified human behaviour in cognitive tasks. The aim of this study is to investigate the influence of rTMS on visual exploration during an angle discrimination task. We applied rTMS to the superior parietal lobe as this region is known to play a crucial role in performing visuospatial tasks. The stimuli were designed in order either to facilitate (with cues) or to make more difficult (without cues) subjects' use of a visual exploration strategy. Preliminary results suggest that rTMS only affects the cued condition in which the development of a strategy is feasible.

The effect of calibration errors on the accuracy of eye movement recordings

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PA-47

For calibrating eye movement recordings, a regression between spatially defined calibration points and corresponding measured raw data is performed. Based on this regression, a confidence interval CI of the actually measured eye position can be calculated in order to quantify the measurement error introduced by inaccurate calibration coefficients (Fogt and Jones, 1998).

Our simulations and recordings demonstrate that the CI depends critically on residuals at certain calibration points, thus robust regressions are suggested. The overall r2 of the correlation is less informative. Examples of binocular recordings with separate monocular calibrations illustrate the rules how the number and spatial position of calibration points can be chosen in order to reduce the CI in the conditions of the actual eye movement investigation.

PA-48

Gaze vector detection by stereo reconstruction of the pupil contours

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Head-mounted eye trackers extract the contour of the pupil by approximating it as an ellipse. Its projection on the image plane will always be another ellipse, because the projective transformation of a conic is a conic. Two different projections of the same pupil are obtained by using a stereo camera system with defined relative camera orientation. These two ellipses can then be used to calculate position, orientation, and size of the original pupil with respect to one of the camera coordinate systems. An indication of the line of sight can be obtained by determining the normal vector of the reconstructed pupil plane. Except when determining the primary position, this technique does not require additional fixations for proper calibration.

PA-49

fMRI of eye movements in monkeys and humans: Spatially-specific and non-specific preparatory signals for memory- and visually-guided saccades

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Delayed response paradigms are used in monkey electrophysiology and human fMRI of oculomotor behavior to dissociate visual and motor responses and to investigate movement planning. The relationship between these studies is not clear. We compared monkeys and humans with the same tasks using fMRI, recording BOLD activity while subjects made visually- and memory-guided saccades. We applied event-related analysis to delineate responses from different trial epochs. We compared activation preceding saccades to extract signals related to working memory and motor preparation. Frontal and parietal areas exhibited spatially-specific, contralateral cue and preparation activity. In "no-memory" conditions non-specific preparatory signals were manifested as ramp-up towards the end of delay period. Similarities and differences between species are discussed.

A study towards a new eye-tracking approach for CFF measurement

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This eye-tracking study investigated influences of different stimuli on the CFF while participants gazed at scenarios of 24 flickering diodes. The frequency was increased or decreased until the participant indicated changes from fusion to flicker or vice versa. Additionally, eye-tracking parameters were recorded during the experiments. One group was drowsed by performing a Mackworth clock test, while the second group was stimulated by 200mg caffeine.

Results showed that CFF perception was significantly higher in the caffeine group. Fixation durations and saccadic velocities were significantly higher on flickering stimuli than on fused ones. This relationship between eye-tracking parameters and the CFF could be used to design systems measuring the CFF directly from changes in the recorded parameters without user-feedback.

TMS of PPC delays saccades but not when they are combined with predictable divergence

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How the PPC controls the triggering of divergent vertical eye movements has never been examined. A gap paradigm was used to elicit vertical or horizontal saccades (10deg), pure or combined with a predictable divergence (10deg). TMS was applied on right or left PPC at 100 ms after target onset. Twelve subjects participated to the study; eye movements were recorded with EyeLink 2. While TMS could delay the latency of horizontal or vertical saccades, it had no effect on either component of combined movements. This was attributed to the fact that divergence was predictable and probably triggered within a large cortical circuit including frontal areas. Common cortical mechanisms would control both divergence and vertical or horizontal saccades triggering.

PA-52

Artifact-like eye movements but not artifact

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The type of eye movements are categorized into several ones such as saccades, smooth pursuit eye movements, fixations, micro-saccades of tremor, drifts, etc. The discussions have been focused on how the vision and motor control are cooperated each other and managed by the central motor commands. Uncontrollable artifact-like eye movements during strong fixation concentration and rather big artifact-like rapid eye movements during eye blinking are found by the corneal reflection methods together with high speed motion camera. Small but rhythmical eye movements are related with the heart beat originated blood vessel volume change around the eye ball. Upward movements during eye blinks come from eye ball shift toward the sagittal direction and eye ball deformations by the eye lid.

PA-53*

Real-time gaze-tracking for freely-moving observers

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We have developed a real-time mobile gaze-tracker, by combining a high-speed eye-tracker (Eyelink II, 500Hz) with head- and body-tracking (VICON, 200Hz). The position of the observer's gaze on the screen can be measured continuously with an accuracy of <1.0 deg as they walk around and make head movements in a natural way. The system is modular, i.e. individual components can be easily replaced (e.g., different eye and head tracking systems can be used).

The system is primarily developed for interaction in front of wall-sized displays. For validation, the system has been tested with displays of different sizes (from 2.2x1.8m to 5.2x2.5m), and several applications, including psychophysical experiments and a multi-resolution gaze-contingent display.

The effects of font type, character size, and character space in reading Chinese

PA-55

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To investigate the most efficient way representing the text in reading Chinese on computer displays, three typographic variables, font type (Kai and Ming), character size (32 and 24 pixels) and character space (1/4 and 1/8 character width), were manipulated. Results showed that when character size was larger, the fixation duration was shorter, the saccade length was longer, and the regression was more often; when character space was wider, the fixation duration was shorter and the saccade length was longer. Both the overall reading time and the fixation duration indicated that it took longer to read in Kai than Ming. However, no comprehension or preference difference was found in different conditions.

Putting the spatial code on the line - an eye movement investigation of spatial coding in reading

PA-56

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We remember where on a page to find information and can make accurate long-range regressions in reading. These observations suggest that the spatial positions of words are memorized. To study how this spatial code develops, we presented continuous text, one line at a time, so that the current line was either in the same or a different position compared to the previous line. Spatial overlap altered reading speed on the current line and affected eye movement control. These results are used to develop a model of spatial coding in reading and help us to understand pervasive differences between reading from screen vs. reading from paper.

PA-57

A multiple regression analysis of syntactic influence in reading normal text

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Whereas eye movements are routinely used as an index of syntactic processing in psycholinguistic experiments, syntax plays little role in current models of eye movement control in reading (e.g., by occasionally introducing local disruptions in the normal course of reading). The present study was based on the assumption that syntax exerts its influence on a regular rather than occasional basis. In a series of regression analyses conducted on a large-scale corpus of eye movement data, the time spent inspecting a word was found to be influenced by the depth of its syntactic embedding: the more deeply embedded a content word, the less time spent inspecting it; the more deeply embedded a function word, the higher the probability to skip it.

PA-58

The effect of cognitive load on the processing of stereotype-consistent and inconsistent information

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In two eye-tracking experiments, we investigated how readers process stereotype-consistent and inconsistent information. In Experiment 1, participants read gender-occupation stereotype-consistent sentences (e.g., "The babysitter cut herself. . .") and inconsistent sentences (e.g., "The babysitter cut himself. . ."). First pass, second pass and regression path durations were measured for the agent and pronoun regions. As expected, we found longer processing times for the pronoun region when the sentences were stereotype-inconsistent than when they were consistent. In Experiment 2, the reading task was combined with a working memory task (remembering a 5-digit number). The consistency effects of Experiment 1 were not replicated. These findings suggest that the binding of a pronoun to its antecedent is a capacity-demanding process.

Referential processes in text comprehension: The integration of bare plurals with context

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Text comprehension involves understanding how information in the current sentence relates to previous text. There is evidence to suggest that anaphors (Garnham 2001) and quantified noun phrases (Frazier et al. 2005) are rapidly integrated with context. The integration of bare plurals (e.g., 'rabbits') has received less attention. For example, in 'Australia is home to a variety of wildlife. Rabbits are widespread, but they are never seen in Australia these days.' If the rabbits in the second sentence are interpreted as being widespread 'in Australia', difficulty should be experienced at the second mention of Australia, compared to an unambiguous control. Results from two eye-tracking experiments indicate rapid detection of contextual mismatch, suggesting that readers interpret bare plurals with respect to context.

Integrating sentence processing theory with eye-movement control models

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Surprisal (Hale 2001), a parsing model, is shown to predict fixation durations in an eye-tracking corpus (Potsdam Sentence Corpus (Kliegl et al., 2006)) independent of the predictions of an eye-movement control model, SWIFT (Engbert, et al. 2005).

The parser was implemented using two methods to derive Surprisal values; both methods yield similar results. Method 1 applied Stolcke's Earley parser (1995), estimating a PCFG from NEGRA and Tiger treebanks. Method 2 used estimates from the NEGRA corpus to explore states of Nivre's (2004) incremental dependency parser. SWIFT-generated fixation durations and unigram-frequency were used as predictors of observed fixation durations. The residuals from the linear model were treated as dependent measures, with Surprisal as fixed factor and sentences as random factor.

PA-61 **Is the letter identity span modulated by word and phrase boundaries? Evidence from Finnish**

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Processing of parafoveal letter information in sentence reading was examined with an eye-contingent display change paradigm. In the change condition, the first two letters of the parafoveal word were kept intact but the remaining letters were replaced by visually similar letters. The target noun was preceded either by an adverb, an adjective, or the first constituent of a compound (the target is the second constituent of an unspaced compound). The study examined whether letter identity span is modulated by word and phrase boundaries. We tested the hypothesis that the preview effect is largest within an unspaced compound, smaller within an adjective-noun phrase (a space appears between the two words) and smallest across phrases (in adverb-noun pairs, separated by a space).

PA-62 **Evidence for frequency and predictability interactions on word processing times**

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Using an experimental design employed by Ashby, Rayner and Clifton (2005), participants read sentences containing high- or low-frequency target words varying in predictability. Prior to fixation, targets were either correctly spelled, visually similar misspelled, or visually dissimilar misspelled. In contrast to the findings of Ashby et al., Frequency and Predictability had interactive rather than additive effects on processing time. We account for this difference by reference to: (a) the absolute level of predictability in the two studies; and (b) control over launch position prior to target fixation.

Reference: Ashby, J., Rayner, K., & Clifton, C., Jr. (2005). Eye movements of highly skilled and average readers: Differential effects of frequency and predictability. The Quarterly Journal of Experimental Psychology, 58A, (6), 1065-1086.

Long-range reading regressions are accompanied by a P600-like brain potential: Evidence from the co-registration of ERPs and eye movements

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About 15% of reading saccades move the eyes backwards in the text. To study the neurophysiological correlates of such regressions, we co-registered gaze position and ERPs of 54 subjects during natural, left-to-right reading. Sentences were grammatically diverse but contained no syntactic violations or local ambiguities. Accompanying the onset of long-range regressions, we observed a late centroparietal positivity, closely resembling the P600 component commonly observed for syntactic violations and garden-path sentences in traditional ERP experiments. This suggests that the P600 indexes individual comprehension difficulty or parsing problems even in the absence of syntactic ambiguity. Co-registration of eye movements and ERPs may help to differentiate between regressions caused by oculomotor overshoot, word identification failures, and syntactic parsing problems.

Age effects on parafoveal processing in reading

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Prior research in the domains of visual search and driving has suggested that elderly adults have a smaller functional field of view. The present study used a sentence reading task including saccade contingent display manipulations to test the hypotheses that benefit from parafoveal word preview is reduced in this population relative to college age controls. Results indicate that elderly readers are not only substantially slower but also show a more pronounced word frequency effect (Rayner et al., 2006). Critically, the preview benefit was greatly attenuated in the elderly group, suggesting a significantly reduced perceptual span. This provides a more direct empirical base for recent attempts to accommodate age effects in computational modeling (Laubrock, Kliegl & Engbert, 2006).

PA-65   **Parafoveal letter processing predicts serial naming**

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Prior research suggests that reading ability is highly correlated with the rapid serial nam-
ing of letters presented in a grid. None of the pursuant theories accounts for observed
differences between the speed of naming isolated versus serially presented letters. We
hypothesized that this difference can be explained by the benefit from parafoveal preview
available in the serial task.

Participants completed the standard isolated and serial tasks, and a saccade-contingent
version (three, two or one letter window). Preliminary results suggest that naming latency
and gaze duration increase when preview is limited. Preview benefits during reading were
correlated with performance in the serial but no the isolated naming task. We conclude
that parafoveal processing is a powerful determinant of performance in the serial naming
task.

PA-66   **Reading from right to left: Exploring binocular eye-movements
patterns in Hebrew**

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Previous eye-movements (EM) studies suggest that the reading direction modulates some
EM parameters such as the reading span and landing position (e.g. Pollatsek, Bolozky,
Well, & Rayner, 1981). We report data on binocular eye-movements recorded during
reading of multi-line texts in Hebrew. Landing position, refixation probabilities, binocu-
lar disparity and launch site are analysed as well as the interplay between some of these
parameters and word length. A comparison of the results obtained for Hebrew (a left-
going language) with findings obtained for German (The Potsdam Sentence Corpus, Kliegl,
Grabner, Rolfs & Engbert, 2004) reveals mostly similar patterns. The implications of the
similarities and differences are discussed with regard to possible accounts of the effects of
reading direction.

English versus French: Determinants of eye movement control in reading

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This study exploits the fact that the order of adjective and noun is different in English and French. Native English and native French speakers read sentences in their respective languages while their eye movements were recorded. This cross-language comparison provided new findings concerning the time course of lexical access and integration. Moreover, a series of repeated measures multiple regression analyses were undertaken to study the influence of a wide range of predictors (10) on several aspects of oculomotor behavior. By specifying the relative weight of these predictors on temporal and spatial characteristics of the eye movement record, these analyses will help inform computational models of eye movement control in reading.

The Landoldt-C string scanning task as a proxy for oculomotor control in reading

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Prior research attempting to account for "mindless reading" has led to conflicting results. We propose a new non-linguistic task incorporating visuomotor demands similar to reading (Hooge & Erkelens, 1999; Williams & Pollatsek, 2007). Participants detect strings of ooooooo that contain one c, like ooocooo. Visual and cognitive aspects of this task can be adjusted independently to produce reading-like fixation patterns. In the current study we tested four versions of differing complexity in comparison to a standard sentence reading task using the same spatial configuration. Significant deviations from eye movements in reading include a reduced number of within-string refixations and re-inspections of previously viewed regions. Interestingly, the simpler (rather than the more complex) versions of the task were more reading-like.

PA-69

Inference comprehension in native and non-native speakers of English - differences in perception of non-explicitly stated information

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Using eye tracking, we assessed comprehension of inferences (information implied but not explicitly stated) in healthy individuals. Sixteen volunteers, fluent in English (8 native and 8 non-native speakers, balanced for gender), read stories 'sentence-by-sentence' on a computer-screen. The 'Test'-stories induced and then disconfirmed inferences, causing increased reading times compared to the 'control'-condition without inferences. Most native speakers exhibited the expected increase in reading time (mean: $+355$ ms [$=9\%$], SE 75, $p<0.002$) whilst the majority of 'non-natives' did not (mean: $+58$ ms [$=1.5\%$], SE 138, $p=0.68$).

This suggests a previously unnoticed 'native language'-effect in inference comprehension. Our finding illustrates the need to control not only for language competency but long-term language background when examining inference comprehension.

PA-70

Crossed and uncrossed fixation disparities in reading; eye-tracking technologies, individual differences and illumination

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Recent years have seen an unresolved issue of the distribution of crossed and uncrossed fixation disparities in binocular eye-tracking data. In a crossed fixation disparity, the left eye is to the right of the right eye; in an uncrossed fixation disparity, the left eye is to the left of the right eye. The relative proportions of these disparities differ between eye-tracking technologies. We report a case study of a single reader who robustly changed from crossed fixations to uncrossed fixations when the light level was reduced, demonstrating that Eyelink 2 technology can record the range of disparities within a single reader. We review different literatures associating binocular disparities with stimulus properties, experimental set-up and individual differences.

Do headings and text familiarity extend vertically the perceptual span in searching a text? A gaze-contingent eye movement study

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Participants were asked to find an answer to specific questions in chapter-length texts in either a normal or a window condition, where the text disappeared above and below a gaze-contingent region. The texts either contained or did not contain headings: text familiarity was varied by manipulating the number of prior searches. Headings and familiarity strongly affected the eye movement behaviour including number of fixations, fixation duration, saccade length and total search time. The window manipulation had different effects depending on the heading condition: eye movement measures demonstrated that the searchers make different use of extrafoveal vision in signaled than unsignaled text. The potential implications for the perceptual span in reading are discussed.

Re-examining the role of word locations on eye guidance in reading

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In reading, it is generally assumed that eye movements are word based, with the eyes aiming for the center of selected peripheral words. Our study re-examined this assumption based on a-posteriori analyses of adults' eye movement data during text reading. The distributions of saccade landing sites were plotted as a function of both the saccade launch distance to a given word ('n+1') and the length and frequency of Words 'n' and 'n+1'. The full distributions of landing sites were considered, including cases where the eyes landed on Word 'n', 'n+1' or 'n+2'. Results suggest that the length of early-triggered saccades is determined by averaged movement coding. Word location information is integrated later to determine the landing site.

PA-73   **Development of oral reading: A comparison of longitudinal and cross-sectional eye movement data**

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In a longitudinal design reading in German elementary school students was studied in second and fourth grade. Participants read aloud 120 sentences including target words varying in length and frequency and also completed a pro- and antisaccade task and a word naming experiment. With total reading times reduced by 40 percent at forth grade, specific developmental differences were apparent on two levels: In the younger readers a more sequential reading strategy indicated a much stronger emphasis on word decoding, while highly inflated re-reading times are likely to reflect postlexical comprehension problems. Theoretical and methodological implications of these results will be discussed in relation to prior work using the same materials in a cross-sectional design, while the present fourth graders were in second grade.

PA-74   **Eye movement characteristics of skilled and less skilled deaf readers**

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Eye movements differ among skilled and beginning readers, and dyslexic readers (Rayner, 1986; Chace et al., 2005). Beginning readers make more fixations, more regressions and shorter saccades than skilled readers (McConkie et al., 1991). Poor readers and dyslexic readers also show this pattern (Rayner, 1998). Many deaf readers show reading performance that plateaus around the third grade level, but several deaf people also reach expert reading levels (Traxler, 2000). Based on a study by Rayner (1986), the present experiment used the moving window paradigm to compare the eye movements of skilled and less skilled deaf readers, and those of skilled deaf readers and skilled hearing readers. Understanding how skilled and less skilled deaf readers read will help teaching practices.

The optimal viewing position effect: New evidence from eye tracking research

PA-75

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The optimal viewing position (OVP) effect describes the fact that word identification performance declines with increasing distance of the initial fixation from the centre of a word (O'Regan, 1981). During reading, first fixation durations show an inverse pattern: First fixation durations are longest near the centre of the word but decrease with increasing distance from the centre. In three experiments, eye movements were recorded during OVP tasks to systematically explore the inverse OVP effect. Implications of results on the interplay of visual-perceptual and cognitive processing components are discussed.

PB-01

Figure-ground segmentation and shape perception as a function of contour alignment and shape familiarity

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Shape familiarity has been found to influence figure-ground segmentation, but the locus of this effect is hard to pinpoint. We developed a method to examine whether shape familiarity facilitates integration of oriented elements, resulting in a bounded figure. Stimuli consist of Gabor patches that belong to the contour of a meaningful figure or to the background. The degree of contour alignment is manipulated and the shapes are presented in a familiar or unfamiliar orientation. To assess global shape perception, participants have to judge whether a target dot is on the centroid of the figure, presented at different locations. We evaluate whether segmentation tolerates more misalignment in case of familiar shapes by examining task performance and eye movements across conditions.

PB-02

Speed discrimination of ocular following response and perception on the open-loop condition

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We use the ocular following response and a 2AFC task to directly compare the perceptual and oculomotor system with respect to their speed discrimination performance. Our results show that on the open-loop condition the oculomotor system has a systematically lower discrimination performance than the perceptual system and that ocular responses and perceptual decisions are not significantly correlated. We conclude that 1) the oculomotor system shows its best performance only after the control loop is closed, and 2) the variability of the ocular response is unlikely to be explained by noise in the sensory system alone. Additionally, we confirm that the Weber-Fechner law is valid for the ocular following response in the speed range tested here.

Transsaccadic perception of abstract parametric shapes

PB-03

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It has repeatedly been found that the representation supporting transsaccadic information transfer is sparse and not visually detailed. However, recently this view has been challenged by a number of publications (e.g., Melcher & Morrone, 2003). In the present study, we presented subjects with a presaccadic and a postsaccadic stimulus in the same spatiotopic position. Both were drawn from the same metrical continuum of abstract shapes, making transsaccadic information transfer reliant on visual detail. Stimulus congruency effects were found using these stimuli. In an adjustment task, subjects adjusted a probe stimulus to match their postsaccadic perception. On the basis of these data, we sketch the relative importance of postsaccadic stimulus visibility, perceptual bias towards the presaccadic stimulus, and visual integration of the two stimuli.

Competition between luminance and color for target selection in smooth pursuit and saccadic eye movements

PB-04

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Several studies have argued in favor of a common target selection process for smooth pursuit and saccadic eye movements. We studied visual processing of color and luminance in both systems. Observers tracked a moving stimulus which split into a luminance-defined and a color-defined component. The stimuli either jumped to new positions, requiring a saccade, or moved into different directions, requiring pursuit. Observers were instructed to choose the more salient stimulus. Results show that initial pursuit followed luminance, whereas saccades went in the direction of color. An early pursuit response towards luminance was often reversed to color by a later saccade. These substantial differences in decision direction show that luminance and color are processed differently for pursuit and saccadic target selection.

PB-05

The temporal integration strategy of the saccadic system

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Temporal integration is a useful method for dealing with noisy sensory data. We studied the integration strategy of the saccadic system in response to a noisy temporal sequence of luminance fluctuations. We systematically varied the position of a short critical window during which two patterns reliably differed in mean luminance. Observers were asked to saccade to the brighter pattern. Across 3 experiments their performance was best for "early" windows, even when 1) such trials occurred much less frequently than "late" windows, and 2) observers were given trial-by-trial feedback on their accuracy. These data suggest that for luminance defined stimuli, the saccadic system is unable to flexibly move the integration window to periods after the initial display onset.

PB-06

Improved color sensitivity during smooth pursuit eye movements

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Contrast sensitivity for peripheral, luminance modulated stimuli is attenuated during smooth pursuit eye movements compared to fixation. To explore if this suppression is specific for the parvocellular system, we measured the sensitivity for color and luminance stimuli during horizontal pursuit and fixation. Contrast sensitivity was measured by means of a blurred 0.3 deg wide horizontal line that appeared for 10 ms 2 deg above or below the pursuit trajectory. The line was defined by an increment or decrement in luminance or in isoluminant red-green color. The subjects had to indicate the state of the line. The results show that contrast sensitivity for luminance stimuli is slightly reduced during pursuit. In contrast, the sensitivity for color stimuli is improved during pursuit.

Effects of equiluminance color and size on perceived velocity of sigma-movement

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Sigma-movement is an illusory motion caused by smooth pursuit eye movements (e.g., Lamontagne, Gosselin & Pivik, 2002. Exp Brain Res., 143, 130-132). We examined the perceived velocity of sigma-movement by using the method of magnitude estimation. Stimuli were checkerboard patterns presented stroboscopically. In Experiment 1, we examined the effect of stimulus size, and found that the perceived velocity increased as the size decreased. In Experiment 2, we examined the effect of luminance and color (equiluminance), and found that the perceived velocity for the color stimulus was almost equal to that for the luminance stimulus. We discussed that retinal information affects velocity perception of the sigma-movement by the eye-head system.

Comparison of mirror stereoscope and shutter glasses for measuring disparity vergence responses

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Vergence eye movement recordings with disparity stimuli require dichoptic stimuli. For this purpose, a stereoscope with mirrors at right angle and two displays can be used. Shutter glasses are more convenient, but have disadvantages as limited repetition rate, residual cross task, and reduced luminance. Therefore, we compared both techniques using disparity step stimuli of 1 and 3 deg.

The correlation between both techniques was about 0.8 for the objectively measured vergence velocity and higher than 0.9 for the subjectively measured response (with dichoptic nonius lines, flashed for 100 ms with 400 ms delay after the disparity step stimulus). Mean differences were negligible relative to the response amplitude. Thus, shutter glasses and mirror stereoscope gave similar measures of disparity vergence.

PB-09 **Differences between objective and subjective measures of the convergence step response**

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Dichoptic nonius lines are used for subjectively (psychophysically) measuring vergence states, but their validity is still questionable. In a mirror-stereoscope, we estimated convergence with nonius lines flashed at fixed delays after the disparity step-stimulus; for comparison, we made objective recordings (Eyelink II). Relative to the objective, the subjective measures revealed a smaller vergence velocity and a larger final vergence response (by about 20 arcmin), but both measures were well correlated. The average offset between subjective and objective measures varied with disparity step-size (30, 60, 120, 180 arcmin). The subjective/ objective ratio of the vergence error (relative to stimulus disparity) correlated interindividually with the final vergence state (r=-0.84). Further, variation of the step-stimulus pattern showed little effect on the subjective-objective offset.

PB-10 **Binocular coordination during scanning of simple dot stimuli**

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We conducted an experiment in which participants' binocular eye movements were recorded as they made a series of saccades and fixations to horizontal rows of visual dot targets. This task was designed to make similar demands on the oculomotor control system as reading, in the absence of cognitive processes associated with language comprehension. Dots were either presented one at a time (no target preview) or all together (target preview). We also manipulated how the dots were grouped within a row, target size and number of saccades made on a trial. Analyses of fixation disparity in relation to fixation durations and saccadic targeting will be carried out. Results will be discussed in relation to recent studies investigating binocular coordination during reading.

Disparity fixation through rapid serial visual presentations

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We have studied the disparity of fixation in observers with clear eye dominance (Porac & Cohen, 1976) executing RSVP (Raymond, Shapiro & Arnell, 1992) tasks. Both eyes were recorded simultaneously using the EyeLinkII system. The task was to identify two numbers -even or odd- in a rapid sequence of letters. The stimuli could be presented at fixation (experiment 1 and 3), or at several positions around fixation, stepping clockwise (experiment 2). In both cases, the dominant eye was always centred in the area in which the stimuli must be presented (fixation point or around).These results indicate that fixation is the primary method by which items are selected, and demonstrate how vision is used to direct action (Findlay & Gilchrist, 2003).

Depth constancy during vergence eye movements

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We tested between two models (retinal vs. nonretinal) of the implementation of depth constancy by exploiting the errors of reaching movements to memorized visual targets, briefly presented at different depths prior to a vergence eye movement. The nonretinal model predicted an error similar to that observed without the intervening vergence shift, whereas the retinal model predicted an error similar to that of a reach to the target viewed from the same final eye position. Results showed reach errors that depended on the new eye position and on the depth of the target relative to that position. This suggests that the brain codes a dynamic retinal disparity representation, rather than a nonretinal distance representation, to implement the constancy of target depth.

PB-13   **Mislocalization in depth during horizontal saccades**

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Positions of perisaccadically flashed stimuli are indistinguishable over a wide area in space (perisaccadic compression). Thus, depth perception, depending on positional disparity of representations of left and right eye, might be affected during saccades. Using a Wheatstone stereoscope, human observers performed a disparity discrimination of a perisaccadically flashed and a continuously present reference bar.

Subjects perceived perisaccdically flashed bars closer than the reference bar, regardless of their relative disparity. Time course of mislocalization in depth was similar to that of perisaccadic compression. Mislocalization in depth occurred at the start and end point of the saccade. Hence, the pattern of mislocalization in depth can not be explained by independent mislocalization of left and right eye representations of the bar.

PB-14   **Initiation of divergent vertical and horizontal eye movements**

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Divergent vertical eye movements are very frequent in every day life. Yet their initiation has not been studied. We used a gap paradigm to elicit vertical or horizontal saccades (10 degrees), pure or combined with a predictable divergence (10 degrees). Eye movements from twelve subjects were recorded with EyeLink 2. The major results were: (i) when combined with divergence, the latency of horizontal saccades increased but not the latency of vertical saccades; (ii) a tight correlation between the latency of saccade and divergence was found for both vertical and horizontal saccades; (iii) when the divergence was anticipated, the saccade was delayed. We conclude that the initiation of both components of combined movements is interdependent.

Fixation disparity and asymmetry in convergent and divergent disparity step responses: Relation between individual differences

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We estimated vergence step responses to 1 deg disparity step stimuli in 16 subjects with dichoptic nonius lines, flashed for 100 ms with various amounts of delay after stimulus-onset (0-1000 ms). Previously, we showed that this subjective method provides similar results as objective recordings.

Fixation disparity, the vergence error during fixation of a static fusion stimulus, was correlated with the asymmetry between convergent and divergent step responses indicated by the difference in final response level (r=0.76, p<0.001) and the difference in vergence velocity (r=0.63, p<0.01). All subjects with exo fixation disparity (i.e. static under-convergence) had weaker responses for convergent than for divergent step stimuli. This relation may have implications for the understanding of fixation disparity.

A unified model of ocular pursuit that simulates predictive and randomised behaviour

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Although widely accepted that efference copy plays a large part in the control of ocular pursuit, models based on this concept cannot simulate responses to predictable stimuli. To simulate prediction it has been suggested that the efference copy system contains a short-term memory capable of holding motion information derived from prior stimuli, subsequently releasing it for generation of predictive responses. Recent experiments further support this concept. One demonstrates that multiple levels of velocity can be stored, allowing prediction of complex waveforms; the other indicates that a single mechanism is probably responsible for both anticipatory pursuit and the extra-retinal component of sustained pursuit. On this basis a unified model has been developed that simulates responses to both randomised and predictable stimuli.

PB-18

STRAVIS 2.0: Visual feature search is effectively modelled by incorporating biases for recurrent item visits and premature search termination

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In visual search, open questions concern how many items are processed simultaneously, whether recurrent visits occur due to incomplete memory or perceptual uncertainty, and when the search is terminated.

Our model StraViS (Strategies of Visual Search; Müller-Plath & Pollmann, 2003) decomposes the response time in overt feature search into the times of hypothetical sub-processes, and yields individual estimates of the attentional "focus size", the "dwell time", and the "movement time". Assuming specific relations between attentional and oculomotor processes, response times as well as oculomotor data were much better accounted for by a revised model STRAVIS 2.0 that additionally allows for recurrent item visits due to perceptual uncertainty, and premature search termination due to an individual speed-accuracy-tradeoff.

PB-19

Robust portable eye tracking for real-time applications on electronic whiteboards

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Large-scale touch screens (aka electronic whiteboards) are well suited for diagram-based reasoning –e.g. with maps, sketches– as diagram parts can be manipulated by hand gestures. Additionally, haptic and eye fixation data from such manipulations can be used for studying mental reasoning and for real-time interpretation of human actions. Mapping of eye position and screen content is tricky for large screens since markers on screen borders will easily fall outside the camera view. We discuss an inventive setup for portable, robust eye tracking during whiteboard interaction and show its application to geometric problem solving. The setup combines in novel ways several video-based position mapping techniques and largely off-the-shelf hardware with real-time data processing constraints.

A theory of the dual pathways for smooth pursuit

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PB-20

Smooth pursuit eye movements are mediated by two parallel cortico-ponto-cerebellar pathways, one originating in the medial superior temporal area via the dorsolateral pontine nuclei to the cerebellar floccular lobe, the other from the frontal eye fields via the nucleus reticularis tegmenti pontis to the cerebellar dorsal vermis. However, the functional role of these pathways that carry different signals is not yet fully understood. Here, we present a nonlinear model of smooth pursuit incorporating the dynamic gain control mechanism (i.e., the feedforward gain is controlled by eye velocity) that accounts for several behavioral results. Using this model, we can show how to map the nonlinear gain control loop onto the anatomical topology of the dual pathways for smooth pursuit.

Different processes are used during reading and search tasks: Evidence from eye movements and Hidden Markov Model

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PB-21

A discriminative hidden Markov model (dHMM) was applied to capture statistical regularities of eye movements and to identify variations in processes. We studied three types of tasks: (i) simple word search, (ii) finding a sentence that answers a question and (iii) choosing a subjectively most interesting title from a list. After training the dHMM it predicted the task type at 60.2% accuracy (pure chance 33.3%). The model that gave best predictions for unseen data segmented each task type into three states (nine states in total). Analysis of the parameters of the dHMM states showed different processing features at the beginning, in the middle and at the end of the tasks, suggesting that processing states vary during task performance.

PB-22

Parafoveal processing of phonological features during visual word recognition

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A parafoveal preview lexical decision experiment investigated whether readers process phonological features (e.g., voicing) parafoveally and use that information during word recognition. Word targets were preceded by nonword previews that either agreed in voicing (e.g., fak-fat and faz-fad) or disagreed (e.g., faz-fat and fak-fad). Unexpectedly, gaze durations differed most for disagreeing sequences: they were shortest for voiced previews preceding voiceless targets and longest for voiceless previews preceding voiced targets. Gaze durations for agreeing conditions were intermediate and comparable to each other. We account for the observed asymmetries by applying underspecification theory to visual word recognition.

PB-23

Investigating unscripted spoken dialogue processing using eye-tracking: Givenness marking in indefinite referring expressions in Danish

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A pilot study of a collaborative task where two participants are simultaneously eye-tracked shows that it is possible to measure fine-grained language-driven differences in attention on linguistic referents in relatively natural dialogue.

Both producers and comprehenders of indefinite referring expressions had earlier peak proportions of fixations on intended referents the more reduced the expression was: earliest for 'One', later for 'an Adj', and latest for 'an Adj N'. This result suggests that givenness plays a role in referential processing within the category of indefinite referring expressions as well as between indefinite and definite noun phrases and definite noun phrases and pronouns, as described in most accounts (e.g. Ariel 1990, Gundel et al. 1993, Lambrecht 1994, Prince 1981).

The effect of expectation on the focusing properties of quantifiers: An on-line test of the Presupposition-Denial account

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Presupposition-Denial Theory states that the focusing properties of quantifiers arise from the difference (or 'shortfall') between the amount conveyed by a natural language quantifier and the expected amount. For example, if 'Few people attended the party', the negative quantifier 'few' indicates that a larger amount is both presupposed, and simultaneously denied, leading to a focus on the shortfall; the set of people that might have attended, but didn't. By explicitly manipulating what is expected, Moxey (2006) found evidence to support the use of this mechanism during language production. In a series of eye-tracking studies, we investigate whether this finding holds for on-line language comprehension. Results suggest that explicitly manipulating what is expected can influence on-line processing of quantifier focus.

Conceptual access during speech production: Evidence from the visual-world eye-movement paradigm

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A key issue in sentence production is how far in advance people plan speech. Using the visual-world paradigm (Cooper, 1974; Tanenhaus et al., 1995), we examined the time-course of conceptual access for words that occurred either in the beginning or the middle of a sentence. Following conceptual access to a word (piano), people look more at conceptually-related (trumpet) than unrelated pictures (Huettig & Altmann, 2005). If conceptual planning occurs incrementally, the timing of looks to a trumpet should depend on where in the sentence piano is produced. However, if conceptual planning is holistic, timing should be unaffected by its position. Our results confirmed the latter account: The timing of the fixation bias for related pictures was unaffected by word position.

PB-26   **Syntactic priming in the comprehension of ditransitive structures**

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Building on findings by Arai et al. (2007), we report two visual-world experiments investigating how syntactic priming affects anticipatory eye movements during the comprehension of ditransitive structures. Experiment 1 addressed the question of whether both DO and PO structures prime, or whether priming is limited to one structure. Our results show that DO and PO structures both prime.

Experiment 2 investigated the role of animacy. Specifically, does priming occur because comprehenders anticipate the animacy of the upcoming noun, or because they anticipate structural properties such as its grammatical or thematic role? Animacy did not modulate priming, so priming of ditransitive structures during comprehension is due to anticipation of structural properties.

PB-27*   **Estimating word's predictability on lexical processing using latent semantic analysis – verification from eye movement data**

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Word's Predictability influences the lexical processing time in both early and late stages of word identification in EZ Reader Model. This study estimates the word's predictability by calculating the semantic similarity between the target word and its precedent information using Latent Semantic Analysis (LSA). Considering frequency effect in content words from eye movement data of 16 expository texts from twelve college students, the higher semantic similarity shows less first fixation duration, gaze duration, and total time ($F = 13.818, 30.762,$ and 37.679 respectively). The result suggests that LSA could estimate word's predictability and reflect eye movement measures more on late stages (phonological / semantic form) of word identification than on early stages (orthographic form).

Parafoveal processing in reading: Manipulating N+1 and N+2 previews simultaneously

PB-28

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Recent findings on the effects of manipulating the preview of the second word to the right of fixation (N+2) have so far been inconclusive with respect to whether there were parafoveal-on-fovea effects (Kliegl et al., in press, Rayner et al., 2007).

To further examine this issue, we used a new experimental manipulation based on the boundary paradigm to mask either word N+1, N+2 or both words N+1 and N+2 before participants crossed the boundary. Words N, N+1 and N+2 were all content words, and word N+1 was either a high or a low frequency word. We will examine the results in the context of serial and parallel accounts of saccade generation during reading.

Targeting regressions: Do people pay attention to the left?

PB-29

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Readers sometimes regress when encountering material that is difficult to integrate. The current study examined two questions: First, is letter and word information to the left of fixation used to program regressions; second, how accurately do readers land on the regression target. Sentences were presented so that, as readers moved left to right, the text behind them switched to nonwords (and back to words after a regression). Critical sentences contained either a garden-path or an implausible pronoun-antecedent relation. We found that readers consistently landed 1-3 words short of the intended regression target. Regression saccade length increased with distance between regression trigger and target. Masking had little effect, indicating that word information from the left is not used for programming regressions.

PB-30 **Do visual signals extend the perceptual span in reading below or above the fixated line? A gaze-contingent eye movement study**

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This study investigated whether useful information can be obtained above or below the fixated line when a multiple-topic expository text containing visual signals is processed. Participants read texts with visual signals in either a normal or a window condition, where the text disappeared above, below, or both above and below a gaze-contingent region. The mental representation of the hierarchical topic structure of the texts was assessed by a card-sorting task after the reading. The fixation times and the card-sorting task results suggest that some kind of information can be obtained above and below the fixated line when multiple-topic expository texts with visual signals are processed. The potential implications for the perceptual span in reading are discussed.

PB-31 **Effects of syntactical context on eye movements while reading continuous text**

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Eye movements in reading are known to be guided by various attributes of the currently fixated as well as the surrounding words. The present study deals with the question to what extent reading of syntactically varied prose passages might influence reading behavior on an identical following target sentence across sentence and line borders. For this purpose, passages of continuous text were designed in active vs. passive voice and as embedded vs. non-embedded sentence structures. These passages were followed by identical target sentences. Eye movements on the target sentences revealed carry-over effects with respect to temporal and spatial parameters. The results will be discussed in relation to previous research on syntactic priming effects.

Reading disappearing text: Adults' and children's oculomotor control

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PB-32

We monitored readers' eye movements as they read sentences that literally disappeared as they read. Adults, 10- to 11-year old children, and 7- to 9-year old children read two sets of sentences - one which was normally presented, and one in which each word disappeared 60 ms after fixation onset. We replicated Rayner et al.'s (2003) finding that adults can read normally under disappearing text conditions. However, both groups of children showed different oculomotor behaviour when reading disappearing text compared to normal text. There were also differences between both groups of children's oculomotor behaviour, as well as between the children and the adults. These data indicate a different relation between foveal and parafoveal processing in children of different ages and adults.

The optimal viewing position in Chinese word recognition

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PB-33

The present study investigated the viewing position effect and its determinants for Chinese word recognition. In a lexical decision task, we manipulated the initial fixation position of Chinese two-character words. There were seven possible fixation positions relative to word center and the eye position was monitored by an eye tracker. The results showed that response latencies increased when words presented away from fixation location. Moreover, the best performance of response was at the first half of the end characters, where is at the location to the right of the center of words. The further analysis of the information distribution of words suggests word ambiguity at different character positions affects the shift of the optimal viewing position.

PB-34

The accuracy and function of regressions during reading

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Readers often make regressions during reading but the accuracy and function of these regressions is unclear. Four experiments were conducted in which regressions were triggered either explicitly by telling readers which word to go to; or implicitly by having people perform a regression-inducing task. Results show that accurate spatial memory is available but not always used to guide regressions. Moreover, incidental regressions were clearly directed towards the target but often missed it and no consecutive efforts were made to reach it. It is proposed that regressions often do not occur because the reader intends to refixate a particular word but because retrieval of a word reactivates the spatial coordinates that are stored with it, thereby triggering a regression.

PB-35

Meeting a virtual anthropomorphic character: Effects of characters' emotional expression on eye movements and facial EMG of human observers

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We modified Schilbach et al.'s (2005) paradigm in order to investigate the physiological reactions to, and subjective experience of, virtual characters. Subjects watched animated male and female agents, which varied in terms of gaze direction (direct, averted) and facial expression (anger, neutral, happiness). After each clip subjects indicated the characters' gaze direction and ranked their own emotional experience on the Self-Assessment Manikin (Lang, 1980). Eye movements and EMG measures (corrugator and zygomatic sites) were recorded. The valence of the characters' emotional expression was more strongly reflected in both the SAM-rankings and EMG measures associated with direct gaze, probably indicating a basic form of theory of mind. Analysis also revealed an immediate effect of all manipulated variables on eye movement behaviour.

Parafoveal-on-foveal effects in Chinese reading: An eye-movements study

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The class of sequential attention shift (SAS) models assumes that one word is recognized at a time. Lexical properties of a to-be-identified word thus cannot influence ongoing word identification. Models of guidance by attentional gradient (GAG) maintain, by contrast, that two or more words can be processed in parallel. The present study examined the influence of lexical properties (frequency) of a parafoveally visible post-target word on the processing of a fixated target (parafoveal-on-foveal effects) when two words were not visuo-spatially distinct. The result revealed longer single fixation durations on the target with the low frequency post-target word. This finding is difficult to reconcile with the SAS assumption; however, consistent with the assumption that the lexical processing of consecutive words can overlap in time.

Serial or parallel? Using depth of processing to examine attention allocation during reading

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Models of eye-movement control make different assumptions about attention allocation during reading: Whereas serial-attention models posit that only one word is processed at a time, attention-gradient models posit that several words are processed simultaneously. These assumptions were tested in two experiments in which participants viewed 1-4 words and performed one of four "lexical" tasks: asterisk detection, letter detection, rhyme judgments, or semantic judgments. The number of fixations and reaction times increased with both the number of displayed words and with task "depth", with an over-additive interaction suggesting additional cost for processing multiple words, especially with the "deeper" tasks (e.g., semantic judgments). The implications of these results for models of eye-movement control will be discussed.

PB-38   **Crossed disparities are preferred over uncrossed disparities:**
             Evidence from binocular lexical decision in a stereoscope

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Both crossed and uncrossed fixation disparities occur in binocular reading; their relative proportions vary. We report an experiment in which participants responded to an isolated lexical decision task presented in a stereoscope, such that complementary four-letter parts of five-letter stimuli were presented to different eyes, causing the perception of a single five-letter word or nonword. In three conditions, the presentation mimicked crossed, uncrossed and conjoint binocular fixations, with respect to the initial fixation point on each trial. Lexical decision times were significantly greater in the uncrossed condition compared with the other two conditions. Accuracy data followed suit. We discuss these data in the light of converging evidence on the role of crossed and uncrossed fixation disparities in related literatures.

PB-39   **Visual search of emotional faces: Eye-movement assessment of**
             component processes

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In a visual search task using photographs of real faces, a target emotional expression was presented in an array of six context neutral expressions, or all facial expressions were identical. Eye movements were monitored to assess attentional orienting and processing efficiency. Target faces with happy, surprised, or disgusted expressions were (a) responded to more quickly and accurately, (b) localized and fixated earlier, and (c) detected as different faster and with fewer fixations, in comparison with fearful, angry, and sad target faces. This implies that there was a happy, surprised, and disgusted face advantage in visual search, and that this involved both earlier attentional orienting and more efficient processing of expression. The advantage remained equivalent across parafoveal and peripheral presentation conditions.

Are eye movement parameters dependent on induced mood? PB-40

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Individuals in a happy mood tend to have a more global distribution of attention than people in a sad mood, whose processing is characterised by greater attention to local features. We tested this "Level of Focus Hypothesis" (Gasper & Clore, 2002) in an eye tracking experiment. Subjects had to inspect photographs of landscapes in a free viewing picture task before and after induction of happy vs. sad mood. While both types of mood induction significantly influenced mood, no effect of mood on subsequent eye movement behavior was found (see however Pannasch, Helmert & Velichkovsky, 2006). Results are discussed with respect to the material used in the study and the specific combination of eye movement parameters used to analyse the data.

Eye movements in emotions: The influence of basic emotions on eye movement patterns PB-41

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The aim of the present study was to investigate the influence of emotional picture content on eye movement patterns. The underlying question was whether the known pattern of increasing fixation durations could also be observed in emotional pictures. Furthermore, we were interested whether those patterns could differentiate between various basic emotions.

Eye tracking of 20 subjects was measured while viewing a set of 80 IAPS pictures in different emotional categories, i.e. fear, disgust, amusement and neutral. We found that eye movement patterns in emotional conditions clearly differ from those during neutral condition. We also observed pattern differences between amusement, fear, and disgust. Especially fear elicited a unique eye movement pattern, which exerted the opposite of that in neutral condition.

PB-42   **Regarding pictures: The task of music. A study of the impact of music on visual attention in viewing still images**

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The study forms part of an investigation of the cognitive processing of film information. A previous study on verbal tasks and film viewing has shown that visual attention is influenced by a combination of task specificity and ways in which film information is presented.

Film music is a bearer of emotional content and may impact cognitive processing in ways similar to priming by verbal tasks. Prior to considering film music we should examine the influence of music on visual attention in the viewing of still images. This study emulates Yarbus' work on task impact by having subjects view "The Unexpected Visitor" in silence, or accompanied by music in different emotional modes, and comparing the resulting eye movement patterns.

PB-43   **Autonomic responses and eye movement patterns when looking at family members, friends, strangers and objects**

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Autonomic responses (skin conductance response, SCR) and eye movements (EM) are involved in face perception; the first considered an index of subcortical processing, the second commonly used as an index of cognitive processing. Recent studies have highlighted the importance of subcortical modulation on cortical functions in face perception.

Sixteen healthy participants were tested while observing eight photographs of familiar faces (four family members and four friends), eight photographs of unfamiliar faces matched for physical likeness and eight filler photographs of neutral objects. EM parameters and SCRs were collected. Relationship between SCR levels and time spent fixating the eye region and differences in EMP between familiar and unfamiliar faces are discussed considering the reciprocal interactions between central and autonomic face processing.

Differences in gaze behavior and task performance in patients with homonymous visual field defects (HVFDs)

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The visual impairments of HVFD patients should result in a reduction of the information input. To overcome this limitation, patients may develop functional compensations by adaptation of gaze (head and eye) movements.

In this study we investigated these different compensatory gaze strategies and the resulting task performance of HVFD patients and normal subjects in two different cognitively demanding experiments. We used the cognitively simple dot counting paradigm as visual sampling task and a more demanding visual comparative search paradigm. Based on task performance and gaze parameters we identified two groups of patients. The 'adequate' group was identified as close to normal and the 'insufficient' one showed significantly poorer performance and suboptimal gaze strategies.

Predictive saccades are impaired in biological non psychotic siblings of patients with schizophrenia

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PB-45

Schizophrenic patients show impaired predictive saccades (PS). Yet, this has never been explored in their biological relatives. We compared PS performance of 30 healthy siblings of schizophrenic patients, 30 patients, and 30 healthy matched controls analyzing non-anticipated and anticipated saccades separately. Primary and final eye position were hypometric in patients and siblings compared to controls while the proportion of anticipated saccades was not different between the three groups. Only patients showed decreased maximum velocity. Similar alterations in the PS task for patients and siblings, albeit tending to be at a lesser degree, support PS as a endophenotypic marker for schizophrenia. Further research is necessary to understand the physiopathological value of those disturbances and their link to a visuo-spatial representation deficit.

PB-46

Interaction between eye and hand movements in patients with intention tremor due to MS

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Both intention tremor and eye movement deficits such as saccadic dysmetria and unsteady fixation occur in Multiple Sclerosis. They often co-exist and relate to dysfunctions of the cerebellum or brain stem.

A study with 16 patients showed a preserved temporal and spatial coupling during visually guided wrist step-tracking despite abnormalities in both motor systems. Differences between coordinated and isolated tracking suggested that a one-way influence of the ocular system on the hand movements with the enlarged initial saccade contributing to hand target overshoot and reduced hand tremor amplitude in conditions without preceding saccadic movement. The latter seemed related to the visual feedback provided by (un)steady target fixation, as revealed in a second experiment.

PB-47*

Length perception in hemispatial neglect: Having a Look at the Brentano illusion

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In the Brentano version of the Müller-Lyer (ML) Illusion, one half of the line looks longer than the other. Recently, it has been shown that different versions of the ML-Illusion do not only affect manual bisection performance, but also eye movements. Patients suffering from visuo-spatial neglect after brain injuries show systematic spatial asymmetries in eye movements as well as in bisection of simple lines.

The present study was aimed at investigating illusion effects in neglect patients by comparing the relationship between eye movements and manual bisection performance in different versions of the Brentano Illusion. Results suggest that illusion effects in both oculomotor and manual behaviour are modulated (e.g. left-right asymmetries, position effects) by hemispatial neglect.

The role of the basal ganglia in eye-movements control - a study on oculomotor disorders in patients with Wilson's disease

PB-48

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Damage to prefrontal cortex causes disorders of planned, goal-directed behavior. In the presented study saccadic and smooth-pursuit eye movements of 31 neurologically impaired patients with Wilson's disease (with basal ganglia degeneration), 21 asymptomatic and 30 healthy controls were compared. Analysis revealed significant increase (over 2 times) in mean error rate and mean latency of antisaccades (while there were no differences in prosaccades) in the neurological group. This group also showed lower pursuit gain and higher mean amplitude of saccadic intrusions.

We conclude that disturbed suppression of unwanted, reflexive saccades as well as impaired initiation of voluntary saccades are common features of brain pathology in Wilson's disease. The most likely reason is dysfunction of fronto-striatal circuits which modulate human voluntary actions.

Characteristric eye movement and cognitive visual field in Alzheimer disease during visuospatial working memory task

PB-49

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In Alzheimer's disease (AD), we studied how to get visual information and use it for doing performance by recoding EMV with EMR-8(NAC Inc.). The subjects were four AD patients (MMSE score more than 21) and four age-matched controls. They performed the touch-panel computer task, which was to touch the cell (3-6 divided) in the same order as it appeared on the screen. In the correct performance to the tasks which were the cell moving neighbor position, the EMV of AD was the same as the control. However, in the error performance, the EMV of AD could not almost catch the next cell which moved randomly. In AD, their cognitive visual field seemed to be smaller than the control.

PB-50   **An increased virtual foveal hemianopic field defect reduces the**
scanpath similarity of visual imagery and perception

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We report findings about scanpath eye movements (EM) during visual imagery in naïve subjects that were exposed to a simulated "virtual hemianopia" (VH) and subjects with an increased virtual hemianopic field (iVH) defect including the foveal region. Using string editing methods we compared the scanpaths and found significantly lower string similarity between viewing and imagery scanpath in subjects with iVH.

Several studies have shown that EM play an important functional role in visual imagery. The foveal region is mainly involved in fixations of interesting subfeatures of a visualised scene. We hypothesized therefore that foveal masking will impair visual mental imagery significantly - just like other top-down processes.

PB-51   **Paragraphed text reading with a central scotoma: The transient**
disengagement eye movement pattern

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Reading in subjects with central scotomas is associated with various eye movements including fixation instability, pseudo-line losses and pseudo-regressions. Here we report here a new pattern of these eye movements. We investigated five patients suffering from age-related macular degeneration. Four exhibited a particular recurring eye movement pattern while reading paragraphed texts. This consisted of a succession of back and forth saccades shifting the scrutinized image to a much more eccentrically located retinal area, then bringing it back. We named this strategy the "transient disengagement eye movement pattern". The orientation and the amplitude of the movement was highly consistent in each patient. Transient projection on very eccentric retinal areas characterised by higher spatio-temporal capacities might improve perception of the text.

How well do the new combined anti-tobacco warnings capture visual attention? An eye tracking study to analyse the impact level of the image

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Recent European directives against tobacco suggest that new combined health warnings (image and text) be inserted in tobacco products. The main objective of this research was to analyse the impact of the image and its influence to capture and hold visual attention. Two variations of the same tobacco advertisement were designed: one of them with a high-impact image and another with a low-impact image.

The number of participants who noticed the warning, the time to first fixation within the warning, and the time spent looking at the warning were recorded. In addition, recall and recognition measures were also analysed. Overall results showed that warnings with a high-impact image were more effective in holding attention than those with a low-impact image.

Influence of product arrangement on consumer behavior

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The purpose of this study was to investigate how product arrangement influences consumers when buying bottled beverages. Two types of arrangements were compared: equal shelf space (two bottles per product) and unequal shelf space (two, four, or five bottles per products). Eye movements of subjects were recorded. From a distance, subjects looked more frequently at products that occupied a larger space on the shelf. This tendency was especially strong during unplanned purchases, but was not observed when subjects were in front of the shelf. The results indicate that unequal product arrangement can attract consumers to certain products.

PB-57

Influence of color and position on conspicuity of point-of-purchase advertising

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This study investigated the influence of color and position on the conspicuity of point-of-purchase advertisements (POPs). Subjects were shown four POPs with the catchphrase "new" at the top, bottom, right, and left of a screen. Each POP was of a different color (yellow, black, green, and purple), whose position changed from trial to trial. Eye tracking data showed that subjects tended to look at POPs in yellow and black first and for a longer time, and that the POP at the bottom of the screen was looked at less frequently. These results suggest that yellow or black POPs located in the upper half of the visual field can better attract the attention of consumers.

PB-58

Driving and advertisements: A simulator study with eye movements recorded

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Eye fixations were recorded in a simulator to investigate whether road-side advertisements affect driving performance and to what extent ads were remembered. The independent variable was the number of ads along the road. The dependent variables were driving time, lateral position of the car, eye fixations on different parts of the display, free recall, and the recognition of advertisements. The presence and number of ads had no effect on lateral deviation and driving speed. Free recall and recognition of advertisements were strongly associated with previous fixations on the ads. Drivers were able to stay within their lane and to perceive and remember the ads based on foveal and parafoveal vision, but other extrafoveal distractions from the surrounding impaired their driving.

Which element on a cosmetic advertisement attracts consumers' interests?

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This study used eye tracking and subjective evaluation to examine the effect of cosmetics advertisements. Subjects looked at advertisements containing five elements: (1) pictures of models, (2) catchphrases, (3) feature descriptions, (4) a picture of packaging, and (5) names of brands and products. Eye tracking data showed that subjects tended to look at models first. In addition, they paid more attention to the feature descriptions of products that they had the most interest in buying. It was also found that subjects' ranking of attractiveness of model photos correlated with their attraction to whole advertisements. It is concluded that photos of models are the most important elements in advertisements, and they strongly influence the image of products.

Effect of point-of-purchase advertising with rankings on consumer behavior

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The purpose of this study was to clarify how point-of-purchase advertisements (POPs) attract a subject's attention. Two types of POPs were compared: sales rankings (from 1st to 5th) and phrases ("new item", "seasonal", "recommendation", "leader" or "hot item"). Eye movement data revealed that subjects looked more frequently at POPs with rankings than with phrases. Eye movements from one ranking POP to another were frequently observed, sometimes in order of rank. Moreover, fixations on a POP elicited subsequent fixations on products carrying the POP. These responses were clearly observed for unplanned purchases. The results indicate that POPs attract consumers' attention to additional item types and to particular brands, and POPs with rankings can guide consumers.

PB-61

The challenge of extracting "golden" scan paths

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When analyzing web interfaces with eye tracking equipment it can be beneficial to be able to aggregate scan paths from several test subjects into a simplified mean scan path. Using n-gram analysis I will demonstrate how such "golden" scan paths could be extracted, and discuss pro and cons of this method. Furthermore I will suggest how gestalt laws can be applied to the process of defining Areas Of Interest ahead of such a scan path analysis.

PB-62

Can verbs make us look up or down?

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Recent research shows that there is a link between language and eye-movements. In the current study, we investigated if reading motion verbs influences the direction of eye movements for real-life stimuli. Subjects were presented with action verbs like "climb" and "fall" in order to see if the arbitrary direction of the action could influence the direction of the next saccade. The stimuli used were print ads, presented on a computer screen. Each ad consisted of two images positioned vertically and the target action verb between them. Analyses showed that subjects moved their gaze upwards significantly more often after viewing an "up" action verb than after reading a "down" action verb.

pEYEdit: Gaze-based text entry via pie menus

PB-63

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Text entry is one of the central functionalities computers offer. In order to enable motor-handicapped users to communicate with others, one can provide them with gaze-based systems. Several suggestions in this domain require to control a virtual keyboard presented on a monitor, a rather long-lasting and uncomfortable procedure. We developed a text entry based on marking or pie menus, these are circled menus which have been shown to work well in various environments. A user study with novice users comparing text entry performance using pEYEdit with performance with a virtual keyboard and with Dasher revealed several advantages of pEYEdit relative to Dasher. Surprisingly, in novice users, the virtual keyboard produced the best performance. Improvements for gaze-based text entry are discussed.

The dynamics of saccadic responses as Mental Workload [MW] index in microworld simulation

PB-64

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In the present research, saccadic velocity and amplitude' peak of saccadic velocity were been analyzed to verify their sensibilities and diagnostic abilities, to measure variation of MW during a simulation with FireChief® microworld. A multidimensional methodology was applied, comparing behaviour, subjective and physiological data. As theoretical framework of reference was used the Wickens's multiple resource model. A video-based eye tracking system integrated with an infra-red system was used to sample eye movements.

The analysis carried out on 40 psychologist students (sex-balanced) showed the high sensitivity of the investigated indices during the execution of visual-dynamic complex task and the great potential diagnostic capacity in the filed of applied ergonomics. A training effect could be reflecting on the results, too.

PB-65

Multimodal comprehension of language and graphics: Graphs with and without verbal annotation

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Understanding the nature of the interplay between graphics and text in multimodal documents has crucial importance to understanding how perceptual and cognitive processes take place during reading of such materials as well as the role of graphics as communicative tool. Nevertheless, compared to research on eye movement control in reading, there are few studies investigating eye movement characteristics in multimodal documents.

Our purpose in this study is, based on previous theoretical work, to investigate the role of annotations in multimodal documents, specifically documents including text and statistical graphics by the analysis of eye movement characteristics. Results of our experimental study show that presence of annotations on graphs change eye movement patterns, number of fixations and gaze times significantly.

PB-66

Analysis of realistic speech and gaze interactions inside a VR environment: Can gaze help disambiguate deictics in speech commands?

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Speech and gaze are two of the most natural input modalities for HCI systems. But, research on multimodal speech and gaze based interaction is still in its early stages, especially when used in immersive virtual environments (VE). Our research focuses on the role of gaze as a pointing modality for disambiguating reference phrases and deictics in speech commands during interaction with virtual objects and scenes.

We collected a corpus of realistic multimodal interactions with a complex 3D VE using the "Wizard of Oz" technique. Participants performed several tasks involving manipulation of virtual objects using successively spontaneous or controlled gaze and speech multimodal commands. The subsequent analysis of gaze patterns and speech utterances shows promising possibilities for improving deictic recognition accuracy.

Real-world scene perception: About the influence of priming and expertise

PB-67

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We tested the hypothesis that scanpath patterns depend heavily on person's previous knowledge and expertise. Eye movements were collected from three groups of partipiciants who viewed photographs of real-world scenes during an active search task. Experts (Police Officers) and partipiciants who received preparatory object priming were faster and needed fewer fixations to detect dangerous objects in case- and security-relevant scenarios than naive controls. Moreover, postidentificatory processes were significant shorter only for experts compared to controls. We conclude that cognitive factors in the course of information processing account for typical patterns of eye movement parameters during active search. The results recommend the application of eye tracking technologies as a diagnostic tool in acquisition, training and evaluation of occupational skills.

Eye movements made during diagnosis from fundud photographs

PB-68

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A set of 12 test photographs were presented to 9 ophthalmologists with various levels of training in the interpretation of fundus photographs. The subjects were asked to identify the diagnostic features in the photographs. The eye movements of the subjects were recorded during their inspection of the photographs. In some cases an incorrect diagnosis was made because a diagnostic feature was not recognised, and in other cases the correct diagnosis was not made because the significance of the identified features was not understood. We conclude that measurement of eye movement scanpaths can be used to distinguish between cases where appropriate training will involve identifying features of the image and cases where training in interpretation of features is required

PB-69

Multiple communication modalities and visual alignment in dynamic joint action

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Task performance and the coordination of visual attention of two individuals engaged in joint action were investigated using the Joint Construction Task experimental paradigm. Using interconnected EyeLink IIs, 32 dyads were eye-tracked whilst cooperatively constructing tangrams in a shared virtual environment. Indications of each partner's intentions were manipulated by factorially varying three communication modalities: interlocutor gaze position, interlocutor mouse position and spoken dialogue. Each possible communication channel was exploited successfully when made available. However, the combination of different modalities did not improve performance in a simple additive fashion. Using cross-recurrence analysis, the temporal alignment of participants' gaze during the task was examined. Interestingly, while any non-verbal modality significantly improved gaze alignment over no-modality conditions, speech appears to reduce visual coordination.

PB-70

Video replay of eyetracking as a cue in retrospective protocol . . . Don't Make Me Think Aloud!

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Post Experience Eyetracking Protocol (PEEP) is presented as a new method for usability user testing that improves upon deficiencies with the popular 'think aloud' method. PEEP is a retrospective verbalisation technique that uses identification of signature gaze patterns to probe prior naturalistic behaviour. Think aloud methods change behaviour by forcing the user to introspect and verbalise during task completion. We show how natural gaze behaviour differs from well published claims of a "golden triangle" (Eyetools) or "F-shape" (Jakob Nielsen) measured using inappropriate methods, and how independent validation of our technique by researchers at Lancaster University has shown that PEEP identifies significantly more usability problems, elicits a significant increase in task-success rates and is significantly preferred by participants.

Influence of distractor size and contrast on the remote distractor effect

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It is well known that a distractor stimulus presented at the same time as the saccade target prolongs saccadic latency (remote distractor effect). We examined the influence of distractor size and contrast on the remote distractor effect. Gabor patches were used as targets and distractors. Subjects were asked to execute a saccade to a target presented either to the left or right of a central fixation stimulus. Distractors were presented foveally after offset of the fixation stimulus. The results show a significant influence of distractor contrast: The remote distractor effect increased with increasing distractor contrast. No effect of distractor size and no interaction were found. We suggest that high-contrast stimuli are more potent saccade targets as well as remote distractors.

Hemifield effects on the read-out of the visual analog

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The existence of visually detailed informational persistence (visual analog) has been documented both within fixations and across saccades (e.g. De Graef & Verfaillie (2002). Progress in Brain Research, 140, 181-196). Because of the short-lived nature of the visual analog, the amount of information that can be read out from it is constrained by the time needed to focus attention on a specific location. Combined with recent evidence for independent attentional resources in left and right hemifields, this entails the possibility of hemifield effects in the read-out process. Using a spatial location change detection task where attention was directed in the interstimulus interval by cueing locations either within a hemifield or across hemifields, we assessed the presence of such hemifield effects.

PB-73

Developmental progression in children's allocation of attention

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In this study, we investigated children's ability to control their attention following specific learning instructions. Children were presented with several slides, each consisting of two pictures and were told do attend only to the pictures in a frame of one of the two colours. Motivation to allocate attention to the relevant information was manipulated by introducing a reward and a penalization condition. Visual attention was measured by an eye tracking system. Results indicate developmental progression in the ability to pay attention to the relevant information. Additionally, the manipulation of motivation resulted in better attentional control for the targeted information. Especially younger children were able to increase their performance. The results are discussed in terms of theoretical and practical implications.

PB-74

Presaccadic allocation of attention to translating vs stationary objects as a determinant of transsaccadic target position change detection

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Integration of object position across saccades is enhanced for translating objects compared to stationary objects (Gysen, De Graef & Verfaillie (2002). Vision Research, 42, 379-391). One determinant of this phenomenon may be the duration and focus of presaccadic allocation of attention to moving versus stationary objects.

To investigate this, we examined saccade latencies in a transsaccadic change detection paradigm where an auditory cue served as a saccade release signal. Saccade latencies were shorter towards moving versus stationary target. Furthermore, they were slowed down by the presence of a background.

Differences between languages yield different attention distributions: The case of manner

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We know from previous studies that languages differ in the degree they use a semantic manner component to describe a motion event. However, if this is the case, then this would also result in listeners receiving different concentrations of this manner component. Simply put, the language of the speaker influences what information is shared with the listener.

The present study, which is currently being analyzed, examines the temporal unfolding of the manner processing from a listeners point of view. The question whether the langugage used influences the visual attention of the listener will be discussed.

Positive EEG-potentials during eye fixation reflect attention and saccades preparation in man

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Positive EEG-potentials (IP - intermediate positivity and AP - advanced positivity) have been allocated during eye fixation in paradigms Gap and Step. IP arose at transition of early component of CNV in late and potential AP arose directly before saccadic visual target onset. They have been more strongly expressed at backword averaging from the saccade beginning, at short-latency saccades and at "express-makers" subjects. They were localized in frontal and sagittal areas. IP prevailed in the left hemisphere and AP in controlateral to a saccadic direction hemisphere. We assume, that IP reflects motor attention, anticipation and decision-making. AP can reflect the latent orientation of attention and the processes of decision-making.

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