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Maps

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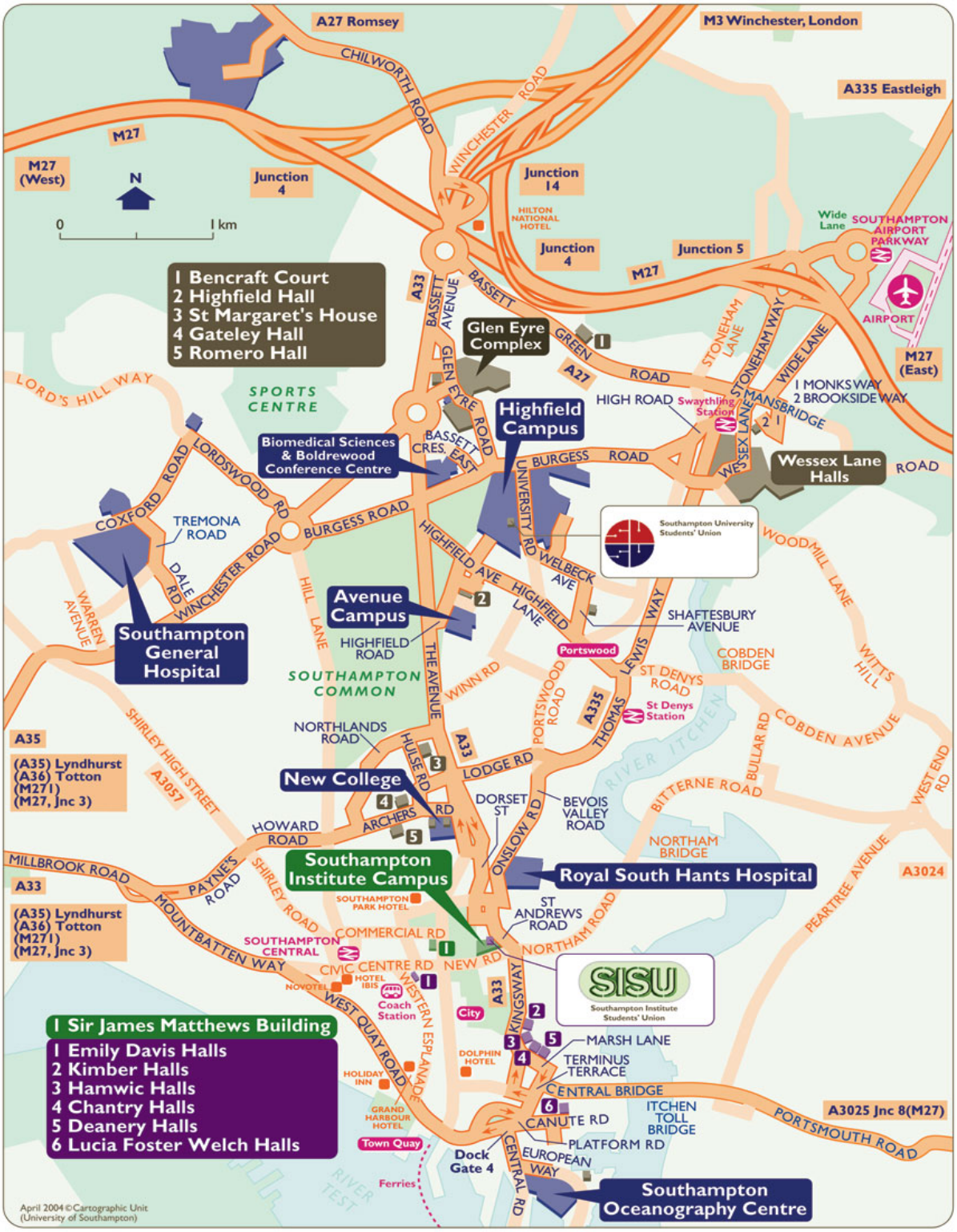
Southampton Area



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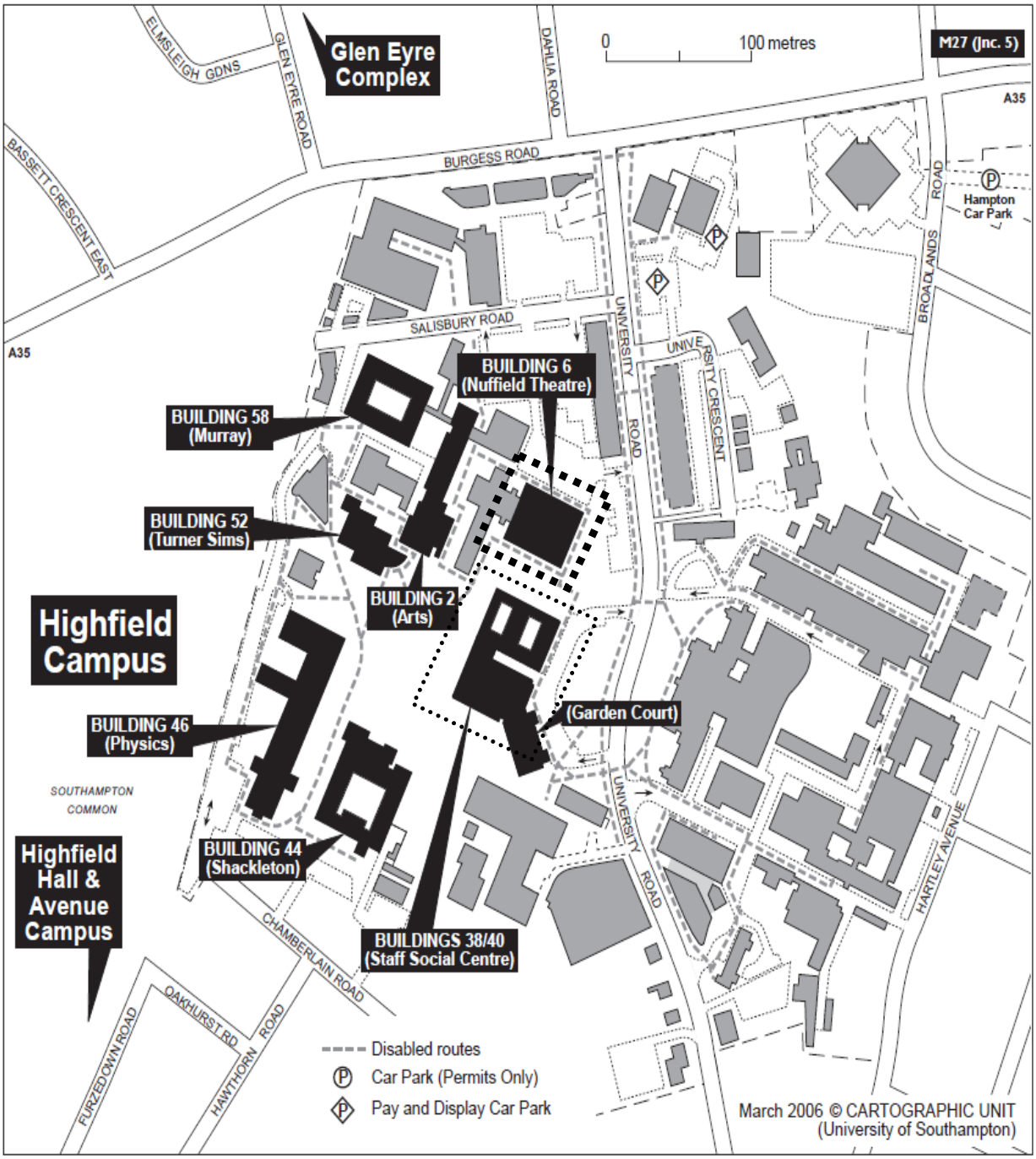
Southampton University Campus



▪▪▪▪▪▪▪ The talks will take place in the Nuffield Theatre and associated lecture theatres.

····· The posters and exhibits will be situated in the Garden Court.

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Information for Conference Delegates

Welcome to the 15th European Conference on Eye Movements. The conference will begin with an address by the Mayor of Southampton, followed by a brief welcome from Professor Rudolf Groner. This will then be followed by a packed scientific program of almost 350 presentations. We hope you enjoy both the academic and intellectual aspects of the conference, as well as the social events that we have organised.

Organisers

Simon Liversedge

Sheena Au Yeung

Valerie Benson

Hazel Blythe

Denis Drieghe

Julie Kirkby

Louise-Ann Leyland

Kathryn Smith

Website Support

David Davies

Richard Dudley

Website Design

Matthew Vitiello

Abstract Reviewers

Valerie Benson

Hazel Blythe

Monica Castelhano

Trevor Crawford

Denis Drieghe

Stefan Everling

Alastair Gale

Wolfgang Jaschinski

Reinhold Kliegl

Simon Liversedge

Susana Martinez-Conde

Kevin Paterson

Keith Rayner

Benjamin Tatler

Françoise Vitu-Thibault

Robin Walker

Sarah White

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Keynote Speakers

Robert H. Wurtz

Laboratory of Sensorimotor Research, National Eye Institute, NIH

"Keeping track of saccades: Brain circuits for corollary discharge"

Mary M. Hayhoe

Center for Perceptual Systems, University of Texas Austin

"Adaptive gaze control in the natural world"

Eyal Reingold

Department of Psychology, University of Toronto

"Using eye movements to determine the time course of mental processes"

Reinhold Kliegl

Department of Psychology, University of Potsdam

"Distributed processing during reading fixations"

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Conference Schedule

Monday 24th August 2009

8.30-9.00	**OPENING ADDRESS GIVEN BY THE MAYOR OF SOUTHAMPTON** **Theatre Auditorium**			
9.00-10.00	**INVITED TALK by Robert H. Wurtz** **Theatre Auditorium**			
10.00-10.20	BREAK			
Room	**Theatre Auditorium**	**Lecture Theatre H (Room 2065)**	**Lecture Theatre J (Room 2077)**	**Nuffield Lecture Room A**
10.20-12.00	**Imaging of the saccadic system** Chairs: Iain Gilchrist and Robin Walker	**Language processing during reading** Chair: Barbara Juhasz	**Scene perception 1** Chair: Ralf Engbert	**Attention** Chair: Jan Theeuwes
10.20-10.40	Everling et al.	White et al.	Smith & Henderson	Belopolsky & Theeuwes
10.40-11.00	Gilchrist et al.	Juhasz et al.	Follet et al.	Kerzel & Souto
11.00-11.20	Sumner et al.	Warren & Morris	Nuthmann et al.	Oksama & Hyönä
11.20-11.40	Hodgson	Scougal & Murray	Lintu & Carbonell	Lange et al.
11.40-12.00	Walker et al.	von der Malsburg & Vasishth	Mergenthaler & Engbert	Mathôt & Theeuwes
12.00-14.00	LUNCH **POSTER SESSION (A) Garden Court**			

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Room	Theatre Auditorium	Lecture Theatre H (Room 2065)	Lecture Theatre J (Room 2077)	Nuffield Lecture Room A
14.00-16.00	**Parafovealprocessing during reading** Chair: Denis Drieghe	**Eye movements & concurrent electrophysiological measurement (ERPs, EEGs)** Chair: Thierry Baccino	**Eye movements in special populations** Chair: Paul Bays	**Applications 1** Chair: Eva Siegenthaler
14.00-14.20	Drieghe et al.	Dambacher et al.	Adam et al.	Voβkühler et al.
14.20-14-40	Masserang et al.	Dimigen et al.	Krejtz et al.	Kenny
14.40-15.00	Risse & Kliegl	Simola et al.	Landgraf et al.	Kotani et al.
15.00-15.20	Angele & Rayner	Hawelka et al.	Kaltenbacher & Hummer	Droege & Paulus
15.20-15.40	Miellet, O'Donnell et al.	Graupner et al.	Bays et al.	Holmes & Zanker
15.40-16.00	Wotschack & Kliegl	Baccino	Van der Stigchel et al.	Pasupa et al.
16.00-16.20	BREAK			
16.20-18.00	**Neurophysiology & eye movements 1** Chair: Stefan Everling	**Reading in Chinese and Thai: A challenge to current models** Chair: Ronan Reilly	**Eye movements in Autism** Chair: Valerie Benson	**Binocular eye movements** Chair: John Semmlow
16.20-16.40	Shen & Paré	Yang et al.	Benson et al.	Kitamura et al.
16.40-17.00	Ford & Everling	Reilly et al.	Stagg et al.	Semmlow et al.
17.20-17.40	Ikeda et al.	Yan, Kliegl et al.	Norbury et al.	Yang & Kapoula
17.40-18.00	Goonetilleke et al.	Yan, Shen et al.	Kuhn & Leekam	Horii et al.
18.00-20.00	**POSTER SESSION (B) Garden Court** (CHEESE & WINE RECEPTION)			

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Tuesday 25th August 2009

9.00-10.00	**INVITED TALK by Mary M. Hayhoe Theatre Auditorium**			
10.00-10.20	BREAK			
Room	**Theatre Auditorium**	**Lecture Theatre H (Room 2065)**	**Lecture Theatre J (Room 2077)**	**Nuffield Lecture Room A**
10.20-12.00	**Higher order influences on reading** Chairs: Erik Reichle & Tessa Warren	**Oculomotor control 1** Chair: Paul Knox	**Neurophysiology & eye movements 2** Chair: Fred Hamker	**Eye movements in the real world** Chair: Christina Howard
10.20-10.40	Staub	Nystrom & Holmqvist	Hamker	Dalzel-Job et al.
10.40-11.00	Reichle & Warren	Laurutis et al.	Ziesche & Hamker	Vikstrom
11.00-11.20	Warren et al.	Godijn & Theeuwes	Kasprzak et al.	Fukuda et al.
11.20-12.20	continued	continued	**Visual Search** Chair: John Findlay	continued
11.20-11.40	Mitchell & Shen	Lavergne et al.	Jacob & Hochstein	Grinberg et al.
11.40-12.00	Paterson	Etchells et al.	Humphrey et al.	Howard et al.
12.00-12.20	Vasishth et al.	Knox et al.	Thompson & Crundall	Essig et al.
12.20-14.00	LUNCH			

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14.00-15.00	**INVITED TALK by Eyal Reingold** **Theatre Auditorium**			
Room	**Theatre Auditorium**	**Lecture Theatre H (Room 2065)**	**Lecture Theatre J (Room 2077)**	**Nuffield Lecture Room A**
15.15-16.15	**Top-down and bottom-up** Chair: Doug Munoz	**Modelling & reading** Chair: Patryk Laurent	**New ways of usability research based on eye tracking** Chairs: Rudolf Groner & Eva Siegenthaler	**Oculomotor control 2** Chair: Ralf Engbert
15.15-15.35	Berg & Itti	Nilsson & Nivre	Siegenthaler & Groner	Born & Kerzel
15.35-15.55	van Zoest	Laurent & Reichle	Bente	Panouilleres et al.
15.55-16.15	Paré & Shen	Shillcock et al.	Zambarbieri et al.	Tandonnet et al.
16.15-16.35	BREAK			
16.35-17.35	continued	**Oculomotor control & reading 1** Chair: Rebecca Johnson	continued	continued
16.35-16.55	Theeuwes et al.	Johnson & Eisler	Underwood et al.	Liu & Altmann
16.55-17.15	Munoz & Boehnke	Obregón et al.	Koga & Groner	Trukenbrod & Engbert
17.15-17.35	McSorley & McCloy	Vitu & Blanes	Aoki et al.	Vanyukov et al.
18.00-20.00	**POSTER SESSION (C) Garden Court** (FOLLOWED BY HOG ROAST)			

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Wednesday 26th August 2009

9.00-10.00	**INVITED TALK by Reinhold Kliegl** **Theatre Auditorium**			
10.00-10.20	BREAK			
Room	**Theatre Auditorium**	**Lecture Theatre H (Room 2065)**	**Lecture Theatre J (Room 2077)**	**Nuffield Lecture Room A**
10.20-12.00	**Prediction in smooth pursuit eye movements** Chairs: Andreas Sprenger and Rebekka Lencer	**Scene perception** Chair: Monica Castelhano	**Oculomotor control & reading 2** Chair: Albrecht Inhoff	**Face processing** Chair: Valerie Benson
10.20-10.40	Ilg & Freyberg	Wang et al.	Slattery et al.	Nummenmaa & Calvo
10.40-11.00	Barnes & Brohan	Castelhano & Heaven	Inhoff & Wang	Van Belle et al.
11.00-11.20	Burke & Barnes	Corck-Adelman et al.	Schad & Engbert	Caldara et al.
11.20-11.40	Sprenger et al.	Hyönä et al.	Radach et al.	Richards et al.
11.40-12.00	Lencer et al.	Miellet et al.	Engbert & Krügel	
12.00-14.00	LUNCH	**POSTER SESSION (D) Garden Court**		
14.00-15.20	**Gaze guidance** Chair: Peter De Graef	**Dyslexia** Chair: Jukka Hyönä	**Applications 2** Chair: Kenneth Hulmqvist	**Eye-hand coordination** Chair: Heiner Deubel
14.00-14.20	De Graef et al.	Koesling et al.	Alacam et al.	Deubel & Jonikaitis
14.20-14.40	Tatler	Jones et al.	Urbina & Huckauf	Huestegge & Koch
14.40-15.00	Howard et al.	Schattka et al.	Lindström et al.	Drai-Zerbib et al.
15.00-15.20	Rasche et al.	Chen et al.	Cristino et al.	Laurent & Reichle
16.00	EXCURSIONS			

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Thursday 26th August 2009

9.00-9.20	**Closing Address** **Theatre Auditorium**			
Room	**Theatre Auditorium**	**Lecture Theatre H (Room 2065)**	**Lecture Theatre J (Room 2077)**	**Nuffield Lecture Room A**
9.20-10.00	**Inhibition of return** Chair: Casimir Ludwig	**Eye movements & ageing** Chair: Robin Hill	**Children's reading** Chair: Hazel Blythe	**Reading in Japanese & Thai** Chair: Ralph Radach
9.20-9.40	Ludwig et al.	Hill et al.	Joseph et al.	Hirotani et al.
9.40-10.00	McSorley et al.	Alahyane et al.	Häikiö et al.	Aranyanak et al.
10.00-10.20	BREAK			
10.20-11.20	**Binocularity** Chair: Wolfgang Jaschinski	**Parafoveal processing** Chair: Keith Rayner	**Visual world** Chair: Roger van Gompel	**Applications 3** Chair: Alistair Gale
10.20-10.40	Kapoula	Hand et al.	Carminati & van Gompel	Hasse et al.
10.40-11.00	Jainta et al.	Ilkin & Sturt	van Gompel & Carminati	Menneer et al.
11.00-11.20	Vernet et al.	Schotter et al.	Müller et al.	Chen & Gale
11.20-11.40	BREAK			
11.40-1.00	continued	**Complex scene perception** Chair: Ignace Hooge	continued	**Antisaccades** Chair: Samuel Hutton
11.40-12.00	Kirkby et al.	Hooge & Camps	Engelhardt & Ferreira	Hutton
12.00-12.20	Roberts et al.	Vo & Henderson	Apel et al.	Derakhshan & Ansari
12.20-12.40	Blythe et al.	Malcolm & Henderson	Sichelschmidt et al.	Gregory & Hodgson
12.40-1.00		Hamon et al.		Zambarbieri & Carniglia
	END OF CONFERENCE			

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Invited Talks by Keynote Speaker

Keeping track of saccades: Brain circuits for corollary discharge.

Robert H. Wurtz

Laboratory of Sensorimotor Research, National Eye Institute, NIH, Maryland, USA

There is no doubt that we keep an internal record of the saccades we make and that we use this record to both control subsequent saccades and to inform our visual system of the impending saccade. The necessity for such internal monitoring was recognized as early as the 17th century by Descartes and was formally proposed by von Helmholtz in the 19th century. Sperry along with von Holst and Mittelstaedt demonstrated the need for these internal signals experimentally in the 20th century and referred to the signals as corollary discharge or efference copy. The circuit for such a corollary discharge for saccades has recently been identified in the monkey, and this has provided information at the level of single neurons on the organization of the monitoring system. It extends from the superior colliculus in the brain stem, through the medial dorsal nucleus of the thalamus, to the frontal eye field of frontal cortex (Sommer and Wurtz, 2002, 2004). The characteristics of the signals carried in this pathway have the characteristics that would be required of neurons carrying a corollary discharge. The pathway can be experimentally interrupted in the thalamus by reversible inactivation, and such interruption has revealed two contributions of the corollary discharge. First, the corollary discharge enables the generation of a rapid sequence of saccades that can be made in the absence of visual guidance. A "double-step" task shows that the second saccade of the two steps compensates for errors in the first saccade on a saccade by saccade basis. This has now been demonstrated for humans as well as for monkeys, and for monkeys this compensation is significantly reduced by interruption of the corollary discharge pathway. Second, the corollary is likely to contribute to the maintenance of stable visual perception in spite of the images shifting on the retina as a result of each saccade. Many frontal eye field neurons receive an anticipatory input indicating that the visual information they are about to receive results from the moving eye rather than from a moving environment (Duhamel, Colby, and Goldberg, 1992). Inactivation of this pathway reduces this anticipatory activity, and along with other characteristics of these frontal cortex neurons, suggests that their activity is part of the mechanism underlying visual stability (Sommer and Wurtz 2006, 2008).

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Invited Talks by Keynote Speaker

Adaptive gaze control in the natural world.

Mary Hayhoe

University of Texas Austin, Center for Perceptual Systems, Texas, USA

Relatively little is known about how vision functions in the natural world, and many important issues arise in this setting that are absent, or difficult to address, in standard paradigms. A central feature of natural vision is that information is dynamically acquired from the environment to guide ongoing actions and behavioral goals. Information from a scene is actively sampled by a sequence of gaze changes as a consequence of the limited acuity of the peripheral retina. In addition, attention limits the information that can be processed within a single fixation, and working memory limits the information retained across gaze positions. Thus to understand vision we need to understand how this sampling process is controlled, and what factors are involved in the acquisition of visual information in the context of these constraints.Previous attempts to explain gaze patterns have almost exclusively concerned only static, restricted stimulus conditions, and focused on the properties of the stimulus rather than the behavioral context. Such models cannot extend to natural behavior because the visual input is dynamic, and most importantly, the observer's behavioral goals play a dominant role. In the absence of these factors, none of the existing image-based models of gaze control are able to predict performance in realistic natural environments.

The overriding importance of the observer's goals suggests a different approach that explicitly represents the behavioral agenda. Recent results have illuminated the importance of goals and the role of secondary reward in setting up and shaping those goals. Foremost of these is the pervasive effect of reward in the neural circuitry underlying saccadic eye movements. These discoveries are complemented by the development of the mathematics of Reinforcement Learning as a way of determining optimal behavior given delayed rewards. To explore the role of reward-based learning in control of gaze in the natural world, we investigated a walking paradigm in a real world setting. This work suggests that learnt environmental statistics, behavioral significance or reward, and competing tasks are important determinants of gaze in many natural contexts. This is consistent with the role of reward in the oculomotor neural circuitry, and supports a reinforcement learning approach to understanding gaze control in natural environments.

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Invited Talks by Keynote Speaker

Using eye movements to determine the time course of mental processes.

Eyal Reingold

University of Toronto, Department of Psychology, Ontario, Canada

Researchers employing eye movement monitoring to study visual cognition routinely use a variety of saccade and fixation measures to make inferences concerning the time course of perceptual and cognitive processes that mediate task performance. In attempting to determine the time course of mental processes, fine-grained eye movement measures have distinct advantages compared to global performance measures such as accuracy and reaction time. The purpose of this talk is to illustrate these advantages and related challenges by reviewing research that I was involved in during the past 15 years. Some of the specific topics that would be discussed include lexical processes, attention and eye movement control in reading, the use of eye movements to study processing stages involved in higher cognitive processes (e.g., expertise, decision making), as well as related issues concerning visual search and scene processing.

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Invited Talks by Keynote Speakers

Distributed processing during reading fixations.

Reinhold Kliegl

University of Potsdam, Department of Psychology, Potsdam, Germany

The perceptual/attentional span around fixation locations constitutes a productive theoretical framework to examine how the mind orchestrates perceptual, attentional, lexical, semantic, discourse, and oculomotor factors in the service of establishing meaning from text. In addition, parameter specification will also vary between readers due to oculomotor habit, due to different intentions or instructions that can be applied to the reading task, and due to differences between scripts. During the last 35 years most of the progress in our understanding of the complex dynamics has been owed to experimental manipulations of target words. During the last ten years this approach has been complemented by computational models. On the one hand, they provide a coherent account for a wide range of effects. On the other hand, they have also fostered corpus analysis to ensure the generalizability of results. The theoretical progress achieved by flexibly moving within the 3-dimensional methodological space spanned by experiment, computational modeling, and corpus analysis will be demonstrated with select examples from current research with an emphasis on the contribution of advanced multivariate statistics such as (generalized) linear mixed models with random-effect correlations, quantile regression, and a move to a Bayesian perspective for the evaluation of small effects.

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Monday 24th August 2009
Symposium: Imaging of the saccadic system

Event-related potentials associated with pro- and anti-saccades in nonhuman primates.

Stefan Everling[1, 2, 3], Victor Sander[3] and Jessica M. Phillips[3]

[1] *University of Western Ontario, Department of Physiology and Pharmacology, London, Ontario, Canada*

[2] *Robarts Research Institute at the University of Western Ontario, Imaging Research Laboratories, London, Ontario, Canada*

[3] *University of Western Ontario, London, Ontario, Canada*

Non-invasive event-related potential (ERP) recordings have become a popular technique to study neural activity associated with saccades in humans. To date, it is not known whether nonhuman primates exhibit similar ERP patterns associated with saccades as those observed in humans. Here, we recorded ERPs associated with the performance of randomly interleaved pro-saccades and anti-saccades in nonhuman primates. Saccade-related ERPs showed a presaccadic negative component, which was larger for anti-saccades than pro-saccades. This negativity was followed by a positive component, which was larger for pro-saccades than for anti-saccades, and more pronounced immediately prior to the response in the hemisphere contralateral to the direction of the saccade. The presentation of the peripheral stimulus evoked P1, N1, P2 and N2 components. In addition, anti-saccade trials were associated with a shift of a negative potential from the hemisphere contralateral to the stimulus, to the hemisphere contralateral to the saccade. These findings demonstrate that macaque monkeys, like humans, exhibit a presaccadic negativity, presaccadic positivity, and a potential shift prior to an anti-saccade. Overall, these data show task-related differences in ERPs associated with pro- and anti-saccades in monkeys that are similar to findings in human subjects.
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The origins of individual saccade latency variability.

Iain D. Gilchrist[1], Petroc Sumner[2], Suresh Muthukumaraswamy[2] and Krish Singh[2]

[1] *University of Bristol, Department of Experimental Psychology, Bristol, UK*

[2] *Cardiff University, School of Psychology, Cardiff, UK*

The time to initiate a saccade varies trial-by-trial. This variability can be extremely large. Within the same participant the slowest saccade can be as much as 10 times slower than the fastest. This variability is present when the stimulus and response are kept constant and even when the task is simple and the saccade is a response to a highly visible target. These differences are not simply explained by systematic slow changes over time or an effect of the latency of the previous saccade. Saccade latency variability could originate at any point from the processing of the visual target to the transformation of that signal into an appropriate ocular-motor response. Here, we use magnetoencephalography (MEG) to investigate the origins of the trial-by-trail variability in saccade latency. Participants made saccades to single supra-threshold targets. By dividing the latency distributions into the fastest and slowest thirds we were able to look for the neural signals that differentiate between fast and slow saccades even when both the response and the stimulus were held constant.
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Is saccade choice determined by processing speed?

Petroc Sumner[1], Aline Bompas[1], Iain D. Gilchrist[2], Suresh Muthukumaraswamy[1] and Krish Singh[1]

[1] *Cardiff University, School of Psychology, Cardiff, UK*

[2] *University of Bristol, Department of Experimental Psychology, Bristol, UK*

In many models of motor decision making, different motor plans compete to govern action. The motor choice is determined by which plan reaches threshold first. Thus it is a fundamental prediction of these models that choice is associated with speed. Here, we use magnetoencephalography (MEG) to investigate the relationship between simple saccade choice and processing speed. Participants made saccades to onset targets, and on some trials had to choose between two targets (left or right). We determined the earliest time-point at which the MEG signal predicted choice. We then tested whether this same MEG signal was associated with processing speed – whether it could also predict saccade latency.

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Mapping inhibitory oculomotor control in patients with focal lesions: Evidence for localization versus equipotentiality accounts of brain function.

Tim Hodgson

Exeter University, School of Psychology, Exeter, UK

Although of pure scientific interest, functional neuroimaging studies which localize particular cognitive and oculomotor functions to discrete brain areas are of little practical value unless they can be shown to help predict deficits experienced by patients with focal neurological damage. Whilst published evidence derived from single case studies and investigations which group patients according to whether damage lies within a particular region or not (e.g. dorsolateral prefrontal) appear to support standard models of the oculomotor system, it is argued that a more hypothesis free analysis of the relationship between lesion site and symptoms is required to adequately test the utility of localizationalist perspectives. The results of a voxel based analysis of lesions (VAL) study will be reported in which correlations between lesion site and extent of deficits in inhibitory oculomotor control were investigated in patients with various types, sizes and loci of frontal lobe damage. The results provide evidence for localization of inhibitory functions in regions outside those normally considered to be oculomotor in specialisation. The analysis also suggests that factors other than lesion site such as aetiology and extent are predictors of deficits, consistent with equipotentiality of function in frontal cortex.

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The neural basis of the parallel programming of saccades: An fMRI study.

Robin Walker, Andy Smith and Yanbo Hu

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This event-related functional imaging study examined the neural basis of the parallel programming of saccade sequences. Fifteen participants performed a delayed two-step saccade paradigm while functional images were obtained using a 3-Tesla Siemens Trio scanner. Participants planned and executed single saccades, or sequences of saccades, under conditions in which advance knowledge of the second saccade goal was provided (parallel programming), or was not provided (serial programming) prior to a 'go signal'. A reduction in second saccade latency was observed in the parallel programming condition compared to that in the serial programming and single-step control conditions. A group analysis was performed (using SPM) and regions of interest (ROIs) were identified in the left and right frontal, parietal and supplementary eye fields. An increased BOLD response was observed bilaterally in the frontal and parietal eye fields, when two saccades were programmed in parallel compared to that observed for serial programming. By contrast the BOLD response in the supplementary eye fields was comparable for the parallel and serial programming conditions. Increased activity in the frontal and parietal eye fields in the parallel programming condition could reflect preparatory processes, and also the encoding and re-mapping of second saccade metrics.

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Session: Parafoveal processing during reading

Parafoveal processing within and between morphemes.

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In an eye movement experiment during the reading of single sentences, parafoveal preview was examined within either an unspaced compound (e.g. bathroom) or a monomorphemic word (e.g. fountain). Prior to fixating the 2nd lexeme or the corresponding letters in the monomorphemic word, either a correct or a partial parafoveal preview (e.g. bathroom or bathroan) was presented using the boundary paradigm. There was a larger preview benefit effect on the monomorphemic words than on the compounds. Differences occurred also early in the word: There was no effect of the preview manipulation on the 1st lexeme of the compound whereas there was a sizeable effect on the corresponding initial letters of the monomorphemic word. Consistent with prior research showing no or little effect of a partial preview of the 2nd lexeme of a compound on the fixation times on the 1st lexeme and with studies showing first lexeme frequency effects, this indicates that there is a level at which constituents of a compound are processed in a serial fashion. The current experiment strengthens this claim by showing stronger disruption of the partial preview when the manipulation occurs within the same morpheme, where all the letters are processed more in parallel.
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No evidence for morphological decomposition with parafoveal previews.

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An eye movement experiment was conducted examining the effect of a parafoveal preview for novel prefixed words (e.g. miscentered), lexical prefixed words (e.g. misapplied), or monomorphemic words (e.g. modified) during the reading of single sentences. Using the boundary paradigm, participants were presented either with a correct (e.g. miscentered), a transposed letter (e.g. micsentered) or a replacement letter (e.g mizventered) parafoveal preview prior to crossing a boundary at the next to last character of the word before the target word. There were significant differences between both the correct and transposed letter conditions and the replacement letter condition; there was also an effect of lexicality, but no interaction between the preview effects and type of target word. Previous studies using foveal masked priming have demonstrated that transposed letter effects disappear or markedly decrease when the transposition occurs across a morpheme boundary. The current set of experiments demonstrates that transposed letter effects can be elicited when the transposition occurs across the morpheme boundary between prefix and root morpheme. This indicates that morphemic decomposition does not affect the parafoveal preview process, which suggests that morphological decomposition may not occur until a word is fixated.

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Delayed parafoveal-on-foveal effects in an N+2-boundary experiment demonstrate parallel processing in reading.

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If words in the perceptual span are processed in parallel, current word processing is assumed to be modulated conditional on parafoveal processing demand, and such parafoveal-on-foveal effects (POF) should decrease with the word's eccentricity from current fixation position. In a series of experiments younger and older adults were tested with the boundary paradigm manipulating word n+2 preview. Although there were no POF effects on the pre-boundary word n, we consistently found effects of previewing the n+2 target in post-boundary fixations on word n+1. Serial models can account for the latter effect by assuming that oculomotor errors mimic a preview benefit effect of the attended target n+2 in mislocated fixations on the prior word n+1. Therefore, in a further experiment, we independently manipulated the pre- and post-boundary frequency of the target word n+2. The results are in agreement with a delayed POF effect with the pre-boundary frequency of word n+2 spilling over into fixations on the post-boundary word n+1; they are not compatible with the assumption of mislocated fixations. The pattern is consistent with an attentional gradient guiding parallel word processing and the notion that spillover effects are modulated directly and may not only result from the absence of preview benefits.

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Parafoveal preprocessing of word N+2: Does a short N+1 word matter?

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It has been suggested that visual acuity limits restrict parafoveal processing of the second word to the right of fixation (N+2) to cases where the first word to the right of fixation (N+1) is very short (Angele, Slattery, Yang, Kliegl and Rayner, 2008). In order to test this hypothesis, we used the boundary paradigm (Rayner, 1975). Word N+1 was either an article or a high-frequency three letter word. Prior to crossing the boundary, words N+1 and N+2 had either both incorrect or both correct preview. In a third condition only word N+1 had incorrect preview. In spite of the short N+1 word length we found no evidence for parafoveal-on-foveal effects or preview benefit effects for word N+2. Additionally, we were able to replicate Drieghe, Pollatsek, Staub and Rayner's (2008) findings concerning Radach's (1996) word grouping hypothesis.

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Parafoveal magnification: Visual acuity does not modulate the perceptual span in reading.

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Models of eye guidance in reading rely on the concept of the perceptual span—the amount of information perceived during a single eye fixation, which is considered to be a consequence of visual and attentional constraints. To directly investigate attentional mechanisms underlying the perceptual span, we implemented a new reading paradigm - parafoveal magnification (PM) - that compensates for how visual acuity drops off as a function of retinal eccentricity. On each fixation and in real time, parafoveal text is magnified to equalize its perceptual impact with that of concurrent foveal text. Experiment 1 demonstrated that PM does not increase the amount of text that is processed, supporting an attentional-based account of eye movements in reading. Experiment 2 explored a contentious issue that differentiates competing models of eye movement control and showed that, even when parafoveal information is enlarged, visual attention in reading is allocated in a serial fashion from word to word.

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On the relation of the selectivity of fixated words and parafoveal-on-foveal effects in continuous reading.

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Under the assumption of distributed processing within the perceptual span in continuous reading, the characteristics of fixated words may interplay with the effect sizes of lexical parafoveal-on-foveal effects. In an age comparative eye movement study on isolated sentence reading, two indirectly induced reading strategies were tested in four experimental groups by altering the difficulty and frequency of comprehension questions. Whereas in young readers, variation in comprehension demands did not influence the selectivity of fixated words in first-pass single fixation cases, clear selectivity effects for single fixations were found in older readers. High comprehension demands induced via difficult comprehension questions led to longer fixation durations and an increased amount of fixated function words that are usually short and high in frequency. Furthermore, the high prevalence of fixated easily processable words led to strong evidence for preprocessing of word n+1: The group that fixated proportionally more function words showed a stronger influence of upcoming word frequency on single fixation duration. This is in line with distributed processing within the perceptual span and its modulation by the difficulty of the fixated word, as predicted by the foveal-load hypothesis. The role of top-down influences on the fixational selectivity in first-pass reading will be discussed.

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Session: Neurophysiology and eye movements 1

Neural mechanisms underlying sequences of gaze fixations during visual search.

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Vision is an active process that entails sequences of saccadic eye movements interrupted by periods of gaze fixations during which the foveal image is analyzed and the next detail in the periphery is selected. To understand how the brain regulates this behavior, we examined the activity of sensory-motor neurons in superior colliculus (SC) while monkeys performed a visual conjunction search task. Monkeys generally made multiple fixations before foveating the target. Fixation durations were significantly shorter than initial responses to the display presentation and shortest one fixation prior to target foveation. And distractor stimuli were rarely re-fixated. The activity of SC neurons substantiated these behavioral results: The programming of a saccade into a neuron's receptive field began too early to be accounted for by visual receptive field activation. Moreover, target-related activity was enhanced when the intervening fixation was short. Consistent with the accumulation of evidence for the search target, distractor stimuli previously fixated were associated with significantly less activity than those not yet examined. Taken together, these results demonstrate how visuo-motor activity programs multiple eye movements concurrently and how visual search saccades should be considered as elements of sequences of gaze fixations that are selected by the pre-processing of visual stimuli.

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Neural activity associated with pro- and anti-saccades in primate caudate nucleus.

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The basal ganglia play a central role in movement, and it has been demonstrated that the discharge rate of neurons in these structures are modulated by the behavioural context of a given task. Here we utilized the anti-saccade task, in which a saccade toward a flashed visual stimulus must be inhibited in favour of a saccade to the opposite location, to investigate the role of the caudate nucleus, a major input structure of the basal ganglia, in flexible behaviour. In this study, we recorded extracellular neuronal activity while monkeys performed pro- and anti-saccade trials. We identified two populations of neurons, those that preferred contralateral saccades (CSN) and those that preferred ipsilateral saccades. CSNs increased their firing rates for pro-saccades, but not for anti-saccades, and ISNs increased their firing rates for anti-saccades, but n ot for pro-saccades. We propose a model in which CSNs project to the direct basal ganglia pathway, facilitating saccades and ISNs project to the indirect pathway suppressing saccades. This model suggests one possible mechanism by which these neuronal populations could be modulating activity in the superior colliculus.

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Compensatory control of saccadic eye movement is impaired after V1 lesion.

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Saccades to a visual target are known to be quite accurate in spite of their variation in initial velocity. This suggests that the saccades are under compensatory control during the movement. However, it is not clear how the eye movements are controlled during saccades and which brain regions are involved in such compensatory control mechanisms. We have reported that saccadic motor control was impaired after lesion of primary visual cortex (V1) and suggested the involvement of geniculo-striatal pathway in compensatory control of saccades (Yoshida et al., J Neurosci., 2008). Here, we further analyzed velocity profiles of saccades in monkeys with unilateral lesions in V1. We found that saccades tend to be less accurate and the initial velocity influences more on the duration and endpoint of the saccade in the affected field (contralateral to the lesion), while saccades are more controlled to minimize the endpoint error in the normal field (ipsilateral to the lesion). In other words, saccades tend to be more ballistic after V1 lesion. This result suggests that saccade velocity was controlled by two factors: a ballistic component which might be generated by superior colliculus (SC) and a compensatory component which requires visual information from the geniculo-striatal pathway.

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Using transcranial magnetic stimulation and electromyography to study excitability of the frontal eye fields in humans.

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Transcranial magnetic stimulation (TMS) enables non-invasive investigation of brain function. TMS of the frontal eye fields (TMS-FEF) modulates saccade latency and target discrimination times but does not elicit saccades. However, FEF is an oculomotor structure which also contributes to head orientation. Accordingly, we investigated whether TMS-FEF evokes a neck muscle response. FEF was localised with fMRI and then co-registered with the TMS. Subjects performed memory-guided saccades to targets presented either left or right. Stimulation (either single pulse or double pulses at 20 Hz) was delivered on 30 percent of trials at GO cue presentation. Bilateral intramuscular EMG recordings of splenius capitus (an ipsilateral head turner) were obtained. Consistent with previous research TMS-FEF modulated saccade latencies. In five of six subjects, TMS-FEF induced a change in neck muscle activity. Although we observed a diversity of evoked responses across our sample (consisting of either recruitment or silencing of a synergy turning the head away from the side of stimulation), evoked responses were greater when TMS was applied to the FEF engaged in contralateral saccade preparation. These results demonstrate that combining TMS and neck muscle recordings provide a direct means to assess the excitability of human FEF during an oculomotor task.

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Session: Language processing during reading

Distributional effects of word frequency on eye fixation durations during reading.

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To date, the effects of word frequency on eye fixation durations during reading have largely been explored in terms of averaged reading times. In contrast, recent research using isolated word recognition paradigms have used additional methods to examine the location and shape of response time distributions from individual subjects. Here we explore effects of word frequency on individual subject distributions of fixation durations in reading, using data from White, 2008, and Drieghe, Rayner, and Pollatsek, 2008. Ex-Gaussian distributions provided good fits to the data, and showed effects of word frequency on both the shift and skew of the distributions. The findings have crucial implications for models of eye movement control during reading. The effects of word frequency on the location of the distributions indicates that word processing is closely linked to eye movement control, such that it influences the duration of essentially all, rather than just a subset, of fixations. Drieghe, D., Rayner, K., Pollatsek, A., 2008. Mislocated fixations can account for parafoveal-on-foveal effects in eye movements during reading. QJEP, 61, 1239-1249. White, S. J., 2008. Eye movement control during reading Effects of word frequency and orthographic familiarity. JEPHPP, 34, 205-223.

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Semantic age-of-acquisition effects in reading ambiguous words.

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Words that are rated as acquired earlier in life receive shorter fixation durations than later acquired words, even when word frequency is adequately controlled (Juhasz and Rayner, 2003; 2006). Some theories posit that age-of-acquisition (AoA) affects the semantic representation of words (Steyvers and Tenenbaum, 2005), while others suggest that AoA should have an influence at multiple levels in the mental lexicon (Ellis and Lambon Ralph, 2000). In past studies, early and late AoA words have differed from each other in orthography, phonology, and meaning, making it difficult to localize the influence of AoA in the mental lexicon. We report two experiments which examined the locus of AoA effects in reading. Both experiments used balanced ambiguous words which have two equally frequent meanings acquired at different times (e.g. pot, quack). In Experiment 1, sentence context supporting either the early- or late-acquired meaning was presented prior to the ambiguous word; in Experiment 2, disambiguating context was presented after the ambiguous word. Meaning AoA and context given influenced late processing measures such as regressions into the ambiguous word and second-pass durations, supporting the theoretical position that AoA influences access to multiple levels of representation in the mental lexicon.

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Phonological similarity effects in reading.

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Reading a sentence with repeated initial phonemes has been found to cause a lag in reading time for both oral and silent reading. The reason for this "tongue twister effect" (TTE) during silent reading for comprehension is still not fully understood. In two experiments, we examined the timecourse of TTE and its source. The results reveal evidence for two distinct effects. The tongue twister phrase caused an early burden, suggesting that the initial access of the phonological forms of the words is affected by phonological repetition. TTE also caused a late burden which increased with the addition of a discourse level text integration manipulation; this suggests that the phonological forms of the words across the phrase are still active during text integration processing. There are several implications for these results. The early effect may be indicative of local phonological neighborhood effects during lexical access. The late effect suggests that phonological similarity also disrupts the maintenance of information during comprehension processing. The degree to which these hypotheses are supported by other recent research and ramifications for models of eye movement control will be discussed.

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Syntactic context and lexical effects on eye movements during reading.

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Current models of eye movement control during reading focus primarily on the process of lexical access and factors that appear to affect it, such as word frequency and contextual predictability. The nature of frequency effects on eye movement parameters and how these relate to the access process is becoming clear (e.g. Murray and Forster, 2008), but questions remain regarding the form of the effect of higher level factors such as sentence context. To date, this has only been considered in terms of overall predictability, but predictability can be decomposed into syntactic and semantic components. The study reported here examined the nature of the syntactic context effect (Wright and Garrett, 1984; West and Stanovich, 1986) and the way this interacts with the access process, as indexed by word frequency effects. If syntactic context acts pre-lexically, there should be an interaction between syntactic and frequency factors on eye movement parameters. The results replicated Murray and Forster's 'Rank' frequency findings and showed clear effects of syntactic context, but with no interaction. However, while this might suggest that syntactic context effects occur post-lexically, the time course of the effect suggests otherwise, with 'early' foveal and parafoveal effects.

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Individual differences in scanpaths and reanalysis strategies while reading temporarily ambiguous sentences.

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An important open question in reading research is: what processes drive eye movements when the reader resolves a temporary ambiguity? Frazier and Rayner (1982) were the first to propose that the eyes are intelligently guided in a regressive sweep to the ambiguous region in the sentence (the Selective Reanalysis hypothesis), and Meseguer, Carreiras and Clifton (2002) found evidence consistent with this proposal. However, Mitchell et al. (2008) found a more mixed pattern: a combination of intelligent guidance and movements controlled by low-level spatial information. However, these studies have largely relied on transitional probabilities to make their case; but transitional probabilities furnish only a fragmentary picture of eye-movement patterns. We present a different approach in which differences in eye-movement patterns can be directly quantified using a similarity measure for scanpaths (Malsburg and Vasishth, 2009). This measure can quantify (inter alia) the extent to which scanpaths instantiate the patterns hypothesized in the above-mentioned theories. We use the Meseguer et al. 2002 data to show that most participants stick closely to their personal fixation pattern with only slight modulations attributable to reanalysis.

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Symposium: Eye movements and concurrent electrophysiological measurement (ERPs, EEGs)

Co-registration of EEG and eye movements: Tracking lag effects in reading.

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Inspection times in reading are modulated by both properties of the fixated and the preceding word. Particularly, fixation durations on word n are longer when word n-1 was of low rather than of high frequency. One, yet debated, explanation for this so-called lag-effect is the assumption that the eyes proceed to a subsequent target when recognition of a difficult stimulus is still incomplete; accordingly, word processing spills over and interferes with recognition of the next stimulus. Here, we show that event-related potentials (ERPs) elicited by word n-1 correlate with temporally coinciding fixation durations on word n, pointing to ongoing processing after the eyes have left word n-1. However, these data stem from independent studies and provide only indirect evidence for incomplete processing. To scrutinize this issue, we manipulated frequency on subsequent words in arrays of isolated nouns and assessed fixation-related potentials during normal left-to-right reading; ERPs were recorded in an eye movement-free control condition. Influences of past stimuli on neural correlates and inspection times on currently fixated words point to processing beyond a fixation and provide a link between electrophysiological and eye movement data. We discuss the results in the light of different theoretical approaches accounting for lag effects.

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Co-registration of EEG and eye movements: Testing the electrophysiological timeline of normal reading fixations.

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We summarize results of four left-to-right sentence reading experiments (N=126) with simultaneous EEG recording. EEG records were time-locked to the initial fixation on a target word whose word predictability and frequency was varied. Gaze-contingent display changes were used to manipulate the parafoveal preview on the target word in two experiments (N+1 and N+2 paradigms). Results are compared to traditional RSVP experiments (N=144) in which the same sentences were presented word-by-word at slow, medium, or reading-like presentation rates. EEG word predictability effects (N400) were remarkably similar in saccadic reading and RSVP. However, N400 effects began considerably earlier in saccadic reading than in reading-like RSVP, indicating that word meaning can be accessed during the word-initial fixation. This latency difference was partly explained by a robust preview benefit at the electrophysiological level (N+1 condition), which was observed to a small extent also in the N+2 condition. Interestingly, electrophysiological preview effects were larger than behavioral benefits, indicating only a partial carry-over of processing advantages into fixation times. Using ERP correlates of visual and motor processing and additional data from a word list reading experiment, we attempt to map the results onto an electrophysiological timeline of visual, lexico-semantic, and oculomotor processing during normal reading fixations.

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Right visual field advantage in parafoveal processing: Evidence from eye-fixation related potentials.

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Readers acquire information also outside the current eye fixation. Parafoveal-on-foveal effects in reading assume that parafoveal words influence the processing of the fixated word. Previous research shows also that words presented to the right visual field are processed faster and more accurately than words in the left visual field. This asymmetry results either from an attentional bias, reading direction or the asymmetry of the brain for language processing. We combined eye-tracking and electroencephalography (EEG), to investigate the visual field differences in parafoveal-on-foveal effects. After a central fixation, a prime word appeared centrally together with a parafoveal target that was presented either to the left or to the right from the prime. Both hemifield presentations included three semantic conditions: the words were either semantically associated, non-associated, or the target was a non-word. First, the participants read the prime and proceeded by making a saccade towards the target, subsequently they made a semantic association judgement. Between 200 – 280 ms post-fixation, an occipital P2 EFRP-component differentiated between parafoveal word and non-word stimuli. This effect was obtained only for the RVF presentation, suggesting a right visual field advantage in parafoveal extraction of word information. The origins of the RVF advantage are further discussed.

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The influence of self-paced processing and parafoveal preview on the time-of-effects in Fixation Related Potentials.

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Hutzler et al. (2007; Welcome to the real world: Validating fixation-related brain potentials for ecologically valid settings. Brain Research, 1172, 124-129) reported that the effects in fixation-related brain potentials occurred earlier than in classical ERP settings whereas the shapes of FRPs and ERPs were similar. The current study investigated two potential explanations for the earlier occurrence of effects: One could be the visibility of the target stimulus before it is fixated (preview benefit), and the other could be the self-determined processing rate in the FRP setting. To assess these accounts, we compared a self-paced ERP experiment with a classical ERP experiment and two FRPs settings where the target stimulus was either visible or masked until fixation. We found a substantially earlier occurrence of effects only in the FRP setting with the visible target which clearly shows that processing of the target was significantly facilitated when parafoveal information had been available.

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Visual processing during a fixation is modulated by the size of preceding saccade.

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Recently, Pannasch and Velichkovsky (in press) reported evidence that the distractor-induced prolongation of a fixation (distractor effect) is modulated by the size of the preceding saccade. However, examining only behavioural data can not clarify how different lengths of saccades might be related to a possible involvement of different brain mechanisms in free viewing. We aimed to clarify this issue in a further study with parallel recordings of eye movements and EEG/ERPs. During free visual exploration of images, gaze-contingent visual distractors were presented 100 ms after the onset of each 5th fixation. Distractor fixations were grouped post-hoc either as preceded by long or short saccades (cutoff at 4°). Eye movement behaviour again demonstrated a stronger distractor effect for fixations preceded by short saccades. In addition to this, the ERP data revealed that P2 component over Pz and Cz was larger for fixations preceded by small saccades. The distractor-induced N1 component over Oz was equal for both saccade conditions. The results are discussed in relation to distinct mechanisms of information processing in the visual system. Pannasch, S. and Velichkovsky, B.M. (in press). Distractor Effect and Saccade Amplitudes: Further Evidence on Different Modes of Processing in Free Exploration of Visual Images. Visual Cognition.

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Eye-fixation related potentials: Past, present and future.

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Eye-fixation related potential –EFRPs- technique is based on electroencephalogram –EEG- measuring electrical brain activity in response to eye-fixations. EFRPs are extracted from the EEG by means of signal averaging but in contrast to conventional event-related potential -ERP- technique the averaged waveforms are time-locked to the onset and offset of eye-fixation, not to the onset of stimulus events. EFRPs have shown to be a useful technique, in addition to eye-movement recordings, to investigate early lexical processes and for establishing a timeline of these processes during reading. Moreover, the technique permits to analyze the EEGs in a natural condition allowing the investigation of complex visual stimuli. However, some challenges remains to be solved. Among them, we will discuss the saccadic contamination and the overlap effects that may distort the findings and we propose some issues that might improve these problems.

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Symposium: Reading in Chinese and Thai – A challenge to current models

Eye movements and parafoveal processing in Chinese reading.

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A great deal is known about the nature of preview benefit in reading alphabetic writing systems. However, very little is known about preview benefit in reading Chinese. In the present talk, we report the results of a series of experiments in which we used the boundary paradigm (Rayner, 1975) and systematically varied the nature of the preview. When the reader's saccade crossed the boundary location, the preview changed to the target word. In one experiment, we manipulated the order of the preview characters. Thus, with two character target words, the order of the two characters was switched from preview to target. In half the conditions, the switch maintained the meaning of the target word, while in the other half it changed the meaning. We'll also report the results of experiments in which we examined how well the preview characters fit with prior context, and experiments in which the semantic relatedness of the preview to the target was manipulated.

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Factors involved in eye guidance in reading Thai.

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Unspaced alphabetic scripts such as Thai present a challenge to a reader's eye guidance system. Analysis of data from two studies of Thai readers involving nearly 40 subjects shows that Thai readers are able effectively to target word centres. Because of the absence of white space in the Thai writing system, other orthographic and/or lexical features must be used. We present evidence confirming that the presence of characters ccurring frequently at word boundaries are important in word-targetting accuracy. In addition, vowel characters and tone marks that occur above the horizontal axis of the line of text appear to attract a disproportionate number of fixations. Moreover, these visually prominent character clusters tend to occur near word centres. The results of our analysis suggest a dynamic interaction between the features of the writing system and the information pick-up strategies adopted by readers. Extensions to the Glenmore model of eye movement control in reading will be described that aim to account for this dynamic aspect of reading.

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Parafoveal load of word n+1 modulates preprocessing of word n+2.

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Two key predictions from the differences between the SAS models and GAG models are preview benefit of the word two words away from fixation (word n+2) and the parafoveal-on-foveal effect. Using the boundary paradigm, this experiment examined parafoveal processing during the reading of Chinese sentences. The main finding was that we obtained (a) preview benefit for word n+2, (b) parafoveal-on-foveal effect due to frequency difference of parafoveal word n+1 on duration of word n, and finally (c) an interaction between word n+1 frequency and PB effect size for word n+2. We discuss implications for notions of serial attention shifts and parallel distributed processing of words during reading.

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Reading spaced and unspaced Chinese text: Evidence from non-native Chinese speakers' eye movements.

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We explored the effect of spacing in relation to word segmentation for four groups of non-native Chinese speakers (American, Korean, Japanese and Thai) who were learning Chinese as a second language. We used Chinese sentences with four types of spacing information: unspaced text, word spaced text, character spaced text, and nonword spaced text. Also, participants' native languages were different in terms of their basic characteristics. English and Korean are spaced, whereas the other two are unspaced. Japanese and Korean are character based whereas the other two are alphabetic. Thus, we assessed whether any spacing effects were modulated by basic characteristics of the native language. Reading times and regression measures all showed least disruption to reading for word spaced text, longer for unspaced, then character spaced text, and longest for nonword spaced text. These effects were uninfluenced by native language (though reading times were different between groups based on Chinese reading experience). Demarcation of word boundaries through spacing reduces non-natives' uncertainty about the characters that comprise a word, thereby speeding lexical identification, and in turn, reading. More generally, the results indicate the word, not the character, is the primary unit of information in Chinese reading.

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Session: Scene Perception 1

Time to return: Dissociating inhibition of return from saccadic momentum during scene search.

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10 years ago, Klein and Macinnes (1999) claimed that Inhibition of Return (IOR) functioned as a 'foraging facilitator', driving attention to new locations during search of visual scenes. However, recent evidence from our lab has shown that during a scene memorisation task IOR does not decrease the likelihood of refixations. In fact, refixations during scene memorisation appear facilitated. In this presentation we show that the absence of a functional role of IOR generalises to visual search. During a scene search task, voluntary saccades and saccades in response to onsets at the 1-back location experienced delay due to a combination of saccadic momentum - the tendency to continue the trajectory of the previous saccade and the time taken to reverse the direction of the saccade - and spatially-specific IOR. However, IOR did not decrease the occurrence of return saccades relative to distance-matched locations. No IOR was observed at the 2-back location suggesting that IOR is coded in retinotopic coordinates. We propose a theory of IOR in which retinotopic IOR is distinguished from spatiotopic attentional "tagging" of earlier fixation locations. These tags may be facilitatory or inhibitory depending on the viewing task.

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Relationship between coarse-to-fine process and ambient-to-focal visual fixations.

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The allocation of overt visual attention can be decomposed into ambient and focal fixations which sequentially occur during the exploration of a complex visual scene and are explained like an intrinsic coarse-to-fine strategy. Many perception studies support a coarse-to-fine visual process between phase and amplitude or between low and high frequencies based on the dichotomy between ventral and parietal pathways or right and left brain hemisphere. However, we don't know whether a link does exist between these two types of fixations and the dual properties of the signal in the scene? In our study, we investigate here whether or not low/high frequencies and phase/amplitud of a visual scene have an impact on the allocation of visual attention. An eye-tracking experiment on natural scene viewing is conducted by decoupling signal properties in using hybrid -frequencies- and chimera -phase, Amplitude- stimuli. Our results will be discussed according to bottom up and top down aspects of visual attention and perception models.

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Computational modelling of fixation durations in scene viewing.

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Most behavioural and computational research on eye-movement control during naturalistic scene viewing has focused on where the eyes fixate. However, eye fixations also differ in their durations. Here, we propose a computational model that accounts for saccade timing and programming and thus for variations in fixation durations in scene viewing. First, timing signals are modelled as random walks. Second, difficulties at the level of visual and cognitive processing can inhibit and thus modulate saccade timing. Inhibition can manifest as a change in mean transition rate or as processing-related saccade cancellation. Third, saccade programming is completed in two stages: an initial, labile stage that is subject to cancellation, and a subsequent, non-labile stage. The model was tested on data from experiments investigating the control of fixation durations during scene viewing. First, model simulations reproduced the mixed-control pattern observed in the scene onset delay paradigm (Henderson and Pierce, 2008). Further, model simulations recovered fixation duration patterns observed when manipulating the quality of the scene input in a parametrical fashion. We conclude that (1) fixation durations are sensitive to moment-to-moment processing demands and that (2) viable models of gaze control in scene perception should be able to account for variations in fixation durations.

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Gaze guidance through peripheral stimuli.

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Guiding gaze using near-peripheral vision improves gaze-contingent-display efficiency by reducing display response latency. We propose a new approach for controlling exploration of static displays through near-peripheral stimuli, and report results of an evaluation of its effectiveness. 10 participants viewed full screen displays of 60 blurred pictures (Gaussian filtering). As soon as a fixation (first strategy) or a gaze sample (second strategy) was detected next to the current stimulus, the area surrounding it was deblurred. An image was totally deblurred when all stimuli had thus attracted the user's gaze. Stimuli are blinking deblurred circles (radius: 1 degree visual angle). They appear in predefined positions on the screen, one at a time. For each picture, successive stimulus positions on the screen reproduce observed gaze patterns. The current stimulus is visible only if the visual angle between its position on the screen and the position of the user's current fixation is superior to 8 degrees (to avoid users noticing it) and inferior to 14 degrees (near-periphery upper limit). Eye movements are detected through an ASL-H6 eye-tracker (120 Hz). Stimulus saliency is estimated, for each picture and stimulus, from contrast ratio and sum of squared differences between blurred and deblurred area around the stimulus.

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Microsaccade induction in natural scene perception.

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Even when we fixate on stationary scenes, our eyes are not fully at rest but are constantly performing fixational eye movements. The most pronounced component of fixational eye movements is represented by tiny saccades called microsaccades. In free viewing, only about 10 percent of visual fixations contain a microsaccade. Furthermore, saccades and microsaccades form a common, unimodal distribution of amplitudes. We present a new experimental paradigm, where increased microsaccade rates were induced by prolonged fixations (20 s) preceding free-viewing trials (10 s). We observe a remarkably increased rate of microsaccades--about 25 percent of all fixations host at least one microsaccade. In addition we obtained the important result that the distribution of saccade amplitudes is bimodal with a trough at 0.6 degrees visual angle and the peak at smaller values (0.15 deg) of the bimodal distribution coincides with the maximum of the amplitude distribution of microsaccades observed in the prolonged fixations. Therefore, in the proposed paradigm a clear separation of microsaccades and inspection saccades is possible. Based on these results, we indentify specific functions for microsaccades.

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Session: Eye movements in special populations

A novel probe of oculomotor impulsivity.

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Why do some people begin to accelerate almost before the light goes green, while others are more cautious? Here we introduce a novel oculomotor task to examine decision making. In our task, a traffic light dictates when subjects make a horizontal saccade as fast as possible in return for reward. Subjects are cued by an amber light to prepare to make a saccade when the light turns green. The duration of the amber signal is randomly selected from a fixed distribution so that subjects build an expectation of the GO signal. Under these circumstances, some subjects generate anticipatory saccades in addition to the expected reactive distribution. Disproportionately rewarding early saccades encourages subjects to behave 'impulsively', increasing anticipatory responses. Young participants (n=20) demonstrated increasing anticipatory behaviour with lengthening amber durations prior to the GO. Anticipations were rare, however, in older volunteers (n=20) and non-impulsive Parkinson's patients. We modelled the two types of behaviour – anticipatory and reactive – as two linear rise-to-threshold processes, one triggered by amber onset and the second by the GO stimulus. The findings show how eye movement control can be used as a quantitative probe of impulsivity, with few parameters required to generate a well fitting model.

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Unlocking the potential of patients with ADHD – oculomotor inhibition before and after training.

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Attention Deficit Hyperactivity Disorder has become one of the most frequently treated disorders in childhood. Behavioral inhibition is proposed to be the core deficit in ADHD manifesting in hyperactivity-impulsivity symptoms. In the present study we tested the effectiveness of attention and working memory training as an alternative way of treating ADHD symptoms. ADHD boys (N=15) underwent 20 sessions of internet training in controlled attention and working memory. At pre- and post-training sessions they were tested on a number of cognitive tasks, among them antisaccade task. During antisaccade task performance their eye movements were recorded to check their ability in overcoming reflexive eye movements, whether the training was effective in reducing their distractibility to external stimuli. As a reference level of performance their parents completed some of the tasks. The correlations between child and parent performance were meaningful only at posttest session suggesting that the training helped children to unlocked their potential.

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Different task, different strategy? Inflexible information acquisition mediates visuo-spatial task performance in chronic schizophrenia patients.

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Impairments in visuo-spatial tasks have been implicated as core deficits in cognitive functions in schizophrenia. How those deficits relate to inefficient information acquisition strategies has, yet, to be determined. We tested 24 chronic schizophrenia patients (SZ) and 25 healthy, age- and gender-matched controls (C) in a mental rotation task with graded difficulty. SZ had slower reaction times in the easiest condition ($F(1,48)=6.299$; $p=0.016$) and higher error rate in the more difficult conditions ($F(1,48)=7.077$; $p=0.011$). Further, while mean fixation time increased with increasing task difficulty in C, patients employed a unique fixation strategy that was independent of task difficulty ($F(3,45) = 4.979$, $p=0.005$). Finally, visual scanning was more holistically global for C, whereas SZ tended to focus on stimulus details ($F(1,47)=4.301$; $p=0.044$). These results suggest that performance of schizophrenia patients in visuo-spatial tasks depends on visual information acquisition strategies independent of information processing. Graded task difficulty mediates distinguishable behavioral outcomes. Easy tasks reveal slowness in patients' strategic information acquisition, whereas in more difficult tasks inadequacy of strategy results in task failure. We conclude that patients' performance in cognitively demanding tasks could be improved if they were trained in more flexible visuo-spatial strategy employment.

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Bimodal speech perception and dyslexia – evidence from eyetracking for an audiovisual integration deficit.

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In an eyetracking setting, where the focus was on subjects' abilities to respond to stimuli involving acoustic as well as visual information, 35 adult dyslexic subjects were tested. The aim was to investigate whether an impairment in the ability to process audiovisual speech might correlate with dyslexia. We tested susceptibility to the McGurk effect - a speechreading effect known to elicit subject responses of the perception of the syllable da when a visual ga is dubbed with an acoustic ba - with dyslexic subjects and controls, while their eye movements were tracked. Subjects' ability to obtain information from lip reading was tested with a - visual only - lip reading paradigm including highly 'lip readable' syllables and mono- and disyllabic words. Results from the first subject trials suggest that, while lip reading abilities were normal compared to controls' performance, the McGurk effect could not be elicited in most dyslexics. We conclude from these results that dyslexics may not able to process simultaneous audiovisual speech signals with the acoustic signal being dominant over the visual input. A malfunction of speechreading in bimodal speech perception tasks seems to correlate with dyslexia and might yet be more than a mere side effect.

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A representation of visual priority revealed by damage to human parietal cortex.

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Where we look is determined both by our current intentions and by the tendency of visually-salient items to 'catch our eye'. Following damage to parietal cortex, this normal process of directing attention is often profoundly impaired. Here we use parietal patients' eye movements during visual search to map the spatial distribution of the attentional deficit. We separately evaluate patients' impairments in goal-directed eye movements to targets and in stimulus-driven gaze shifts to salient non-targets. These deficits are shown to be identical in both magnitude and spatial distribution, consistent with damage to a single topographically-organized 'priority map' in posterior parietal cortex in which top-down and bottom-up signals are combined to select targets for attention. Remarkably, a patient's bias (neglect) in visual exploration can be corrected and even reversed by manipulating the distribution of salience in the visual scene.

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Frontal Eye Fields play a crucial role in oculomotor inhibition of task-relevant and task-irrelevant distractors; evidence from lesion patients.

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Key to successful goal-directed behaviour is the correct selection of the relevant element in the visual field (‘target’) in the presence of other elements (‘distractors’). Previous studies have shown that distractors interfere with correct target selection, because the eyes are erroneously directed to a distractor in a proportion of trials. In these trials, the oculomotor inhibition of the distractor fails which results in an erroneous eye movement before the target is reached. Here we examined the role of the Frontal Eye Fields (FEF) in oculomotor inhibition in two patients with a focal lesion to this frontal area. Both patients were tested on the antisaccade task and the oculomotor capture task. In both experiments, a single strong distractor had to be ignored. Importantly, the distractor is task-relevant in the antisaccade task, whereas it is task-irrelevant in the oculomotor capture task. Results show that the patients made more erroneous eye movements to a contralesional distractor in both tasks compared to an ipsilesional distractor. This indicates that successful oculomotor inhibition of both task-relevant and task-irrelevant stimuli is mediated by the FEF, as a lesion to this area results in more erroneous eye movements to a contralateral distractor.

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Symposium: Eye movements in Autism

Eye movements in Autistic Spectrum Disorder.

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Saccadic orienting was examined for Typically Developing (TD) and Autistic Spectrum Disorder (ASD) participants for three different tasks. Cognitive processing was examined by measuring eye movements during inspection of the 'Repin' picture under two different viewing instructions. Proportions of fixations on people and objects in the scene differed between the two instructions for TD, but not ASD participants. Attentional orienting was examined by using a cueing paradigm with schematic eyes and arrows as distractors. A classic cueing effect was found for both groups, but there was no group difference in errors or latencies for both types of distractor. Processing of social information was examined by looking at orienting to 'people' presented in pairs of real scenes, for a free viewing and a gender discrimination task. Differences between the two groups were evident in the first eye movement made, where TD, but not ASD were more likely to fixate a person in the scene.

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Age of language onset as a predictor of eye-tracking patterns in high-functioning children with Autism Spectrum Disorders.

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Background: Impairments of social functioning are the primary diagnostic criteria for autism. However, adults on the autism spectrum form social stereotypes (White et al.,2006) and similarly affected children demonstrate a viewing preference for people over objects (Van der Geest et al., 2002). Objectives: To determine whether children with an ASD display greater interest in sets of figures in interaction than in non-interaction, and to extend findings to a comparison of children diagnosed with High Functioning Autism (HFA) and Asperger Syndrome (AS). Methods: 12 children with HFA, 11 with AS and 12 typically developing children participated. The children were presented with two sets of figures (interaction v. non-interaction) displayed on a monitor for 10 seconds whilst eye-movements were recorded using a head mounted eye-tracker. Results: The ASD group spent less time looking at the figures than the control group; however, there was no qualitative difference in looking patterns with viewing times longest for interacting figures. The AS group looked significantly longer at the interacting figures with no preference shown by the HFA group. Conclusions: The differentiation between AS and HFA is controversial; our results suggest that advantages in early development may lead to later gains in social skills within Asperger Syndrome.

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Cues to word learning in autistic spectrum disorders.

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Word learning deficits in ASD are frequently attributed to impairments in processing social cues such as eye gaze. It is unclear whether these impairments reflect reduced attention to eyes or an inability to follow gaze cues to intended referents. The use of social cues to word learning was explored in 39 7-year-old children; 13 with ASD, 13 language delay and 13 age-matched peers. Eye-movements were recorded as children viewed photographs of a woman standing behind three novel objects. In a neutral cue condition, the woman stared directly ahead; in a social-biasing condition, the woman gazed at one of the three objects. Word learning was facilitated by the presence of a social-biasing cue in all three groups. Children with ASD were significantly better than peers at learning word forms. These findings suggest that individuals with ASD map eye-gaze cues quickly, and then devote attentional resources to word forms in preference to social meaning. This would be evident in reduced fixations to faces and increased fixations to target objects. In contrast, other children are predicted to spend more time fixating faces gaze contingently from face to target object in the social-biasing condition. These eye-movement analyses will be the focus of my presentation.
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Susceptibility to magic illusions in autism.

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Illusions lie at the heart of magic. One illusion, the vanishing ball illusion (Kuhn & Land, 2006), is achieved by a magician raising an expectation in an audience that a ball will be thrown and then misdirecting attention by skilled use of movement and eye-gaze (Kuhn & Land, 2006). We predicted that individuals with Autism Spectrum Disorder (ASD) should be less susceptible to the vanishing ball illusion because research and clinical evidence suggests they have less sensitivity to social cues in their social interactions. We found the opposite result. High functioning young adults with ASD were more susceptible to the illusion than an IQ-matched comparison group. While this finding suggests that people with autism may be even more sensitive to social cues than those without autism, eye-tracking data indicates that subtle temporal problems in allocating attention might explain this heightened susceptibility. Individuals with ASD revealed similar patterns of looking to the magician's face and eyes compared with the comparison sample, except for one subtle measure. They were slower to launch their first saccade to the face. In addition, they showed a distinct difficulty in fixating the fast moving 'real' ball when it was thrown in the air in earlier trials. The results indicate problems in the rapid allocation of attention towards both people and to moving objects, problems that are possibly connected. They also demonstrate the use of top down perceptual strategies based on event expectations when attention cannot be deployed in time.

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Session: Attention

Influence of shifting of visual attention on the oculomotor system.

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For our understanding of the mechanisms of visual attention it is crucial to know the relationship between attention and saccades. Some theories propose a close relationship, while others view these systems as completely independent. In a recent study using a cueing task we proposed that this controversy can be resolved by distinguishing between the maintenance and shifting components of attention. Specifically, it was proposed that shifting covert attention is always associated with preparation of saccade to that location. To further investigate this issue the present study used a serial visual search task, which is known to require repeated serial shifts of attention in order to find the target. The identity of the target indicated whether an eye movement towards the target or non-target location had to be made. Preliminary results indicated that saccades were facilitated towards the location where the covert attention was shifted to. The findings support the view that shifts of covert attention are accomplished through activation of an oculomotor program.

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Attention and target selection for smooth pursuit eye movements.

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During fixation we are able to voluntarily select objects for enhanced perceptual processing. Here, we examined whether this ability would be reduced when pursuit of a moving object has to be initiated. Two stimuli appeared above and below fixation and moved in opposite directions after a central cue instructed observers to pursue one of the two stimuli (smooth pursuit task). For 80 ms after stimulus onset, a grating was displayed on the opposite stimulus. Observers had to report its orientation at the end of the trial (perceptual task). We varied the priority given to smooth pursuit and perception. The results showed that target selection for pursuit and perception were not independent. Large improvements in perceptual performance were traded for small improvements in pursuit latency. These results indicate that the pursuit system only needs a small attentional bias for target selection. In the condition with equal priority to pursuit and perception, observers frequently pursued the wrong target, suggesting a strong coupling between eye movement and perception. Further, acceleration was higher when the perceptual and pursuit targets were identical compared to a single-task pursuit condition. The additional perceptual task may enhance pursuit by helping to focus attention.

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Eye movements during tracking of multiple moving objects.

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Do observers track multiple moving objects by shifting their eyes between targets? Or can observers track them covertly without any overt eye movements? This fundamental question of dynamic visual attention (parallel vs. serial tracking of multiple moving objects) was examined in two experiments where the number and speed of moving objects were manipulated. In Experiment 1, observers tracked the whereabouts of visually and semantically distinct objects (pictures), while in Experiment 2 identical objects (circles) were used (cf. the classic tracking task of Pylyshyn & Storm, 1988). When the task required what –where –bindings (Experiment 1), observers fixated longer on the targets (45% of the trial duration) than on the background (35%). However, when identical targets were tracked (Experiment 2), observers fixated most of the time (68%) on the background and only rarely on targets (16%). The results suggest an "ecumenical" solution to this issue: When the task includes distinct objects (e.g. aircraft on a radar display), targets have to be visited serially in order to continuously refresh the identity-location bindings (Oksama & Hyönä, 2008). On the other hand, when the target set is identical (e.g. a flock of white sheep), tracking is carried out using peripheral vision (Pylyshyn, 1989, 2001).

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Selective filters of attention.

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We combined a memory task with the presentation of attentional distractors to get more information about the interface of memory and attention. Digits appeared on different locations on a PC screen. For verbal serial recall the digits had to be recalled, for spatial serial recall the locations of the digits. A distractor was presented synchronized with the relevant items, but the distractor stayed on one location for several trials before it changed its location. At this moment, a selection conflict occurs: What is the relevant and what the irrelevant item. This conflict decreased memory performance, particularly for spatial recall. We compared the distraction effect for a salient and a similar distractor. Eye movements were recorded to monitor how often and how long the distractor location was visited for different memory tasks and different distractors, giving inside in the question, how early we can exclude distractors during memory encoding.

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Evidence for the predictive remapping of visual attention.

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When attending an object in visual space, perception of the object remains stable despite continuous eye movements. It is thought that the stability of the world is due to the process of predictive remapping, in which receptive fields shift to their post-saccadic location before the onset of the saccade. Until now, most evidence for predictive remapping has been obtained in single cell studies involving monkeys. The present study is the first to demonstrate predictive remapping of spatial attention in humans. Immediately following a saccade, we show that attention has partly shifted with the saccade (Experiment 1). More importantly, this shift was predictive (Experiment 2): Before the saccade was executed there was attentional facilitation at the location which, after the saccade, would retinotopically match the attended location. This finding indicates that the focus of attention is remapped predictively in the interval preceding saccade execution.

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Session: Applications 1

Gaze3D - Measuring gaze movements during experimentation of real physical experiments.

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We introduce a method and software to record and analyze three dimensional gaze movements of a freely moving subject during experimentation of a physical setup. A gaze-tracking helmet along with a head tracking unit combined using the open source library 'libGaze' provides a world fixed gaze ray. The movement and intersection of this gaze ray with a digitized 3D representation of the physical setup is recorded. Afterwards it can be replayed and used to calculate 3D fixations on components, basis for further statistical analysis. In this talk we will give an insight in the steps to conduct such an experiment. This example will illustrate the prospects and disadvantages of such an approach that can be used in a variety of research areas.

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Non-contact ocular microtremor measurement.

Emer Kenny

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E. Kenny a,b, M. Al-Kalbani a,b, D. Coakley b, G. Boyle a a Department of Medical Physics and Bioengineering, St. Jamess Hospital, Dublin b Mercers Institute for Research on Ageing, St. Jamess Hospital, Dublin Ocular microtremor (OMT) is a high frequency (~80Hz) low amplitude (150-2,500nm) involuntary tremor of the eye present in all normal subjects. OMT frequency is known to change during coma, under anaesthesia, in sleep, in brain stem death and in certain diseases. Current OMT measurement techniques suffer from a number of limitations. Laser speckle metrology is a candidate for a high resolution, non-contacting, portable OMT measurement system. Laser speckle is caused by the interference of light scattered from a rough surface and gives rise to a random intensity distribution. The resulting speckle can be recorded and processed to measure surface movement in the order of wavelengths. Here we introduce details of new interferometric eye measurement techniques and present the preliminary results obtained using (i) laser light scattered from the sclera and (ii) an OMT simulator. The principles of the techniques will be explained and the experimental method described. We will introduce the concept of using new high frame rate cameras as a solution to the measurement problem.

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Hands-free inspection system as an application of eye-typing interface using saccadic latency.

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We introduced a mechanism for an eye-typing interface and its application to a hands-free inspection system. It is well-known that the designers of the eye-typing system have faced a difficulty known as the Midas touch problem; people look at an object on the computer screen regardless of their intention, and the system cannot differentiate the user's incidental eye movements from the unintentional ones. Our proposed system used the concept of saccadic latency, a silent period of 200 to 250 ms precedes the initiation of a saccade, for identifying the users' intention for inspection process. We first developed an assistive eye-typing system prototype for a certain users who suffered from diseases such as ALS and muscular dystrophy. Compare with conventional eye-typing interface, our proposed eye-typing interface worked well with an average typing speed of 27.1 cpm and error rates of 3.2 percent. We also introduced a hands-free inspection system as an application of the mechanism. The inspection system is coupled with an automated conveyance system and it is typically useful for some industries, where the inspectors require wearing gloves so that they cannot touch the system interface, or the inspectors cannot touch products directly due to food hygiene regulations.

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Improved pupil center detection in low resolution images.

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Thousands of beneficiaries of high quality eye tracking systems prove the value of such systems for people with severe handicaps. For many of them such systems provide the only way of communication without further human assistance. For a large number of affected people however, such high quality systems are not affordable. Within the COGAIN network research is performed to use inexpensive input devices like common "web cameras" to construct simple, medium quality systems for these users. Investigations show that algorithms developed for high resolution systems do not perform sufficiently on such low cost systems. We present new algorithms specifically tailored to such low resolution input devices, based on combinations of different strategies. Approaches like ellipse fitting to gradient derivations, image based correlation with adaptive templates and gradient direction voting are combined to improve the accuracy of pupil center estimation.

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Beauty is in the eye-movements of the beholder.

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Ever since Fechner's early investigations into preference for rectangular ratios, experimental aesthetics has attempted to develop objective methods for studying the ineffable. Eye-movement measurements have been used to investigate how people look at images and applied commercially in the development of advertising, computer interfaces and packaging. We use a combination of dwell time and fixation sequence, which has been shown to correlate with aesthetic preference to provide selection pressure in an evolutionary algorithm. Samples from a population of 5x7 arrays of coloured shapes were presented on a screen and participants were simply instructed to look at the images with no further guidance given. Eye-movements were tracked and the algorithm was allowed to run for 20-40 generations. Individual preferences varied considerably, but subsequent 2AFC presentations of the evolved patterns showed individual preferences for the evolved patterns, with robust preferences being maintained on a re-test performed 7-10 days later. Participants also exhibited a strong preference for their own patterns when compared with those evolved by others. The results show that individual aesthetic preferences can be detected using evolutionary algorithms that take occulomotor statistics as input, providing a reliable and robust paradigm for use in future subjective studies. Suppported by EPSRC Grant 05002329.

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Can relevance of images be inferred from eye movements?

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Searching for images from a large collection is a difficult task for automated algorithms. Many current techniques rely on items which have been manually 'tagged' with descriptors. This situation is not ideal, as it is difficult to formulate the initial query, and navigate the large number of hits returned. In order to present relevant images to the user, many systems rely on an explicit feedback mechanism. A machine learning algorithm can be used to present a new set of relevant images to the user -- thus increasing hit rates. In this work we use eye movements to assist a user when performing such a task, and ask this basic question: "Is it possible to replace or complement scarce explicit feedback with implicit feedback inferred from various sensors not specifically designed for the task?" We give initial results on a range of tasks and experiments which extend those presented in the Multimedia Information Retrieval conference (MIR'08). In reasonably controlled setups, fairly simple eye movements' features in conjunction with machine learning techniques are capable of judging the relevance of an image based on eye movements alone, without using any explicit feedback -- therefore potentially assisting the user in a task.

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Session: Binocular eye movements

How may asymmetry be accommodated by an ocular-motor map?

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This study returns to the often-neglected distinction between the physical world and the visual space that our eyes make of this. These paired eyes are separated by a distance of approximately 65 mm. Once a target has been selected, triangulation allows the eyes to construct of the physical world a visual space that can be geometrically conceptualized as an ocular-motor map. Since accepted methods such as IVC or Hillebrand's model, while accommodating both binocular vision and vision distortion, fail to reflect vision asymmetry, due to their shared presupposition that the ego-center can safely be presumed to be stationary, on the visual midline. Our model instead employs a dynamic ego-center that may shift in position. The adoption of such an ego-center drastically improved test results, bringing them into line with both Ogle's data gained in investigating the Panum area, and also those obtained through array experiments. Given that the angle of vergence functions as a major key factor in the unification of physical view and vision space, the strength of our model lies in its successful unification of the effects of asymmetry with the angle of vergence, producing results that are consonant the tests mentioned above.
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Direct measurement of feedback delay.

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Visual feedback mechanisms driving eye movements face substantial delays between position errors detected visually and the resultant motor response. The saccadic system uses open-loop control to circumvent the control problems associated with these delays, but responses such as oculomotor vergence must rely on visual feedback to attain highly accurate final positions. The response latency includes the other delays along with feedback delay so it can not be used to determine the feedback delay. We have developed a new technique that estimates feedback delay directly from the response. In a feedback control system, the instantaneous velocity is directly proportional to position error; or to prior error if there is delay in the system. The correlation between position error and shifted velocity will be greatest when the shift equals the feedback delay. Simulated responses having a range of feedback delays show that this analysis can determine feedback delay with an accuracy of less than 10 msec. Applying this methodology to vergence eye movement data shows a range of internal delays from approximately 100 msec to 200 msec and in some cases the delays relate directly to overall motor behavior or general visual behavior such as the ability to adapt to progressive lenses.
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Short-term memory studied by saccades and vergence: A TMS study of the role of FEF.

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Objects in 3D space are located at different directions or depth; their fixation requires saccades, vergence or combined eye movements. The frontal eye field (FEF) is known to control initiation of memory-guided saccades. We applied single pulse transcranial magnetic stimulation (TMS) on the FEF. TMS was delivered 100 ms after the offset of the fixation point (the go signal). The results showed: 1) TMS over the left or right FEF prolonged the latency of all saccades (left or right), vergence (convergence and divergence) and both components of combined movements. 2) Only TMS over the left FEF decreases the accuracy of the saccades to right alone or combined with vergence. We attribute saccade latency increase to interference by TMS with the fixation disengagement process and/or with the activity of movement neurons in the FEF known to discharge prior and during memory driven saccades; we suggest similar mechanisms for vergence and combined movements.

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Certain drawbacks caused by diplopia in using the Rosenbach method in order to detect ocular dominance.

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There are several methods of detecting ocular dominance. Due to its material simplicity, the Rosenbach method, which is monoocular, is one of those most commonly used. Not only, however, has ocular dominance not yet been precisely defined; the particular respects in which the ocularly dominant eye is superior in function have not yet been identified. What exactly is the mechanism by which the eye grasps its target object? Does the visual line assist in this? Or is such assistance a function of the field of vision? Binocular test methods likewise face a significant problem, in that they are unable to neutralize the effects of diplopia. It appears generally to be believed that, if the function of the non-dominant eye is temporarily suspended, diplopia cannot affect the results of testing for dominance. Our experiment results have, however, demonstrated that this is not the case. The data indicated that, on many occasions, diplopia impedes the detection of the dominant eye, and that decentered positioning of the target image is the key factor in successful detection. It should be noted that the dominant eye unmistakably shifts from right to left or vice versa, depending on the relative position of the visual target.

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Tuesday 25th August 2009
Symposium: Higher order influences on reading

Exploring the timing of garden path effects on eye movements in reading.

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So-called garden path effects on eye movements sometimes appear as early as the reader's first fixation on a syntactically disambiguating word. However, this timing is variable, with some studies showing these effects first appearing in later measures on the disambiguating word, and other studies finding effects only on downstream material. This talk will present the results of a series of recent experiments designed to assess the contribution of several factors to this variability. The experiments investigated, first, whether the timing of disruption is affected by the frequency of the disambiguating word. If lexical processing must be essentially complete before an input word is attached into the phrase marker, then disruption might be expected to appear later when the disambiguating word is low in frequency. Second, they investigated whether disruption appears most rapidly when the disambiguating word contains an overt morphological cue to its syntactic category, i.e., the regular -ed past tense ending. Finally, they asked whether there are systematic differences in timing depending on the nature of the syntactic manipulation, specifically exploring the hypothesis that garden path effects appear earliest when the parser is in an anticipatory state at the point of disambiguation.

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Using E-Z reader to simulate the effects of higher-level language processing in reading.

Erik D. Reichle and Tessa Warren

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Attempts of model eye-movement control during reading have largely ignored the influence of higher-order language processing. In this talk, we will describe one attempt to redress this limitation using an augmented version of the E-Z Reader model (Reichle, Warren, and McConnell, 2009). The new model assumptions demonstrate how higher-level language processing can operate in the background on on-going lexical processing, remaining largely "invisible" when proceeding without difficulty but causing pauses and/or inter-word regression when encountering difficulty. The model is used to simulate the effects of three sentence-level variables on readers' eye movements: (1) sentence wrap up (Rayner, Kambe, and Duffy, 2000), (2) semantic implausibility (Warren and McConnell, 2007), and (3) syntactic parsing preferences (Frazier and Rayner, 1982). These simulations demonstrate how computational models of eye-movement behavior can be used to evaluate theoretical assumptions about sentence processing. They also suggest that sentence-level variables may provide an important arena for evaluating current models of eye-movement control in reading.

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Wrap-up effects in reading: Evaluating E-Z Reader 10.

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The E-Z Reader 10 model (Reichle, Warren, and McConnell, 2009) provides an account of how post-lexical processing might affect eye movements during reading, by temporarily stopping the forward progression of the eyes. In this talk, we will report on a series of experiments and E-Z Reader 10 simulations we have undertaken to better understand wrap-up effects in reading (e.g. Warren, White and Reichle, 2009). The focus will be on: (1) how E-Z Reader 10 can account for wrap-up, and these simulations might push a slight reconceptualization of one of E-Z Reader 10's post-lexical mechanisms; (2) what aspects of the experimental data E-Z Reader 10 cannot account for; and (3) what similarities and differences across experiments demonstrate about variability in when and whether post-lexical effects appear in the eye-movement record, and what that variability means for modeling and comprehension.

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Post-lexical intervention in eye-movement control during reading: Counterintuitive outputs from E-Z Reader 10, plus areas for future refinement.

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E-Z Reader 10 incorporates two forms of intervention by post-lexical linguistic operations on the control of eye-movements in reading. These are Rapid Integration Failures (RIF), where post-lexical operations suffer complete breakdown; and Slow Integration Failures (SIF), where the higher-level analysis of word N remains incomplete even after lexical work on N+1 has finished. These interventions are relatively short-lived and exert their influence at modest delays, both characteristics that may not be in accord with the empirical data. We measured eye-movements during sentence processing with 60 participants and, corroborating earlier studies, we found that first fixations preceding regressions (and refixations) are shorter than those preceding forward-moving saccades. Under both RIF and SIF regimes, plans for progression to word N+1 are always initiated at an earlier point than those for failure-triggered saccades. Thus, an intuitive prediction from the model might be that shorter fixations should precede progressions – the exact opposite of the empirical findings. In practice, however, explicit simulations showed that over a wide range of conditions, both RIF and SIF readily generate the observed pattern of data. Despite this unquestionable modelling success, imperfections in a range of other predictions point to aspects of the model for which further development is required.

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Lexical priming effects in eye movements during reading.

Kevin Paterson

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Research into the effects of language processing on eye movement control during reading has generally focused on the influence the lexical characteristics of words has on readers' decisions about when and where to move their eyes. In this talk, I will present novel evidence that the lexical relationships between words in a sentence also influence eye movement control. In presenting this evidence, I will focus on findings from a recent experiment by Paterson, Liversedge, and Davis (2009), which show that the experience of processing a word's lexical neighbour earlier in a sentence can carry over intervening words to affect word identification, and that this, in turn, has a rapid influence on eye movement behaviour. I will argue that the fact that this effect occurred between words in sentences read normally indicates that eye movements are sensitive to intra-sentential, inter-lexical influences that occur naturally within sentences. This finding is discussed in relation to accounts of lexical processing in current models of eye movement control and the role of episodic memory in word identification during reading. Paterson, K. B., Liversedge, S. P., & Davis, C. J. (2009). Inhibitory neighbor priming effects in eye movements during reading. Psychonomic Bulletin & Review, 16, 43-50.

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Parsing processes and reading difficulty: A computational investigation.

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Fixation durations during normal reading correlate with syntactic processing difficulty, but the cognitive mechanisms reflected in these measures are not well understood. This study draws on two distinct theories of syntactic processing difficulty to account for German readers' fixation durations. The first theory, syntactic surprisal (Hale 2001), models comprehension difficulty as a change in probabilities of predicting the correct syntactic structure of the upcoming words. The second theory, skilled memory retrieval (Lewis & Vasishth 2005), derives comprehension difficulty from similarity-based syntactic interference and fluctuation activation in working memory. A dependency parser based on the Nivre algorithm serves as a unified architecture to calculate predictions for both theories. Syntactic surprisal accounts for all types of fixation durations except Re-Reading Time, the only purely late measure of processing. In contrast, on the assumption of a serial parser, skilled memory retrieval accounts only for Re-Reading Time. We propose that unlikely structure-building as well as working memory retrieval both tax the sentence comprehension system in ways attested by eye movements. Some of the implications of this proposal for models of eye-movement control will also be discussed.

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Symposium: Top-down and bottom-up

Modeling bottom-up and top-down guidance of eye movements in humans and monkeys.

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Active visual processing of complex natural environments requires animals to combine, in a highly dynamic and adaptive manner, sensory signals that originate from the environment (bottom-up) with behavioral goals and priorities dictated by the task at hand (top-down). Together, bottom-up and top-down influences combine to serve the many tasks which 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 and other primates 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 and eye movement programming 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.

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Dynamic visual representations.

Wieske van Zoest

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Representations of visual information develop over time and this influences how observers select visual information. Here I present eye-tracking and ERP results showing how behaviour in overt and covert visual selection varies as a function of when selection occurs. Eye-movement tracking results show that short-latency saccades are directed to salient stimuli regardless of their task-relevance, while long-latency saccades are directed to task relevant stimuli. ERP results measuring the deployment of covert attention are consistent with these results. This overall pattern of findings is consistent with two claims. First, salience degrades as time passes, and second visual representations integrate endogenous information over time. When observers are slower and more time has been allowed for visual processing, selection is guided by top-down control. Taking into account how representations change over time may lead to new and converging insights in other domains in human visual cognition where time is of critical importance.

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Visual search strategy explained by featural attention modulation of superior colliculus neuronal activity.

Martin Paré and Kelly Shen

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The search for a visual object is thought to entail the selection of visual representations distributed on a visual salience map and modulated by both spatial and featural attention. How the brain translates featural information distributed among several stimuli into single spatial motor programs for eye movements has not been demonstrated experimentally. Here we show that visual search strategies are expressed by the flexible modulation of stimulus-related discharges in sensory-motor neurons in superior colliculus, a midbrain structure believed by many to be exclusively associated with motor processing. The feature-based suppression of activity associated with irrelevant stimuli results in these distracters being filtered out, thereby facilitating the process of discriminating the search target. These findings demonstrate that the superior colliculus is integral to the visual salience map and provide new insights into the interplay between the salience map and the motor system by which eye movements are selected.

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Early and late modulation of saccade deviations by target distractor similarity.

Jan Theeuwes[1], Stefan Van der Stigchel[2] and Manon Mulckhuyse[1]

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In order to inspect the environment, people continuously select objects as saccadic goals. This selection process can be guided by top-down knowledge, or driven by salient bottom-up information. We investigated the time-course of oculomotor competition between bottom-up and top-down selection processes using saccade trajectory deviations as the dependent measure. We used an oculomotor distractor paradigm in which we manipulated saccade latency by offsetting the fixation point at different time points relative to target onset. Moreover, we manipulated relevance of a distractor by making the distractor either similar or dissimilar to the target. Results showed that the strength of deviation was modulated by target distractor similarity. When saccade latencies were short, we found more saccade deviation towards a similar distractor than a dissimilar distractor. However, when saccade latencies were longer we found more saccade deviation away from the similar than the dissimilar distractor. In contrast to previous findings, our study shows that task-relevant information can already influence the early processes of oculomotor control. We conclude that competition between saccadic goals is subject to two different processes with different time-courses: one fast activating process signalling the saliency and task relevance of a location and one slower inhibitory process suppressing that location.

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Sensory adaptation and bottom-up visual processing in the superior colliculus.

Doug Munoz and Susan E. Boehnke

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Salient events in the visual world have consequences on future actions. Stimulus-driven (bottom-up) visual events activate components of the "visual grasp reflex" which have implications for attentional (covert) and oculomotor (overt) processing. The abrupt onset of a visual stimulus (i.e., a cue) may briefly capture attention overtly or covertly. However, after some delay, this initial facilitation is replaced by delayed orienting (inhibition of return: IOR). Here, we show that many of the behavioural consequences of reflexive overt and covert orienting arise from direct mapping of visual signals onto motor systems, and may not require a contribution from higher brain structures subserving cognitive strategies. Monkeys were trained to perform versions of an oculomotor cueing task and neural signals were recorded from the superior colliculus (SC). The visual responses in both the superficial (visual only) and deeper (visuomotor) layers of the SC adapt to repeated sensory stimulation whether a motor response (e.g., saccade) should be made or be suppressed. This reduction in visual responsiveness is correlated with delayed saccadic reaction times that characterize IOR. We speculate that components of reflexive covert orienting can be produced by simple sensory-to-motor transformations in brainstem structures like the SC. Supported by CIHR.

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Saccadic eye movements as a measure of perceptual decision-making.

Eugene McSorley and Rachel McCloy

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We have examined the processes involved in decision-making using saccadic eye movements. The eye movements of participants were recorded as they were asked to saccade to one of two peripheral stimuli (left and right) on the basis of a random dot motion coherence patch shown centrally. The level of coherence was varied. Participants moved their eyes to a target on the basis of the direction of the perceived motion within the patch. We found that correct performance decreased as motion coherence diminished. Saccade landing positions and trajectories were also found to become more affected by the non-target location, ie with decreasing motion coherence strength they were drawn toward the non-target location. Thus, as the decision became more difficult to make (ie the strength of motion coherence decreased) the influence of the other possible choice (ie the other target location) became more apparent in the eye movement response. We suggest that the extent of this is a direct behavioural measure of the relative neural activation associated with each visual stimulus' location which in turn is a measure of activation associated with decision-making.

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Session: Oculomotor control 1

Role of glissades in event detection algorithms.

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Due to over- or undershoots, the eye frequently needs to correct its gaze position at the end of a saccade. This corrective movement is known as a post saccadic drift or a glissade. Current fixation detection algorithms do not take glissades into account as separate events, treating them differently and unsystematically. The duration of a glissade can be added to either a fixation or a saccade. We have devised a new algorithm for separate detection of fixations, saccades and glissades, and investigated the prevalence of glissades as well as how fixation and saccade duration are affected by how the glissades are treated. It has been tested on raw data acquired with the SMI Hi-Speed system from 10 subjects reading for 12-15 minutes. Our results show that glissades can easily be defined as separate oculomotor events, and that they have a significant impact on calculated fixation and saccade duration, as well as saccadic amplitude. We argue that glissadic data should be reported whenever fixation or saccade values are presented.

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Information theory application for tracking eye movements.

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In this research we proposed quality of the smooth pursuit and saccadic eye movements control systems to evaluate using not accuracy, as usual, but measuring amount of information transmitted over the oculomotor system. Using information theory concepts tracking eye movements control system could be defined as information transfer channel. In this case, target trajectory is defined as source (input) information, eye movement trajectory as output information and difference between them (error) as lost information. Continuous-time analog information transfer model was applied for the smooth pursuit system and discrete model - for the saccades. Oculomotor channel capacity or maximum information transferred over channel during unit of time was defined. For a smooth pursuit eye movements control system it is about 5-10 bits/sec and 15-20 bits/sec - for the saccades.

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Saccades to blank regions as indicators of working memory processes.

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In the present study we examined the relationship between oculomotor behaviour and the maintenance of visuo-spatial information in working memory. In a series of experiments participants viewed displays containing several items and were required to memorize the location and identity of these items. After removal of the memory items the display remained blank for several seconds prior to the presentation of a series of memory probes. It was found that participants regularly scanned display regions at which items had previously been presented even though the displays had been blank for an extended interval. Furthermore, oculomotor behaviour during memory rehearsal was related to oculomotor behaviour during perception. The findings indicate that the oculomotor system plays a role in the rehearsal of visuo-spatial information in working memory.

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The spatial pattern of peri-saccadic compression for small saccades.

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Stimuli flashed around the saccade onset are perceived closer to the saccade target (ST) than they actually are. Here, we investigate if such a saccadic compression does exist for saccade sizes shorter than those usually studied. STs were presented at seven locations on the horizontal meridian from 2° to 10° right from the fixation cross. Additionally, a bar was flashed at eleven positions (from 1° to 12° from fixation cross), so that its distance and side relative to each ST varied. Preliminary results show that compression occurs for the smallest saccades. Considering the effect of the bar's side ("before" vs "beyond" ST), when bars are flashed "beyond", there is a gradient of compression depending on the saccade size : for smallest saccade size, only the most distant bars are compressed, and the amount of compression per bar increases with the saccade size. For bars flashed "before" this gradient is less blatant: even the closest bars to the ST are mislocalized, but the amount of compression still increases with the saccade size. We attribute these results to effects taking place in different cortical areas relative to the ST position, and to the different receptive fields size in the areas involved.

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Estimation of temporal motion integration in saccades to moving targets.

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Even in highly constrained experimental situations, saccade latency is subject to a large amount of variability from trial to trial. This is an important issue in considering 'when' and 'where' processes in saccade programming. In the case of moving targets, it is reasonable to suggest that 'when' processing (how long the latency will be on a given trial) will dictate the 'where' outcome – longer latencies result in greater target displacement, which requires a different saccade endpoint. Here, we investigate how speed information about moving targets is integrated in the run-up to a saccade being generated. Participants were presented with two Gaussian patches moving at 18deg/s. The contrast of one of the patches increased unpredictably, indicating the saccade target. In half of the trials the patches were subject to a step-change to either a faster (30deg/s) or slower (6deg/s) speed at a variable interval after the contrast change. We find evidence of a period of motion integration of some 200 ms upon which the speed estimate determining saccade landing position is based. These results suggest that the saccadic system is able to produce accurate saccade landing positions based on a rolling average of target speed acquired during the latency period.

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The Müller-Lyer illusion and saccades: a meta-analysis of 19 independent studies does not support the "two visual systems" hypothesis.

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The two visual systems hypothesis (TVSH) proposes a functional division of labour between vision-for-action and vision-for-perception cortical visual processing streams. Support for the TVSH has come from experiments demonstrating that while perception is affected by visual illusions such as the Müller-Lyer (ML) illusion, actions are substantially immune to the effects of the illusion. We identified 19 papers assessing the effects of the ML illusion on saccadic eye movement and reanalysed their published data using a corrected percentage effect metric. We found that, contrary to what the TVSH would predict, saccade amplitude was always influenced by the illusion. The average percent effect size for 30 experiments, including both between- and within-study variations, was 14.7±1.4 (mean±SEM). There was little evidence that illusion effect size was influenced by the type of saccade required (ie reflexive vs voluntary) or by concurrent hand or arm movement. But it was modulated by display duration and spatial variability of stimuli. Overall, saccade studies provide little evidence of dissociable spatial representations for perception and oculomotor actions.

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Session: Modelling and reading

Eye movements in reading: Learning where to look.

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While machine learning methods have become increasingly influential in computational research on eye movements in scene viewing in recent years, there have been only few attempts to model eye movements in reading using machine learning algorithms. We present research using supervised machine learning techniques to learn the eye movement behavior of individual readers. The model we introduce predicts the saccadic eye movements of an individual reader reading a specific text, using as training data the eye-tracking record for the same person reading other texts. More precisely, the current model is based on three components. First, a transition-based system defining saccadic eye movements, second, a log-linear classifier that predicts the next saccade target, and third, a search algorithm that derives complete fixation sequences over texts guided by the classifier. We report an experiment in which the model is trained on data from ten different readers and evaluated with respect to its performance in simulating the eye movements of each reader when reading previously unseen text. We show that the model performs significantly better than baseline on this task. In addition, we demonstrate that the model reproduces word frequency effects on eye movements observed in human readers.

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Using reinforcement learning to examine word-parsing strategies in the reading of Chinese.

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Reinforcement learning has proven useful in explaining the emergence of eye-movement behavior during reading (Reichle and Laurent, 2006) and in understanding the role of attention in word identification (Laurent and Reichle, 2009). In the present work, we used this modeling approach to examine a key question related to the reading of Chinese: How do readers parse a continuous string of Chinese characters into individual words? Artificial reading "agents" were allowed to learn how to (1) move their eyes, (2) allocate their "attention" dynamically to one or more characters, and (3) parse characters into words, in order to read as efficiently as possible. The agents were trained to perform these actions until all words in the training sentence became identified, subject to visual acuity and attention allocation constraints. Agents were provided with a scalar reward in proportion to the speed with which they completed each sentence. Simulation results showed that the agents adopted different overt (eye-movement) and covert (attention-allocation) strategies when the availability of perceptual and cognitive information, such as visual complexity and predictability, was modulated. These results provide a computational account of how the eye movements of Chinese readers are guided by on-line parsing of Chinese characters into words.

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Models of reading: principles for model development.

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We respond to the review of the current state of eye-tracking research in Rayner (2009) with a set of explicit philosophical principles for the development of implemented computational models of reading. We re-evaluate the conventional views of the relationship between universality, abstractness and concreteness. We make a specific claim of isomorphism between events in the world and their cognitive reflection, and the desirability that computational models should follow suit. This means (a) exploring, by means of implementation, the productive contradictions inherent in all of the component parts of existing models, (b) recognizing the inexhaustibility of such complexity, (c) making the models progressively more concrete by instantiating more real-world detail, and (d) re-evaluating the interactions between components of the models. We provide examples, with data, from differing points along the data-path for word recognition in reading, involving (a) the words themselves, (b) the eyes, (c) the fovea, (d) the visual pathways, (e) the cortical hemispheres, and (f) styles of cortical processing. We discuss the type of model that emerges from this enterprise with respect to issues of parsimony, emergent effects, and coverage of the data.

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Session: Oculomotor control and reading 1

The role of letter position and spacing in reading.

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Research suggests that the first and last letters of a word are more important than the interior letters during reading. A question that has yet to be studied is why this is so. One possibility is that exterior letters are privileged because they are next to spaces and so they receive less lateral masking from other letters. Another possibility is that exterior letters are more important for reading because they are intrinsically related to how we process and access lexical information. In the current study, participants read sentences containing words with transposed letters occurring at the beginning of the word, in the middle of the word, or at the end of the word (in the style of White, Johnson, Liversedge, and Rayner, 2008). Furthermore, in some of the sentences, the spaces were removed and replaced with hash marks. The results indicate that although the first letter of a word has a privileged role over interior letters regardless of spacing (suggesting that it is intrinsically related to processing), the last letter of a word is more important than interior letters only when spaces are intact (suggesting that its importance is driven by the effects of lateral masking).

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Separate word-beginning and -ending N-gram effects in both haploscopic recognition and eye-tracked lexical decision.

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Split foveas will separate letter strings of centrally fixated words such that half-words in temporal visual fields travel to contralateral hemispheres and half-words in nasal visual fields project to ipsilateral hemispheres. We hypothesise that word beginnings and endings will initially be processed separately by each hemisphere. We tested this hypothesis with two experiments: (1) A perceptual recognition task with half words presented briefly and haploscopically; (2) A monocular eye-tracked lexical decision task for each eye. We selected 200 six-letter words from a full range of frequencies and type-count beginnings and endings for both experiments. In (1) we briefly presented half-words to both eyes, either contralaterally or ipsilaterally. People phenomenologically perceived single whole words. Linear mixed effects analyses (with participant and item random effects) showed better word perception for targets presented contralaterally than ipsilaterally. While words with "few" type-count endings were associated with correct word identifications for both sexes, "many" n-gram type-count beginnings favoured females but not males. In (2) participants showed comparable effects in reaction times, controlled for fixation accuracy. Vestigial binocular behaviours were present in monocular processing. All the results are only transparently interpretable within a split fovea paradigm.

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From the global effect to eye movements in reading: The missing link.

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In two-stimulus visual displays, the eyes tend to move towards an intermediate location between the stimuli. This well-known phenomenon referred to as the global effect results from spatial integration processes at the level of the superior colliculus. The present study shows that the same processes are at work in reading and that they are at least partly responsible for the robust effect of launch site on initial landing sites in words. On each trial, participants read word triplets in an animal name search task, while their eye movements were recorded. Words were presented either simultaneously or sequentially at a variable eccentricity from an initial fixation point, with the space in front of the first word being either filled or left empty. As in previous studies, a launch site effect was found; the eyes landed closer to the beginning of the first word as word eccentricity increased. The novel finding was that the effect was greatly reduced in the sequential compared to the simultaneous presentation mode and to a lesser extent in the absence of foveal stimulation. More than a challenge to current models of eye guidance in reading, these results illustrate how spatial integration processes operate in multiple-stimulus visual displays.

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Session: Neurophysiology and eye movements 2

The relation of perisaccadic mislocalization to visual stability.

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Multiple experiments have demonstrated peri-saccadic effects of spatial mislocalization when stimuli are briefly presented or abruptly change their position, such as the misperception towards the saccade target (Ross et al., Nature, 1997), a shift in direction to the saccade vector (Matin and Pearce, Science, 1965) and the inability to detect small displacements (Deubel et al., Prog Brain Res, 2002). On the neurophysiological level, at least two different patterns of dynamic receptive field changes have been observed (Duhamel et al., Science, 1992; Tolias et al., Neuron 2001). Often these experimental findings have been related to the phenomenon of perceptual stability (Wurtz, Vis. Res., 2009). On the basis of two computational models that can account for some of the experimental observations, I will argue that the above phenomena do not all originate from a single mechanism. While the misperception in direction to the saccade target is an attention phenomenon, the misperception in direction to the saccade vector relies presumably on spatial updating. Moreover, I will provide potential explanations for dynamic receptive field changes and discuss how they relate to perceptual stability. According to the proposed framework, perceptual stability relies on spatial and as well on object continuity.

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A computational neural network model of perisaccadic mislocalization in total darkness.

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Normally visual space is perceived as stable across eye movements, but under certain conditions it becomes illusory. We are proposing a computational neural network model to explain a spatial misperception called “perisaccadic shift” which occurs typically in complete darkness (Honda, Vision Res., 1991). Classically, the subtraction theory assumes a continuous extraretinal eye position signal (EEPS) which compensates any saccade-induced movements of stimuli on the retina (Pola, Vision Research, 2004). A major problem of the continuous EEPS is that there has been no neurophysiological evidence for it so far. We improve in several ways on existing models. We use a realistic “binary” eye position signal representing only pre- and postsaccadic eye positions (Wang et al., Nat. Neurosc., 2007) instead of its intermediate path. This eye position signal is accompanied by a phasic corollary discharge signal (Sommer and Wurtz, Annu. Rev. Neurosci., 2008; Sommer and Wurtz, Perception, 2008). Coordinate transformation is achieved by a basis function network (Pouget et al., Nat. Rev. Neurosc., 2002) which is embedded in a fully dynamic model. We show that our model is able to reproduce for the first time new experimental findings (van Wetter and van Opstal, J. of Vision, 2008).

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Measurement and spectral analysis of the cornea displacements due to the cardiopulmonary system activity.

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Our work presents results of measurement of normal displacements of the corneal surface and its deformation due to the respiration and blood pulsation. Normal displacements of chosen points on the corneal surface were registered by use of ultrasound transducers with accuracy of about 2 micrometers and at sampling rate of 100Hz. Deformations of the corneal topography were measured by projection of the ring pattern on the cornea and recording its reflection by fast CCD camera. To detect fine variations of the corneal topography, shape and size of the ring reflections were analyzed. To reduce the head movement, that can influence measured results, we used custom designed head rest with a bite bar. Synchronously with all measurements, the ECG signal or blood pulsation were recorded, at sampling frequency of 100Hz. Frequency and time-frequency analysis of all registered signals were carried out. Coherence function was calculated to examine relationships existing between considered pairs of signals. Results show, that a very high correlation exists between displacements of the corneal surface and cardiopulmonary system for frequency up to about 25Hz. Fine variations of the corneal topography are also linked to the cardiac activity, however this effect is smaller due to the higher noise.

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Session: Visual search

The role of target fixations in the process of recognition.

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Why do we perceive some elements in a visual scene, while others remain undetected? We compared fixations on detected vs. undetected items (Jacob and Hochstein, 2009). Our Identity Search Task display, with 4x4 scrambled arrays of black and white squares, included exactly two pairs of identical cards, while participants search for one. We found that detected pair cards were fixated more often and for longer times than undetected pair cards. In a backward dynamics alignment, we observed a bifurcation point, where these differential characteristics begin. We now conducted another Identity Search experiment, with one target pair, appearing in only half of the displays. Following a variable number of fixations we turned off the display and asked if it contained a target. We find that the greater the number of target fixations, the better the recognition, as measured by a decrease in response time, increases in Hit rate and detectability, d', as well as an increase in participant reported response confidence. We suggest that several target fixations are needed for processing visual information to achieve recognition. Target fixations lead to an early implicit recognition which in turn leads to more fixations, and ultimately to full explicit recognition.

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Expertise and congruency in comparative visual search.

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Two groups of participants – domain specialists (Chemists) and controls - were given a comparative visual search task, where they had to ‘spot the difference’ between two pictures side-by-side. The stimuli either had a difference, no difference but an incongruous feature (e.g. a person with a green hand), a difference and an incongruous feature, or no change at all. Half the stimuli were photographs of Chemistry labs and half were photographs of orchestras. Domain knowledge increased accuracy and decreased reaction time of comparative visual search; Chemists were reliably faster and more accurate on Chemistry pictures than on control pictures and compared to control participants. Regions of Interest analyses showed that participants fixated on incongruous features of the pictures apart from when viewing stimuli from their own expert domain. In these cases, a cognitive override took place and the number of fixations and total time fixated in the ‘incongruous’ region significantly decreased and domain specialists focused on the difference between the picture. First fixation analyses showed that when viewing pictures from their own domain, specialists were reliably less likely to initially fixate on the incongruent feature than control participants.

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The transference of eye movement strategy between two unrelated visual search tasks.

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Three experiments were conducted to investigate the carry-over of a location-based attentional set from a low-level visual search task to a search of natural images, using eye movements as the dependent measure. In each trial participants searched through letter strings arranged horizontally, vertically, or randomly across the screen, and then searched a natural image. Across all three studies the orientation of the letters influenced the spread of search in the picture task; participants showed wider search in the horizontal axis following a horizontal letter search, and wider search in the vertical axis following a vertical letter search. In Experiment Two this 'carry-over' effect also persisted to a second viewing of the natural images. Despite being unrelated to the picture search task, the strategy used to complete the letter search was therefore influencing the way participants searched the pictures. Data from Experiment Three revealed that the strategy used to complete the picture search could also transfer to the letter search. When the task demands in the picture search were manipulated in order to influence fixation duration this had an impact upon fixation duration in the letter search task. The implications of these findings will be discussed.

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Symposium: New ways of usability research based on eye tracking

Multifunctional Usability Analysis and its application to the comparison of eBooks with conventional books.

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Usability analysis is an approach aimed at discovering the users' needs with respect to a tool, recognizing the difficulties and optimizing the ease of handling. We propose an approach, which takes into account different functions of human information processing which are in interaction with each other:
(1) attentional control (measured by eye gaze analysis),
(2) cognitive processes (assessed by verbal reports),
(3) human computer interaction (measured by logfile analysis),
(4) emotional reactions (measured by ratings of facial expressions)
(5) acceptance (assessed by retrospective interviews)
(6) performance characteristics (measures of achievement, errors, failures, success).
We show how the different measures can be integrated in the Multifunctional Usability Analysis within a common framework of human information processing. As an example for the demonstration of this method, eBooks were chosen. E-Books are currently on the rise. They are under discussion because of their alleged equal-to-print readability and their multi-device integration. However, the usability of eBooks is not yet investigated. We report a comparison between the usage of five different types of eBooks and a conventional book. The results will be presented and conclusions will be drawn for possible improvements in eBooks of the next generation.

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Short glances and broad overviews. Measuring attention distribution on websites.

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Web usability research recently has shifted its focus from qualitative to quantitative measures of human attention emphasizing the use of eye-tracking. While numerous devices are now available allowing for unobtrusive and robust measurement of eye movements and fixations, data analysis is often restricted to aggregates of dwell times and graphical representations of scan-paths. Constraints arise from the fact that most calculations are based on predefined areas of interest, which often limits the studies to static presentations of singular (home-)pages. Analyses during truly interactive site visits are mostly limited to replays of screen recordings with overlaid eye-traces. The paper introduces recent methodologies developed to overcome these constraints and to equally serve the needs of basic and applied research. A browser is presented which permits the tracking of web-pages, the objects they contain and the user-gaze. Site-objects can then be selected from the resulting data base and submitted to automated parameter formation and statistical analysis. Special emphasis will be laid on the calculation of an Attention Distribution Coefficient, indicating the diffusion of visual attention on websites. The validity of this value will be demonstrated comparing visual attention during different phases of web inspection using either attention tracking by mouse or eye-tracking.

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The integration of eye tracking with heart rate and skin resistance data yields further insight into usability studies.

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The evolution of miniaturized and wearable sensors allows the recording of many physiological variables during everyday activities without interfering with subjects' behaviour. Galvanic Skin Resistance (GSR), used to identify subjects' relaxation conditions, is measured from two electrodes on the second phalanx of the forefinger and median finger of the subject's left hand. A 1.5μA current flow through the electrodes and the electric potential across these electrodes is measured to estimate skin resistance. The ECG sensors, from which the heart rate (HR) is computed, are textile electrodes embedded in a t-shirt for a real non intrusive monitoring approach. The level of complexity and difficulty that a subject experiences when interacting with the Web is reflected by the patterns of exploratory eye movements and can be inferred from quantitative parameters such as number of fixations, fixations duration, total permanence time, normally used to assess the level of usability. Since HR and GSR signals acquisition can be synchronised with eye movement recording during subject's interaction with the computer, the aim of the study is that of verifying the existence of any correlation among variations of physiological parameters related to stress and emotion with the eye movements parameters, able to provide further insight into usability studies.

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Gaze-controlled interfaces for access to picture databases: Scanpaths in usability research.

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Picture databases can contain millions of digital images that a librarian will need to access. Name tagging or using short verbal labels has been shown to limited effectiveness, and we are exploring the use of scanpaths as an interface between the user and the library. Perhaps scanpaths - sequences of fixations made when looking at an image – are sufficiently unique to help eliminate a large proportion of non-targets, and sufficiently like a signature to an image to help identify a small number of alternatives. To establish the plausibility of using scanpaths as image signatures it is first necessary to demonstrate that users can move their eyes volitionally to indicate their retrieval of a specific object or specific image, and to demonstrate that individuals can generate scanpaths when attempting to retrieve a picture that are similar to those generated during picture inspection. Experiments on object and picture retrieval will be presented, to demonstrate the use of scanpath measures in a gaze-controlled interface.

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Visual transaction in telescience - Gaze information as supplementary tool.

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Telescience requires communication between commander and operator over far distant places, and it brings along conditions of reduced information transmission due to poor video and voice quality and, in addition, to the time delay. These factors cause frequent misunderstandings between commander and operator due to insufficient information about the usually quite complex operations which have to be performed. This situation does not only hold for telecommunication in extraterrestrial space but also for analogous problems in ICT educational systems such as eLearning mediated by internet communication. Usually the video image of the sender is transmitted as an image of the face and upper body. We propose to transmit, instead of such a portrait image of the sender, or in addition to it, the eye fixations superimposed on the image of the visual field, for both, the sender and the receiver. Such a display helps to make visible and to communicate what the sender and receiver are looking at, and such a procedure might ultimately lead to a new kind of mutually shared attention.

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Application of an eye tracking approach to the medical domain - Eye-tracking analysis of skilled performance in pump-oxygenator artificial heart-lung machine operation.

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Pump-oxygenator artificial heart-lung machine (AHLM), which are operated by a clinical engineer during cardiac surgery, require highly sophisticated cognitive processes based on visual information obtained from sources such as indicators in AHLM, doctors, surgical instruments, and so forth. An eye tracking approach is expected to be a powerful means to analyse such processes that are performed automatically and speedily. This paper presents a case study in which an eye tracking approach was applied to analyses of AHLM operation tasks conducted in real cardiac surgery. We recorded four clinical engineers' gaze data combined with their physical behaviour while manipulating the AHLM. The clinical engineers' years of experience in their career ranged from 2 (novice) to 26+ (expert). Through a comparative analysis among the engineers, 16 information sources appeared to be gazed in more than 75% of total time by the expert when starting the machine (approx. 10 min.), whereas only 7 sources were gazed by the novice in an identical task. We also found that the expert showed frequent gaze shifts to many information sources. For the novice, in contrast, the majority of gaze shifts occurred among very few information sources which are critical in the task.

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Session: Eye movements in the real world

Maximising mutual gaze: Exploring social attention in Second Life.

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Mutual gaze is an important component of successful social interaction. Much research into mutual gaze assumes that the way to maximise eye contact in a dyad is to have one conversational partner stare continuously at the eyes of the other. This assumption is open to challenge, on the grounds that it is unnatural and off-putting behaviour, and is likely to result in gaze avoidance behaviour. Here we present a novel paradigm for testing this assumption by recording the eye movements of a user during interaction with a programmed avatar within Second Life, a 3D virtual environment. By manipulating the amount of time the programmed avatar looks into the user's eyes, we aim to establish the amount of such looking behaviour by the avatar that maximises mutual gaze. Second Life is an ideal platform for investigating social interactions, as it provides a high degree of visual and behavioural realism whilst allowing precise control of all aspects of the environment. This method can be used to study social interactions and eye movement behaviour within a highly controllable environment.

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Yarbus goes shopping.

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We used eye tracking in the supermarket to study the differences between the process of making the decision in front of the shelf (on-the-spot decisions) and pre-made decisions. Following Yarbus (1967), we used the same scene, in our case a product shelf, to compare the eye movements between the different strategies. The results show that there are no differences in how much information the consumer acquires either from the entire product shelf or from each individual product using strategies for on-the-spot decisions or pre-made decisions. The difference between the strategies lies in the process itself. The evaluation phase, which is manifested through refixations, is more dominant in on-the-spot decisions compared to pre-made decisions. This implies that strategies used in pre-made decisions are not used to reduce the amount of information acquired while making the decision but to minimize the number of comparisons between different products.

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What do we look at in a museum?

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What do we look at when we visit a museum? Information about visitors' behaviors can offer hints for providing better service in museums. For this purpose, an eye tracking study was carried out in the Nagasaki Museum of History and Culture. Eight pairs of participants were asked to look around the museum for about an hour. Meanwhile, the eye movements of one participant and utterances of both participants of each pair were recorded. Later, the participants were interviewed about their thoughts during their visit to the museum. Results revealed two problems. One problem was paying less attention to exhibits. The large explanation panels on the walls attracted some participants' attention. Thus, they concentrated on acquiring information about the exhibits but failed to look at them. Particularly, in the beginning, they took more time to read all explanations; therefore, they later spent less time in each room. The other problem was difficulty in navigation. There were few signs for navigation, which were overlooked by some participants. They would try to determine their location in the museum by consulting the map. Results suggested the need for improvement in terms of organizing the exhibition and providing more information for navigation.

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Looking at paintings: The influence of titles.

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How do people perceive art? We explore this question using eye-tracking recordings. We recorded eye-movements while participants were looking at famous paintings belonging to various artists and styles. Two factors were varied in a factorial design: the task of the viewer and the information about the painting. The tasks were used: 'aesthetic rating' (rating the paintings for liking) and 'semantic task' (describing the content of the paintings). For half of the viewers no information about the paintings was presented, while for the other half of the viewers paintings' titles were displayed. We analyzed the change in the looking patterns (looking time at various zones, scan paths) related to the painting style, the viewer's task, and the information available. We also compared the aesthetic ratings and the content descriptions. For classical paintings, when the titles were presented, the change in eye-movements was small, but the aesthetic ratings showed a dramatic increase. On the other hand, for surrealist paintings, when titles were presented, the change in eye-movement patterns was considerable, while no change in the aesthetic ratings was noticed. Titles seem to influence the content description in both styles.

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Expertise affects visual-motor lags during continuous sports monitoring.

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Studies of the visuo-motor lag in motor racing (Land and Tatler, 2001) and batting in cricket (Land and MacLeod, 2000) have suggested an expertise-invariant lag of about one second (e.g. Land and Furneaux, 1997). We previously reported that such a constant lag could not account for expert-novice differences in a CCTV monitoring task (Howard et al., 2008). We here examine the relationship between eye movements and manual responses while experts and novices watch a football match. Observers used a joystick to continuously indicate the current goal likelihood. We videotaped a real 5-a-side football match, which was representative of real world inspection tasks in which non task-related salient events frequently occur. We performed correlations between manual responses and the between-subjects variability in eye position. To examine the magnitude of a visuo-motor lag, we repeated these correlations at all possible time lags and searched for the maximal negative correlation coefficient. We find expertise-dependent lags which are longer than would be expected from a constant one second lag. The current task involves a less direct, over-learned, mapping between vision and response and so variable levels of cognitive processing may account for these differences.

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Phenomena of Perception-Action-Coupling in teamsports - An analysis of attention control on the basis of eye movements in soccer.

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We investigate the relationship between the quality of mental representation and that of visual perception by means of the instep-kick. Of particular interest is the interdependency between mental representation structures and the gaze patterns of experts and novices. Twenty experts and twenty novices were shown pictures of soccer players performing the instep-kick and their eye movements were recorded. Red and blue cues were placed either on the ball or near the players' head. Participants had to react to the colour of the cue by pressing a right or left pedal, i.e. their reaction was either compatible or incompatible with the depicted kicking direction. The mental representation structure was ascertained by the Structural Dimensional Analysis-Motoric method (Schack, 2004). Results show that experts have a better mental representation of the instep-kick. They apply a spatial, whereas novices perform a functional gaze strategy. Reaction errors of novices result directly from an attention shift to irrelevant cue positions. Such an attention shift does not usually lead to reaction errors for the experts. The recording of mental representation structures as a cognitive reference structure of performance control and eye movements as an indicator for attention control, is a new paradigmatic approach to sport-related expertise research.

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Session: Oculomotor control 2

Timing is not everything - stimulus onset asynchrony cannot compensate for all effects of contrast in the remote distractor paradigm.

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A distractor presented at the same time as the saccade target prolongs saccadic latency (remote distractor effect, RDE). Previously, we found that high-contrast central distractors did not produce a RDE when target contrast was low (Born, S. and Kerzel, D. 2008. Influence of target and distractor contrast on the remote distractor effect. Vision Research, 48, 2805-2816). We hypothesized that the high-contrast distractor signal arrives too early in the oculomotor control structures to compete with the slower signal of the low-contrast target. This suggests that differences in contrast may be compensated by stimulus onset asynchrony (SOA). Presenting the high-contrast distractor slightly after the low-contrast target will delay the distractor signal, thereby matching arrival times of the two signals. Strong competition and a large RDE should result. In a first experiment, we varied target and distractor contrast as well as the SOA. When distractor contrast was higher than target contrast, the RDE indeed reemerged when the distractor was presented after the target. However, a distractor of lower contrast than the target failed to produce a RDE at all SOAs. Therefore, a pure temporal explanation cannot account for all effects of contrast on the RDE.

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Non-visual signals used for programming sequence of saccades originate downstream from the locus of saccadic adaptation.

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Saccadic eye movements allow precise perception of our environment by bringing to our fovea the image of objects of interest. Because of their high velocity, these movements cannot be modified during their execution; nonetheless their accuracy is maintained by adaptation mechanisms despite physiological or pathological alterations. We studied here whether adaptation of a single saccade direction affects a sequence of two saccades directed either to rapidly flashed targets or to a peripheral target and back to initial position. We used the double-step target paradigm to increase (forward adaptation) or decrease (backward adaptation) the amplitude of reactive or voluntary rightward saccades in separate conditions. In all 4 conditions, rightward saccade adaptation largely transferred to rightward saccade 1 of the sequence, and this adaptive change was highly compensated by a modification of the horizontal amplitude of saccade 2 performed in the non-adapted direction. This compensation suggests that non-visual feedback necessary for saccade 2 programming encodes the veridical amplitude of saccade 1 and therefore originates downstream from the adaptation locus. In addition, differences of adaptation transfers to saccade 2 when performed in the adapted direction confirm that forward and backward adaptation, for both reactive and voluntary saccades, rely on separate mechanisms.

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Does size really matter? Influence of visual stimulus properties on saccade metrics in two-stimulus visual displays: revisited.

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Visual stimulus properties such as stimulus size influence the landing position of visually-triggered saccades in complex visual displays. Stimulus size is intrinsically confounded with other parameters such as the area within the stimulus boundaries and the location of the boundaries. The objective of the present experiments was to disentangle the respective contributions of these parameters. To assess the influence of the location of stimulus boundaries independently of size and luminance, the orientation of ellipses (vertical vs. horizontal) was varied; the size of the stimuli (circles) was also manipulated. Participants performed a saccade-target task in one- vs. two-stimulus visual displays with stimuli presented at variable eccentricities on the horizontal axis. When two stimuli were displayed, saccades landed at an intermediate location between them, showing a 'centre of gravity' or 'global' effect. Interestingly, this effect was a function of size but not boundary location. Our results suggest that the area covered by the stimuli is more critical for specifying saccade metrics than the location of stimulus boundaries.

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What can a moving dot tell us? Language interferes with the attentional control of eye movements.

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The questions of concern are first, whether high-level cognitive functions can influence low-level motoric responses; second, if this is the case, how their interaction is achieved. Specifically, we explore how the semantics of single words affects the psychophysics of eye movements via a common attentional mechanism. We find that word meaning has a systematic effect on oculomotor control regardless of the type of the eye movement (pursuit or saccadic), the type of the word (verbs or nouns), and whether the target is present or absent. All results will be discussed under a framework of attention in which it functions at a system level.

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Control of fixation durations: Experiment and model.

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Eye movements are used to study cognitive processes. Nonetheless, the relation between fixation durations and cognitive processes remains unclear. While the direct control hypothesis assumes that fixation durations reflect processing demands at the fixation location, the indirect control hypothesis assumes that fixation durations are adapted to current task demands, but are unaffected by the current fixation location. We studied the adjustment of fixation durations to a stepwise change in processing difficulty. Participants searched for a closed ring in a sequence of rings with a small gap. We manipulated processing difficulty by varying similarity between target and distractors (variation of gap size). For increasing processing demands, fixation durations increased immediately. For decreasing processing demands, fixation durations remained unaltered on the first fixation. Subsequent fixation durations were adjusted to processing demands. The results suggest indirect control of fixations durations with a delayed adjustment to task demands. However, increasing processing demands can immediately prolong fixation durations. We successfully reproduce the results with a computational model that is in agreement with fixation durations in other continuous oculomotor tasks.

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Examining attention allocation in gaze-contingent visual search tasks using diffusion models.

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Two eye-movement experiments examined whether attention is allocated serially or in parallel during three visual search tasks using 2-8 character arrays subtending two degrees of visual angle: (1) single-feature detection; (2) conjunctive-feature detection; and (3) ordered-feature detection. In the first experiment, participants' eye movements were recorded; in the second, a gaze-contingent paradigm was used to evince covert attentional shifts. Behavioral and eye-tracking data suggest that, in the single-feature detection task, attention is allocated in parallel, with target detection RTs being unaffected by the number of distractors. In contrast, the conjunctive- and ordered-feature detection tasks seemed to require serial attention shifts, with RTs and number of fixations increasing linearly with the number of distractors. These results suggest that tasks necessitating feature binding and/or maintaining feature order require serial allocation of attention. This hypothesis is tested using computational modeling: Random-walk (diffusion) models of parallel and serial search (Thornton and Gilden, 2007) are fitted to the experimental data to determine which type of search best accounts for the patterns of reaction times and error rates in the three tasks.

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Symposium: Prediction in smooth pursuit eye movements

Smooth pursuit eye movements as a handle to quantify anticipation.

Uwe J. Ilg and Sylvana Freyberg

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Classically, smooth pursuit eye movements can only be executed in the presence of a moving target. However, if the appearance of such a target is highly predictable, human subjects can execute smooth pursuit without retinal image slip. Initially, we modified the gap paradigm in which the disappearance of the central stationary fixation target indicates the motion onset of an initially invisible pursuit target. This target becomes visible with a delay of 500 ms. We asked whether there might be substantial differences in the ability to perform anticipatory pursuit between human subjects and rhesus monkeys. We found that both species were able to produce smooth eye movements adjusted to the expected target velocity. Subsequently, we addressed the underlying neuronal substrate in our monkeys. In previous studies, we have shown that individual neurons in the medial superior temporal area (MST) respond to eye velocity in the absence of retinal image motion. Here, we report very similar response properties from frontal eye field (FEF). In addition, we recorded neurons that increased their firing rate during the gap in a directionally selective nature. In conclusion, the analysis of smooth pursuit offers a possibility to quantify the ability to predict future events. The activity of single neurons in the frontal cortex carries information about these events. Supported by DFG IL 34/6-1
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A neural network model of target motion storage that simulates both anticipatory pursuit and prediction in periodic pursuit.

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Prediction is required in pursuit to overcome delays in central processing. Evidence suggests this is largely accomplished through rapid acquisition of target motion information from prior stimulation and subsequent replay of stored information in anticipation of future target motion. In previous representations of this concept gain and phase of sinusoidal pursuit were successfully simulated by assuming storage was accomplished by a delay line acting as a buffer memory (Barnes, 1994), a biologically unrealistic solution. A neural network model has now been developed that could more realistically represent the storage process. The network takes as input a time-base signal, which it converts into a representation of any arbitrary target trajectory. Trajectory information is derived from an internally reconstructed representation of target velocity via an efference copy mechanism. Timing is derived from the same internal signal if periodic or from independent timing cues signalling onset of repeated transient stimuli. Network incorporation within the efference copy loop allows gain and phase of sinusoidal pursuit to be simulated over its normal frequency range of operation (~0.1-2Hz). Additionally, as an emergent property, the network generates realistic anticipatory movements to repeated transient stimuli. Barnes, G.R. (1994). In: Information processing underlying gaze control. Pergammon Press. pp. 279-290.

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The neural correlates of velocity storage in predictive smooth pursuit eye movements.

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Predictive ability in smooth pursuit is reliant upon the successful storage and subsequent release of velocity information. Without this predictive store, smooth pursuit usually relies on visual feedback of a stimulus to invoke smooth movements of the eyes. It has been previously suggested that the storage of this short-term velocity information is reliant on a network of brain areas including MT, FEF and DLPFC (Schmid et al., 2001; Lencer et al., 2004). In this experiment we developed a novel smooth pursuit task to uncover mechanistic differences in the storage of predictive information between "active" following and "passive" observation of a smooth pursuit stimulus. During this task subjects were instructed (via a coloured visual cue) to either follow two identical serially presented smoothly moving targets (Go-Go, active following), or maintain fixation during the first presentation and follow the second (NoGo-Go, passive observation). This paradigm resulted in greater predictive responses to the active condition when compared to the passive condition in the eye movements. The significant differences in the network of brain areas involved in the storage of short-term velocity information for these conditions will be discussed.
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Can predictive mechanisms help patients with severe mental disorder to overcome a sensorimotor deficit during smooth pursuit?

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To what extent predictive mechanisms during smooth pursuit are impaired in patients with schizophrenia and under which circumstances they are sufficiently intact to compensate for sensorimotor processing deficits is still an open question. We assessed unmedicated patients with severe mental disorders on fully predictable oscillating tasks, less predictable pure ramp and foveo-petal step-ramp tasks, each presented at a range of different target velocities. With less predictable tasks, patients with schizophrenia, bipolar disorder and major depression with psychosis demonstrated reduced pursuit initiation and maintenance gains whereas pursuit latencies and the error of catch-up saccades on moving targets were unaltered. In patients with schizophrenia, introduction of second generation antipsychotic medication further led to a considerable reduction of pursuit gains in less predictable tasks. In all patient groups, maintenance gains with predictable oscillating tasks were normal compared to healthy participants, irrespectively to the influence of medication. The results underline the notion of sensorimotor dysfunctions underlying the smooth pursuit deficit observed in patients with severe mental disorder that may be worsened by second generation antipsychotic medication. Unaltered predictive mechanisms provided by cerebellar mechanisms may help to compensate for such sensorimotor dysfunction. Also, there was no evidence for a pure motion processing deficit.

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Evidence for specific velocity processing impairments during smooth pursuit in patients with schizophrenia.

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The aim of this event-related f-MRI study, 3T, was to further elucidate the underlying mechanisms of target velocity processing during smooth pursuit in schizophrenia. To specifically evaluate velocity effects during visual and non-visual pursuit, velocity ramps of different target speeds were presented in randomized order both with and without intervals of target blanking. Seventeen patients with schizophrenia and 17 age-matched controls participated. Eye movements were registered during scanning sessions. Compared to controls, neuronal activity in patients was generally reduced in V5 and basal ganglia, but was increased in cerebellar regions. More specifically, regression analysis of visual pursuit showed that in patients target velocity was not associated with either supplementary eye field, basal ganglia or cerebellar activation and was less strong correlated to neuronal activity in V5 than in controls. During ramps with target blanking only slight differences between groups were found with respect to velocity related activity in frontal and supplementary eye fields and V5. In cerebellar regions, correlations in patients were weaker than in controls. Velocity processing in sensory-motor networks is impaired in patients with schizophrenia during pursuit with continuously visible targets. During target blanking, patients seem to rely less on cerebellar mechanisms than healthy participants.

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Symposium: Gaze guidance

Gaze guidance: Unobtrusive modulation of visual processing.

Peter De Graef, Geoffrey Hamon, Tiberius Strat, Vasile Buzuloiu, Erik Groenewold, Frans Cornelissen and Karl Verfaillie

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Visual information processing is selective and strongly biased towards processing the information that is currently fixated or that is about to be fixated. In the past decade, great progress has been made in understanding what image characteristics of the visual stimulus are likely to draw a viewer's attention and gaze, and how the viewer's task set will influence the ultimate saliency of various image regions. The goal of our research is to use this knowledge in order to effectively and unobtrusively guide a viewer's gaze towards the image locations that are most relevant to task performance. By carefully controlling timing and intensity of gaze guidance manipulations relative to position and duration of the ongoing fixation, this external control over visual processing can reach high levels of efficiency without interfering with normal visual processing. This will be demonstrated using examples from various visual search tasks in which we enhanced or decreased viewers' performance by selectively enhancing or decreasing the attentional saliency of task-relevant image regions.

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Looking and acting: Vision during natural behaviour.

Ben Tatler

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While understanding the role of the eyes and vision in natural behaviour is surely a key goal in eye movement research, most current understanding is drawn from studies of how people look at static pictures presented on computer monitors. This popular picture-viewing paradigm is often considered an analogue of how observers look at real environments. However, picture-viewing is a very limited domain of explanation for gaze allocation in natural behaviour. Not only are the stimuli and display conditions very unnatural, but also much of the work has employed a 'free viewing' task in which no explicit instructions are given to viewers. The recent models that are emerging as explanations of picture-viewing require a set of assumptions in order to generalise to natural behaviour, which do not hold up to empirical scrutiny. In this talk I will consider the limitations of current picture-viewing approaches and models and instead emphasise what can be learnt from studies of eye movements during natural behaviour. There emerge consistent principles for eye guidance in natural behaviour, suggesting new theoretical accounts of eye guidance. Importantly, these principles have not been uncovered from static picture-viewing paradigms, highlighting the importance of studying eye movements under natural conditions.

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Continuous manual responses and continuous gaze tracking during closed circuit television (CCTV) monitoring.

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The typical CCTV operator is required to monitor a large number of events to identify potential incidents. This is an active task in which the eyes move from event to event and operators rate the potential risk associated with each event. Here operators watched real CCTV footage and moved a joystick to continuously indicate perceived suspiciousness during continuous gaze recording. By comparing manual responses with between-subjects variability in eye position at each time, we examined the magnitude of the visuo-motor lag. We performed correlations at all possible lags between these two measures and searched for the maximal negative correlation coefficient. The presence of a visuo-motor lag of around one second has been proposed for a range of tasks including motor racing, batting in cricket, making tea and sandwiches and has been suggested to be constant across levels of expertise (see Land, 2006). However, in CCTV monitoring there is a heavy cognitive component to the task. We report both substantially longer lags and an effect of expertise. We propose that these measures provide a novel way to calculate lags across a range of tasks as well as to identify critical spatio-temporal episodes in CCTV footage.

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Gaze guidance: Developing design recommendations from psychophysical experiments.

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The idea of gaze guidance is to lead a viewer's gaze through a visual display in order to facilitate his/her search for specific information. This study elaborates on the process of guiding gaze from one spatial position to another, whereby the goal is to create a guidance process that is as least-obtrusive as possible. A list of guidance aspects is discussed and to explore some of those aspects, an experimental framework is introduced in which subjects perform a difficult letter search and identification task in dynamic 1/f noise. To facilitate this recognition task, the viewer is guided by a luminance 'marker'. It is investigated how the marker's spatio-temporal properties influence the recognition performance. For instance, motion markers are better gaze attractors than static markers – not surprisingly – however they are potentially detrimental to recognition performance at their location of appearance due to masking. We also characterize the orienting properties of saccades and find that undershoot is compensated by attentional shifts – again not surprisingly – but only to a certain degree. From such results we derive a number of design recommendations for the process of gaze guidance, and we discuss how such gaze guidance can be achieved in natural videos.

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Session: Scene Perception

Frequency and predictability effects on eye fixation time in real-world scene viewing.

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When reading texts or viewing real-world scenes, humans move their eyes to retrieve information. For text reading, the duration of eye fixations was found to decrease with greater word frequency and predictability of the currently fixated word (see Rayner, 1998, for a review). However, it has not been tested whether the results of text reading studies apply to scene viewing studies in analogous ways. This study computed object frequency and predictability from both linguistic and image data sources. Latent Semantic Analysis (Landauer, et al., 1998) was applied to estimate predictability based on a linguistic corpus and on the LabelMe image dataset. In a scene-viewing experiment, the effects of object frequency, predictability, and size on fixation duration measures were examined. For the linguistic source, we found significant influences of frequency and size on gaze duration (GD) and total time (TT). Surprisingly, the frequency effect was opposite to the one found in reading studies. For the image source, frequency had an effect on GD, predictability had effects on first fixation duration (FFD), GD, and TT, and size had effects on GD and TT. Similar to reading studies, GD decreased with higher frequency, but predictability effects were inverted as compared to reading studies.

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The relative contribution of scene context and target features to visual search in real-world scenes.

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Many experiments have shown that knowing specific target features improves search efficiency. In addition, it has separately been shown that scene context can facilitate object search in natural scenes. In the present study, we concurrently examine how these two sources of information impact search efficiency and determine if they interact. Using eye movement measures, we also investigate how target features and scene context impact two components of search: early attentional guidance processes and later verification processes involved in the identification of the target. We find that although responses show a greater efficiency gain for knowing the target features versus the scene context, this advantage is not seen in the attentional guidance component. Both top-down sources contribute equally and independently to improving guidance, but target features also increase the efficiency of target recognition.

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Memory for objects in scenes: acquisition and recall.

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We report two experiments investigating visual encoding and memory for objects in scenes. Eye movements were recorded as participants inspected a photograph of a room that contained 12 objects in preparation for a memory test. Participants were then taken to the room, presented with 24 objects (12 in the photograph, and 12 distractors), and instructed to select and place the original 12 objects accurately in their locations. Experiment 1 varied viewing duration (5 or 10s) and test delay (zero or 24 hour delay), while Experiment 2 varied object saliency (6 objects were made salient by enclosing each with a green outline box). Salient objects were fixated more often and more quickly than non-salient objects. Object and location memory were better for longer than shorter viewing durations and for immediate than delayed recall. Of greatest interest is that object selection and placement accuracy were both better when the object was fixated during acquisition in both experiments. We conclude that scene perception and the nature and quality of the memory representation for objects in scenes are fundamentally related.

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Semantic recognition precedes affective evaluation of complex visual scenes: Evidence from rapid classification with saccadic eye movements.

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We compared the latency of affective and semantic recognition by using a forced-choice saccade response task. Participants viewed paired emotional and neutral scenes involving humans or animals flashed rapidly to the periphery and preceded by a gap period. The participants were instructed to saccade as quickly as possible towards the location previously occupied by a predefined target scene (e.g. unpleasant scene or a scene containing an animal). It was found that both affective and semantic target scenes could be reliably classified in less than 200 ms, but semantic classification was always faster than affective classification. This pattern of results was also observed when manual responses were required and target scenes were presented singly to foveal vision, but foveal presentation speeded up the recognition of affective targets more than that of semantic targets. Low-level differences between the images cannot explain the results. These findings suggest that affective analysis of scenes cannot bypass object recognition.

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Investigating cultural diversity for extrafoveal information use in scenes.

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Culture shapes how we look at faces. We have shown that Western Caucasians predominantly fixate the eyes during face recognition, whereas East Asians focus more on the nose region (Blais et al., 2008). Moreover, by restricting extrafoveal information with a gaze-contingent technique, we recently revealed that cultural factors uniquely shape the strategies used to extract information from faces, but do not modulate facial information use. Both Westerners and Easterners rely on information from the eye region to achieve face recognition, but fixate on different face areas during information extraction (i.e., Westerners on the eye region; Easterners on the nose region). Therefore, fixations towards the nose region used by Easterners suggest a more effective use of parafoveal information for this group of observers compared to Westerners. Here, we directly investigated this hypothesis by using a gaze-contingent technique designed to dynamically obscure central vision with parametric blindspots, permitting only extrafoveal information use. The task was to detect and subsequently identify animals in complex visual scenes. The culture of the observer impacted on performance as a function of the gaze-contingent blindspot and target sizes (2º, 5º or 8º of visual angle). These results support the view that cultural determinants influence visuo-attentional processing.

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Session: Dyslexia

Controlling overt attention in dyslexia during bi-stable image perception.

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Recent findings by Manahilov et al. (2008) suggest that dyslexics have reduced abilities to control facilitative and suppressive processes during fixed-focus perceptual rivalry tasks. Here, we present data from dyslexics and non-dyslexics freely examining bi-stable Rubin vase/face images. Subjects performed a standard passive rivalry task and tasks requiring to hold or switch the dominant percept. Results confirm that dominance durations significantly increase (hold) or decrease (switch) relative to the passive condition for non-dyslexics, whereas dyslexics show significantly weaker effects of attentional control in hold and switch conditions. We tested if these effects reflect different behaviour of eye movements in dyslexics and non-dyslexics during perceptual rivalry. Oculomotor data show that clustering gaze points produces more spatially confined attention areas for non-dyslexics than for dyslexics. For non-dyslexics, these areas are located almost exclusively around the geometric centre or do not deviate from (semantically) salient points of the respective percept. Dyslexics‘ saccades are significantly longer and not directly targeted at such saliency points, displaying less "purposeful" attention patterns scattered across larger stimulus parts. Considerable between-subjects variations within the dyslexics groups indicate, however, that apparent deficits in controlling suppression and facilitation in overt attentional processes during perceptual rivalry may not persist in all dyslexics.

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Non-dyslexic and dyslexic readers' gaze and eye-voice span differences on object naming tasks.

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We synchronise eye-movements and voice data to examine the cognitive processes underlying reading fluency. Jones, Obregón, Kelly and Branigan (2008; Cognition) compared dyslexic and non-dyslexic readers on letter versions of Rapid Automatized Naming (RAN), manipulated for visual (p-q; b-d) and phonological (g-j; q-k) confusability (similarity) vs. non-confusability (P-Q; B-D and k-g; q-j respectively). Confusable conditions implicated longer gaze-durations for non-dyslexics and longer eye-voice spans (production times) for dyslexics. The current experiment compared non-dyslexic and dyslexic readers on a RAN-objects task. We examined whether the dyslexic readers' eye-voice span lag extends to global visual and phonological confusability (e.g., whether pen – nail; pen – pig elicit eye-voice span lags compared with the non-confusable pen - shoe). We also examined whether dyslexics' eye-voice lag is characteristic of a general problem with confusable stimuli, extending to the semantic domain (e.g., pen – desk). Our results show that both groups show domain-general influences on gaze durations and eye-voice spans. Dyslexic readers again show more persistent deficits in the eye-voice span measure. Semantic similarity also influenced naming times. We discuss these findings in terms of domain-general influences on naming times, in addition to implications for our understanding of non-dyslexic and dyslexic reading fluency.
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Eye movements in acquired dyslexia: Case studies of 'segmental' and 'lexical' reading in aphasic patients.

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Except for recent work on pure alexia (Behrmann et al., 2001; Johnson and Rayner, 2007), no research has so far attempted to analyze word based viewing time measures and local fixation patterns in acquired dyslectics. We report data on two patients with moderate non-fluent aphasia that were asked to read lines of target words aloud. Based on linguistic error analysis, patient WG was classified as a segmental and CM as a lexical reader. WG's reading was characterized by scanning in small steps as reflected in short progressive saccade amplitudes and very long first pass gaze durations that increased substantially with word length. Re-inspections of the same word were quite rare, with number of passes comparable to controls. Initial saccade landing sites were centered on the first letter irrespective of word length. In contrast, CM showed dramatically shorter gaze durations, which even decreased for longer words, combined with a dramatic increase in total reading time. It appeared that, with long words, CM tended to give up on whole word recognition during first pass reading and preferred to re-inspect words several times. This 'jumpstart strategy' did not have an impact on first fixations and saccade landing position varied with word lengths.

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Dyslexic children and control group eye movement differences for Chinese texts comprehension.

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Word-based processing strategy play important role in Chinese reading has been well-documented special for skilled readers. A clearly developmental tend is while Chinese children's character knowledge increased, they are more sensitive to word characteristics, and adopt word-based processing like skilled readers do. We assessed the eye movements for Chinese dyslexic children (8-12 years) and control participants (8-11 years) in reading four short texts. There was a developmental shift from word-based processing at older unimpaired children to pre word-based processing at younger unimpaired children. In the current study, dyslexic children's Scores of Chinese characters was increased as their age. However, no matter how older dyslexic children are, their initial processing time was not influenced by word-level characteristics. This result revealed that dyslexic children do not develop word-based processing strategy even they know more and more Chinese characters.

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Session: Oculomotor control and reading 2

Eye movements and display change detection during reading.

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In the boundary change paradigm, when a reader's eyes cross an invisible boundary location a preview is replaced by a target word. Readers are generally unaware of such display changes due to saccadic suppression. However, some readers detect changes on a few trials and a small percentage of readers detect many changes. We conducted a series of studies in which we combined eye movement data with signal detection analysis to investigate aspects of display change detection. On each trial, readers had to indicate if they saw a display change in addition to reading for meaning. On half the trials the display change occurred during the saccade (immediate condition); on the other half, it was slowed by 25 ms (delay condition) to ensure that a change would be detected. The various conditions involved case changes and letter changes. Results indicate that the relationship between the preview and the target influenced both change detection and fixation times. In the immediate condition, change detection was better when letters changed than when case changed. However, in the delay condition (where d' was much higher than the immediate condition), detection was equal for letter and case change. Implications for preview benefit findings will be discussed.
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Information acquisition after the skipping of words during reading.

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Not all words are fixated during skilled reading. Skipping can be due to successful parafoveally processing of the next word in the text and/or to oculomotor error. We created erroneous skippings in Experiment 1 by masking a short three-letter target while it was visible in the right parafovea. The target was shown immediately after it was fixated or skipped. No target masking occurred in a control condition. Although target skipping was more common in the control condition, it was also relatively frequent in the masking condition. Masked target skipping was followed by longer post-target fixations and more regressions. In Experiment 2, the post-target word was either fully visible or its center letters were masked for 50 ms after target skipping, the expectation being that a delay in useful post-target information should not impede post-target processing, if readers had to process a masked skipped target before useful information could be extracted from the (erroneously) fixated post-target word. The results were in general agreement with this expectation. They are thus in broad agreement with the view that readers seek to complete the processing of a skipped word before useful information is sought from the next word in the text.
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Eye movements during reading of randomly shuffled texts.

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Eye movements in reading are the result of the coordination of visuomotor behavior, dynamic allocation of attention, and language processing. The importance of cognitive processes related to language comprehension relative to visuomotor aspects of saccade generation is an open research problem. Here we investigate various eye-movement measures during reading of randomly shuffled texts compared to normal reading. In shuffled texts, words from texts are presented in random order. Thus, recognition of single words is present, while other important characteristics of text reading (e.g., syntax, semantics) are suppressed. We observe that refixations occur more frequently and word skippings less frequently in this reading condition. These results lend support to a more serial processing strategy for shuffled texts compared to normal reading. However, we also replicate strong effects of distributed processing over several words at a time from text reading (Kliegl, Nuthmann, and Engbert, 2006). Based on analyses of statistical linear mixed-effect models, we show that our results are compatible with the hypothesis that the perceptual span is more strongly modulated by foveal load (Henderson and Ferreira, 1990) when reading shuffled compared to normal text. We argue that parallel models of word processing during reading can readily account for this result.

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Mindless reading? A new paradigm for visuomotor control and distributed processing during reading.

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Prior attempts to study “mindless reading” using strings of meaningless letters were limited by a lack of clear task specification, which might have invited more or less deliberate scanning strategies. Based on work by Hooge & Erkelens (1999), we developed an alternative paradigm in which visual and cognitive parameters can be varied to approximate visual processing demands in continous silent reading. In this “Landoldt-C scanning task” strings of ooooo are arranged like a line of text and participants are asked to detect strings that contain an open target, as in oocoo. The current version of this task was developed in several iterations and validated in studies with college and elementary school students. Fixation probabilities, saccade amplitudes and landing positions are virtually identical to those found in normal reading. Initial fixation durations and refixation rates are also very similar, while regressions rates and time spent re-reading strings are lower due to the absence of comprehension demands. Importantly, an experiment using saccade contingent display changes demonstrated significant parafoveal preview effects when a target was presented in the parafovea. We conclude that the Landoldt-task not only approximates the spatiotemporal dynamics of continuous reading but also shares typical characteristics of distributed processing.

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Readers use Bayesian estimation for eye-movement control.

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During reading, saccadic eye movements shift words into the center of the visual field for word processing. Saccadic landing positions within words show a pronounced peak close to the word center with an additional systematic error, which is modulated by the distance of the launch site and the length of the target word. Here we show that the systematic variation of fixation positions within words, the saccadic range error, can be derived from Bayesian decision theory. Using eye-movement data, we demonstrate that human subjects use Bayesian estimation for saccade planning during reading. Our results solve the long-standing debate on the presence or absence of a saccadic range error in visual-cognitive tasks by demonstrating that the saccadic range error is a consequence of Bayesian estimation implemented in our visuomotor system.

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Session: Applications 2

Comparison strategies of different event types in different graph types.

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This study aims to investigate the comparison strategies on different event types (trend or cyclic events) represented by different graphs (round or linear graphs). A novel round graph type was designed for that purpose. Three hypotheses were investigated: H1: graph type affects comparison strategies; H2: event type affects comparison strategies; H3: graph type and event type interact. A pilot study was performed with 8 subjects. Number of fixation, gaze time, fixation duration, reaction time, number of transitions between the elements of the graph (scanpath) and recognition were measured. Preliminary analyses showed that graph type had no main effect on the understanding of the events (H1 rejected). As expected in H2, trend events (e.g., change of temperature according to years) needed less gaze duration than cyclic events (e.g., change of temperature according to months in a seasonal scale), however, event type did not differ in the other dependent variables. For all dependent variables, interactions between graph type and event type were obtained (H3 accepted). Cyclic events were less well recognized, were looked at longer and more often with more transitions in linear graphs as compared to trend events. However trend and cyclic events were equally well interpretable in round graphs.

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Pies with EYES: The limits of hierarchical pie menus in gaze control.

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Pie menus offer several features which are advantageous especially for gaze control. In manually controlled pie menus, there exist already studies about the optimal number of slices per pie and of depth layers. However, gaze input is different, not only in spatial accuracy but also in the underlying cognitive processes. Therefore, we investigated the layout limits for hierarchical pie menu in gaze control. Our user study indicates that providing six slices in two depth layers guarantees fast and accurate selections. Moreover, we compared two different methods of selecting a slice. Novice performed well with both, but selecting via selection borders produced better performance for experts than the standard dwell time selection. Furthermore, we studied the effect of learning using pie menus. Even after 128 selections, participants continued improving significantly their efficiency in item selection, with a constant and relatively low error rate. After training, users were capable to select a complete path by marking ahead (without visual cue), where the selection time achieved did not differ from performance reached within the first 32 trials. This confirms the findings with mouse interaction, providing novice users a comfortable and easy to learn interface.

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How students read mathematical representations: an eye tracking study focusing on data over time.

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How do students, with different background knowledge in mathematics (novice vs. experts), read a mathematical representation such as a text, a formula or a graph? 46 students matched one form of a mathematical representation to one out of four alternatives in another form. For example, a formula is matched to the correct text alternative. We developed a new approach to examine eye-movement data over time. First, the proportion over time graphs examines the distribution of attention allocation on the mathematical representation and we can distinguish features such as whether the reading is ordered or not. Secondly, we use transition sequences with unique AOI to investigate the dynamic aspects of student's behaviour. For example, we compare the type of transitions such as pair-wise comparisons vs. overview-looking of the mathematical representation. Further, we determine which is the most probable path a student will take at a given time. Our initial analyses indicate quantitative and qualitative differences between the two groups. For example, the expert group is more systematic and spend more initial time on the mathematical representation than on the alternatives compared to the novice group. We discuss some implications for mathematics education, and the benefits and generalization of the new approach.
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ScanMatch: A novel method for comparing saccade sequences.

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A significant challenge in eye movement research is to quantitatively compare different sequences of eye movements. In such a comparison fixation location, fixation duration and fixation order are all important dimensions in determining how similar two sequences of eye movements are. Previous methods of comparing sequences of eye movements have tended to focus exclusively on one or other of these dimensions. We present a novel approach to compare saccade sequences based on a global DNA alignment method (Needleman-Wunsch algorithm). In the proposed method, the saccade sequence is spatially and temporally binning to create a chain of letters. This allows us to take into account not only the locations of the fixations, but also the fixation time and order. The comparison of two saccade sequences is made by maximising the similarity score computed from a substitution matrix (providing the score for a letter pair substitution) and a penalty gap. The substitution matrix provides a meaningful link between each region of interest. This link could be distance but could also be encoded in any dimension including perceptual or semantic space. We show, by using synthetic and behavioural data, the benefits of this method over other existing methods.
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Session: Face processing

Time course of facial expression recognition: What eye movements can reveal about processing speed?

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Happy, surprised, disgusted, angry, sad, fearful, and neutral faces were presented extrafoveally, with fixations allowed or not. The faces were preceded by a cue word that designated the face to be saccaded in a two-alternative forced-choice discrimination task (2AFC; Experiment 1), or were followed by a probe word for recognition (Experiment 2). Eye-tracking was used to decompose the recognition process into stages. Relative to the other expressions, happy faces, (a) were identified faster (as early as 160 from stimulus onset) in extrafoveal vision, as revealed by shorter saccade latencies in the 2AFC task, (b) required less encoding effort, as indexed by shorter first fixations, and (c) showed more efficient decision-making, as indicated by fewer refixations on the face after the recognition probe was presented. This reveals a happy face identification advantage both prior to and during overt attentional processing. The results are discussed in relation to prior neurophysiological findings on latencies in facial expression recognition.
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Gaze contingent methods reveal a loss of holistic perception for inverted faces.

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The face inversion effect (FIE) is often attributed to the inability of the human face recognition system to simultaneously perceive multiple features of an inverted face and integrate them into a single global representation, a process called holistic processing. If inversion reduces holistic processing, then for inverted faces the functional visual field should be constricted, as opposed to global (expanded) for upright faces. Until now, however, there are only indirect indications supporting this hypothesis. In the current experiment, we directly manipulated holistic processing by using a gaze-contingent technique allowing manipulation of the amount of facial features simultaneously perceived. First, a gaze-contingent foveal mask covering all foveal information prevented the use of high resolution information, necessary for part-based processing, but allowed holistic processing based on lower resolution peripheral information. Second, a gaze-contingent foveal window covering all peripheral information prevented the simultaneous use of several facial features, but allowed detailed investigation of each feature individually. A delayed face matching task showed an increased FIE with a foveal mask compared to full view and an almost absent FIE with a foveal window. These data provide direct evidence that the FIE is caused by the inability to process inverted faces holistically.
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Putting culture under the spotlight reveals universal information use for face recognition.

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Eye movement strategies employed by humans to identify conspecifics are not universal. We have recently shown that Westerners predominantly fixate the eye region during face recognition, whereas Easterners consistently focus more on the nose region, yet recognition accuracy is comparable (Blais et al., PLoS One, 2008). However, natural fixations do not unequivocally represent information extraction so the question of whether humans universally use similar facial information to recognize faces remains unresolved. To address this issue, we monitored eye movements during face recognition of Western Caucasian (WC) and East Asian (EA) observers with a gaze-contingent technique that parametrically restricts information outside central vision. We used 'Spotlights' with Gaussian apertures of 2°, 5° or 8° dynamically centered on observers' fixations. Strikingly, regardless of culture, observers fixated the eyes and mouth with constrained Spotlights (2° and 5°). At 8°, eye and mouth information was available from the nose and only Easterners shifted their fixations towards this location. Social experience and cultural factors shape the strategies used to extract information from faces, but these external forces do not modulate information use. Human beings rely on identical facial information to recognize conspecifics, a universal law dictated by the evolutionary constraints of nature and not nurture.

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Eye movement assessment of attentional capture by emotional faces in social anxiety.

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Research suggests that anxious individuals have an automatic attentional bias for the processing of threatening stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg and IJzendoorn, 2007). We used eye movement measures (e.g., the accuracy and latency of the first saccade) to assess whether social anxiety affects: 1) search for emotional (angry and happy) compared to neutral faces and; 2) the processing of task-irrelevant emotional and neutral faces. In the first study, participants were presented with visual search displays containing an upright target face and inverted distractor faces. The results indicated that there was a bias towards angry faces (enhanced speed and accuracy to find these faces) in individuals with higher levels of social anxiety, but only when self-reported attentional control was low. The second study used a remote distractor paradigm, in which the distractors were emotional or neutral faces presented at central, parafoveal or peripheral regions. The results indicated that the presence of a distractor delayed the initiation of the saccade to the target, but this effect was not moderated by distractor expression or individual differences in social anxiety. These studies suggest that social anxiety is associated with attentional capture by angry faces, but the findings cannot be explained by impaired inhibitory processes.

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Session: Eye-hand coordination

Splitted attention in combined eye and hand movements.

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In everyday situations we frequently reach and look at different objects at the same time, and the degree to which reaching and saccades are coupled has been questioned. We addressed this question by measuring attentional allocation to movement targets during preparation of simultaneous and asynchronous eye and hand movements. In line with previous evidence, we first demonstrate that when subjects are asked either to look or point at a target, attention performance gradually increases at the movements goals before the movement is initiated. Second, we analysed whether attention can be allocated to two targets in parallel when subjects are asked to make simultaneous eye and hand movements to different locations. Results show that subjects allocate their attention in parallel at both locations, with no cost arising from the need to plan two movements instead of one. This suggests that even though eye and hand systems are linked together, this does not arise from attentional limits during simultaneous pointing and looking. Finally, delaying one movement with respect to the other seems to lead to a delay of the respective attention deployment, suggesting that the attentional mechanisms for eye and hand may be even dynamically independent, to some degree.

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Parallel central processing in multitasking - Evidence from saccades and manual responses.

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Response-related mechanisms of multitasking were studied by analyzing simultaneous processing of responses in different modalities - i.e., crossmodal action. Subjects responded to single auditory stimuli either with a saccade, a manual response - single-task conditions -, or both - dual-task condition. We used a spatially incompatible S-R mapping for one task but not for the other. Critically, inverting these mappings systematically varied the asymmetry in single-task processing speed between both tasks while keeping the overall conflict across responses at a constant level. The results revealed mutual interference, but greater dual-task costs for manual responses. Importantly, a substantial increase of temporal task overlap - i.e., similar single-task processing speed - did not affect dual-task costs, challenging the notion of serial processing due to a central response-selection bottleneck. Instead, the results suggest that crossmodal action is processed in parallel by a central mapping-selection mechanism, eventually causing response-related crosstalk.

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Sight-reading expertise and cross-modality integration investigated using eye tracking.

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It is often said that experienced musicians are capable of hearing what they read and vice versa. This suggests that they are able to process and to integrate multimodal information. The present study investigates this issue with eye-tracking technique. Two groups of musicians chosen on the basis of their level of expertise, experts versus nonexperts, had to read excerpts of classical piano music and play them on a MIDI keyboard. The experiment was run in two consecutive phases during which each excerpt was first read without playing, and then sight-read with playing. In half the conditions, the participants heard the music before the reading phases. The excerpts contained suggested fingering of variable difficulty, difficult, easy, or no fingering. Analyses of first-pass fixation duration, second-pass fixation duration, probability of refixation, and playing mistakes validated the hypothesized modal independence of information among expert musicians as compared to nonexperts. The results are discussed in terms of the processing cues and retrieval structures postulated by Ericsson and Kintsch, 1995, in their model of expert memory.
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Evaluating reinforcement learning of hand movements, eye movements, and covert shifts of attention in humans: a model-based fmri study.

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Reinforcement learning has been used to explain the emergence of eye-movement behavior during reading (Reichle and Laurent, 2006; Laurent and Reichle, 2009), with the assumption that reinforcement learning plays a central role in the learning of overt (e.g., oculomotor) and covert (e.g., cognitive) behaviors. However, it remains to be shown whether arbitrary physical and cognitive actions are indeed learned using reinforcement learning. The present experiments test this idea by examining behavioral and fMRI activation measures of humans who were monetarily rewarded as they performed hand movements, eye movements, and covert attention shifts in response to color cues in a forced-choice decision task. Human behavior and brain activity were compared to simulated reinforcement learning "agents" run in parallel on the same forced-choice task. Although there were no differences in asymptotic performance for the different behaviors, the fMRI results indicated that different regions of the basal ganglia, previously implicated in reinforcement learning, were actively engaged during the learning of the behaviors in the three response modalities. These results affirm the assumption that overt and covert behaviors are learned through reinforcement, suggesting that reinforcement plays a prominent role in learning how to coordinate the perceptual, cognitive, and motoric behaviors involved in reading.
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Thursday 26th August 2009

Session: Inhibition of return

Inhibition of saccadic return is sensitive to the probabilistic context.

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Human observers take longer to re-direct gaze to a location they previously fixated (inhibition of saccadic return: ISR). In this study we examined whether ISR reflects a "hard-wired" assumption about the probabilistic structure of the world or whether it is sensitive to variations in environmental statistics. Observers made sequences of 2 saccades triggered in a gaze-contingent manner. The probability of a return saccade to a previously fixated location in the sequence was systematically varied between observers. ISR was pronounced when the return probability was low and, eventually, abolished altogether when the return probability was high (see also Ellis et al., ECEM 2009). Using an evidence accumulation model to fit observers' latency and accuracy data, ISR was best accounted for as a reduction in the rate at which evidence is accumulated to a response criterion. This rate reduction did not depend on the probabilistic context. The strong behavioural dependency of ISR on the probabilistic context was mediated by adaptive changes in the evidence criterion. Flexible adjustment of the criterion allows observers to overcome in-built assumptions about the statistical structure of the world, and ensures that behaviour is more optimally adapted to the local environmental statistics.
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The shape and development of oculomotor inhibition revealed by saccade trajectory modulation.

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Selecting a stimulus as the target for an eye movement involves inhibiting other competing possible responses. The state of inhibition of the competing motor response to the distractor can be seen by examining oculomotor trajectories and landing positions. Here we extend previous work by investigating the temporal development of oculomotor inhibition of distractors presented at a wider range of spatial locations than previously explored. Fixation was removed from display at various times relative to stimuli onset. This manipulation is known to vary saccade latency independently of the influence of competing distractors. The deviation of saccade trajectories and their landing positions were measured. At close distracter distances (10, 20 and 30 angular degrees) both the trajectory and landing position of the saccade deviated toward the distracter position reflecting an excitatory influence of the competing motor programme. At far distances trajectories deviated away from the distracters reflecting long range inhibition but their landing positions were largely accurate. We suggest that this can be explained by the metrics of the saccade reflecting a dynamic coarse pooling of the ongoing activity at the distracter location: saccade trajectory reflects activity at saccade initiation while landing position reveals activity at saccade end.
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Symposium: Binocularity

Binocular motor control in humans: Neurological complexity and function value.

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Keeping the eyes aligned during movements and fixations is essential for obtaining fused vision and also for maintaining attention in the appropriate depth. Eye alignment is important even for body equilibrium and postural stability (Matheron & Kapoula, 2008). Binocular static and dynamic control involves brainstem, cerebellum, frontal-parietal cortical areas; it requires integration of visual proprioceptive, extraocular and perhaps vestibular signals. Its neural substrate presents a complexity beyond the Hering-Hemholtz controversy, concerning mainly brainstem structures. I will review our studies showing difficulty in maintaining binocular eye alignment during saccades and fixations, vergence problems, postural instability in a variety of clinical populations (strabismus, dyslexia, vertigo without clinical measured vestibular deficit, somatic tinnitus). I will also review our studies of healthy subjects showing excellent control of binocular alignment during pursuit eye movements requiring focused attention, but asymmetric or even monocular rapid eye movement during sleep. Finally a TMS study shows loss of dynamic eye alignment during a sequence of reading saccades and fixations due to perturbation of the right posterior parietal cortex. I conclude that binocular motor control is a biomarker of quality of brain function, including the state of attention and awakness; reading activity probably helps to preserve such control over life.
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Vergence movements during reading depend on individual factors.

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Binocular vision requires that the angle between the two visual axes is adjusted for fusion of the retinal images. In optimal conditions, the principal visual directions of both eyes intersect at the fixation point; vergence errors (fixation disparities: FDs) smaller than Panum's area do not lead to double vision. In previous research, about 50 percent of reading fixations were not aligned (FDs larger than character width), thus FDs were as big as 15-20 minarc (on average) and each subject showed crossed (eso), uncrossed (exo) and aligned fixations. In order to test for possible individual factors, we recorded eye movements (EyeLink II), while 18 subjects read sentences (PSC). On group level, average FD was 18 minarc, which resembled the character width (20 minarc). Most FDs were crossed; subject's average FDs did not correlate with dark (tonic) vergence. In contrast to previous findings, some subjects showed only aligned and crossed, but no uncrossed FDs. Further, depending on subjects, we explained 4-65 percent of the FD variance by calculating a regression containing the position of fixation (version), the amplitude of incoming saccade and the number of fixations; these large differences between subjects might emphasise the idiosyncrasy of vergence eye movements during reading.
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The control of binocular motor coordination during reading: a transcranial magnetic stimulation study.

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Reading involves saccades and fixations. During saccades, both eyes move together; yet they are not perfectly coordinated. During fixations, the vergence angle is stable to keep the gaze at the correct depth; yet disconjugate drift can occur, that frequently reduces the misalignment remaining after the saccade. This study examined cortical implication into binocular motor coordination of reading saccades and fixations. Nine healthy adults read silently a text; single pulses of transcranial magnetic stimulation (TMS) were applied over the posterior parietal cortex (PPC) every 5 ± 0.2 sec. Eye movements were recorded binocularly with Eyelink II. After stimulation, saccade and drift disconjugacy increased from .17 to .36 deg and from .11 to .23 deg respectively. After stimulation of the right PPC, higher drift disconjugacy was present at least for up to 600 ms. Moreover, TMS of the left or right PPC deteriorated the correlation between saccade and drift disconjugacy: the drift no longer reduced the misalignment remaining after the saccade. In conclusion, the PPC is actively involved in maintaining eye alignment during automatic reading motor sequences. In particular, the right PPC performs two distinct but interdependent processes: maintaining disconjugacy during saccades small, reducing misalignment during fixations.

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Reading words causes increased binocular disparity in dyslexic individuals.

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The role of visual deficits in dyslexia remains controversial. We examined the possibility that reading difficulties associated with dyslexia are linked to poor binocular coordination. In two experiments we measured the binocular eye movements of adults, typically developing children and children with dyslexia while they read sentences or scanned dot string targets. In both experiments findings of previous binocular studies were replicated. Specifically, fixation disparity was modulated by the amplitude of the preceding saccade and the fixation position on the screen regardless of whether fixations and saccades were targeted to dots or words. Additionally, during the non-linguistic task adult's binocular coordination was improved in relation to children's, but no reliable differences were found for the two groups of children. Critically, a significantly greater magnitude of fixation disparity was found for dyslexic children compared to typically developing children and adults during reading alone. The existence of linguistically modulated differences in binocular coordination is a novel finding. Our patterns of results from the two experiments indicate that poor binocular coordination in dyslexic children is restricted to reading linguistic material.

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Binocular strategies in reading.

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We present a binocular model of visual word recognition the parameters of which transparently represent aspects of the visual system. These include: the degree of bilateral projection to the two hemispheres from each eye, the strength of ocular prevalence, the strength of contralateral preference, and the extent and direction of binocular fixation disparity. We assess the extent to which different combinations of parameter settings explain fixation duration data during binocular reading. We use the model to assess whether fixation durations are better explained by precise foveal splitting or wide bilateral overlap, by strong ocular prevalence or by ocular parity and by strong or weak contralateral preference. These parameters are explored with respect both to the degree of fixation disparity seen in the data and to the visual and linguistic predictors commonly associated with fixation durations, such as word length and frequency. We find extensive differences between individuals, both in the parameters of the visual system and in the weight of visual and linguistic predictors of fixation duration. We discuss these findings with respect to computational models of eye movements in reading and suggest that by-participant parameterization will improve both the fit of models to data and our understanding of reading.

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Are uncrossed fixation disparities more common than crossed fixation disparities?

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Previous studies examining binocular coordination during reading have reported conflicting results – when the eyes are unaligned, data recorded with an EyeLink tracker showed a majority of crossed fixations while data recorded with DPI trackers showed a majority of uncrossed fixations. We directly compared EyeLink 2K and DPI binocular eye tracking systems. Participants read sentences while their binocular eye movements were recorded; for each participant half the data were recorded with the EyeLink and the other half with the DPIs. Sentences were presented under identical viewing conditions in each laboratory, and monocular calibrations were used. In both systems, the majority of fixations were aligned, although the EyeLink system showed greater disparity magnitudes. Critically, for unaligned fixations, both systems showed a majority of uncrossed fixations. These results suggest that variability in previous reports of binocular fixation alignment is attributable to the viewing situation (variables such as luminance and viewing distance), and much less to particular acquisition software and hardware.

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Session: Eye movements and ageing

Age-related differences in eye movements comes down to experience.

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Studies into the effect of age on eye-movement behaviour tend to indicate a propensity for slower movements and longer fixation durations, although the extent of this difference can be task dependent. This is usually just attributed to the more general physiological and cognitive slow-down associated with normal aging. However, across three different tasks based on computer and internet use (free-viewing, visual search, and browser interaction), we show that computer experience rather than age appears to be the dominant factor. Profiles of eye movements for older but experienced computer users provide a close match to those reported for the "general" (typically student-aged) population. In contrast, there are strong differences in the eye movements for older, novice computer users. For example, from a sample of 18 participants (ages 70 to 93) and almost 55000 fixations, the mean fixation durations during the simple free-viewing of webpages show a marked 50ms difference between older experienced (216ms, sd=112) and older inexperienced (266ms, sd=54) participants. Even by 2008, only 30pc of people over 65 had ever used a computer and the Internet (Office of National Statistics). Levels of familiarity and experience with computers may well be stronger predictors of reported eye-movement behaviour than chronological age alone.
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Neural bases of saccade control in the developing brain.

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The antisaccade task (inhibit the prepotent, reflexive, prosaccade to a peripheral visual stimulus and instead initiate a voluntary saccade to an opposite position) is extensively used to investigate executive control of behaviour. But little is known about the underlying neural substrate in the developing brain. We combined functional magnetic resonance imaging (fMRI) and eye movement recording in normal children (11-13 years), adolescents (14-17 years), and young adults (20-25 years). Prosaccade and antisaccade trials were pseudo-randomly interleaved based on an instructional visual cue. Catch trials (containing only the instructional cue, i.e., no peripheral stimulus) were also included to examine the preparation processes (associated with the instruction) and execution processes (associated with stimulus presentation) separately. Children initiated correct responses with the slowest reaction times and had the most difficulties inhibiting inappropriate responses. This immature behaviour was linked to immature function of the frontoparietal and frontostriatal networks, both essential to successfully perform antisaccades. Age influenced mainly the preparatory processes as compared to execution. The progressive maturation of the frontostriatal and frontoparietal network function with age might be related to the ongoing structural brain changes, in particular increased connectivity, myelination and synapse pruning.
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Session: Parafoveal processing

Word-initial letter constraint, word frequency, and contextual predictability: Parafoveal-on-foveal effects.

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The present study examined whether different characteristics of a target word influenced the pre-target fixation duration. Three properties of the target were independently manipulated. First, targets had either high or low constraining word-initial letter sequences (e.g., dwarf or clown, respectively). Second, they were either high or low frequency of occurrence (e.g., crowd or veins, respectively). Third, they were embedded in either neutral or biasing contexts. Parafoveal-on-foveal (POF) effects are said to occur when aspects of word n+1 (the target) are reflected in fixation time on word n (the pre-target fixation). Launch distance (i.e., the distance from the pre-target fixation to the beginning of the target word) was additionally examined. Three conditions of launch distance were used: Near (1-3 characters), Middle (4-6 characters), and Far (7-9 characters). If POF effects are due to "mislocated" fixations, then pre-target fixation time effects of a target word's initial letter constraint, frequency, and/or predictability should be modulated by launch distance (i.e., such effects should only occur in the Near condition). The results obtained were not consistent with the "mislocated" fixation explanation of POF effects. These findings are discussed within the context of current models of eye movement control in reading.

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Prediction and Eye-movement control in reading: Prefoveal processing benefit from projected information from previously processed structures.

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We investigated whether the parafoveal processing is influenced by the previously-processed information in the sentence. Taking advantage of the properties of English cleft construction where any constituents can be located at the beginning of the sentence, we specifically test whether the element located at the beginning of the sentence affect the processing of the upcoming portion of the sentences. Experiment 1 tested the effect of 'each other' which is located at the beginning of the sentence. After each other is read, it is likely that the readers set an expectation for the upcoming plural noun phrase which licenses 'each other'. We found that the readers skip the subject region (the+noun), the first potential position of the licensing NP, if it is plural then singular in sentences like (1a). Also the skipping rate in plural nouns in 1a was significantly more than plural nouns in (1b). 1a. It was to each other that the girl/girls 1b. It was to John and Mary that the girl/girls Experiment 2 investigated the fixation probabilities after reading articles like, 'these/this/the' in phrases like 'these/the blue puppets…' or 'this/the blue puppet'. We will discuss the implications of these results on eye movement control in reading studies.

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Parallel processing in an object naming task: tests of timing, location specificity and task relevance.

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What is the extent of parallel processing in an object naming task? The general conclusion (Morgan and Meyer, 2005; Morgan, van Elswijk and Meyer, 2008) is that information is obtained from fixated and extrafoveal objects in parallel because a related (compared to unrelated) preview of the extrafoveal object speeds looking times when it is ultimately fixated. In a series of experiments, we further tested this hypothesis by determining whether processing of the extrafoveal object happens during the entire time the eyes fixate the previous object (a completely parallel process) or only shortly before the eyes move to the extrafoveal object (a serial process with temporal overlap). We found that a brief preview (200ms) of the extrafoveal object at any time during fixation of the previous object results in equal benefits of related over unrelated preview. Furthermore, our data indicate that this parallel processing is not restricted to objects in the task set. If the preview object appears in an unnamed location there is still a benefit if the preview object is related (versus unrelated) to the target object. This relatedness effect is smaller than when the preview object appears in the named location, indicating that attention modulates parallel processing.

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Session: Complex scene perception

Entropy in scan paths obtained in natural images.

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PURPOSE. Designers of visual communication material (such as advertisements and traffic signs) want their material to attract attention. They also want to retain attention long enough to communicate a message (e.g. a brand logo, pack shot or other message). Fixations are a good estimator for the locus of attention. In an eye tracking study we investigated how the content of an image guides the eyes to a certain location in the image. We expect that good designs evoke similar scan paths in different observers (low entropy). METHODS. We investigated scan paths of 35 subjects in 70 different print and outdoor advertisements. We measured various parameters to describe performance (time to first logo fixation; number of subjects that fixated the logo; time required for 50 percent of the observers to fixate the logo (T50)). We also measured the entropy (disorder) in the scan paths (represented by strings of characters that belong to different areas of interest). RESULTS and CONCLUSION. We found a high positive correlation between scan path entropy and T50. Entropy is a useful measure to investigate scan paths and adds to other existing methods to evaluate visual material on the basis of eye tracking.

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Object-scene inconsistencies do not capture gaze - evidence from the flash-preview moving-window paradigm.

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The study presented here used the flash-preview moving-window paradigm to investigate extrafoveal processing of object-scene relationships in naturalistic scene viewing. We specifically tested whether an object that is inconsistent with its scene context “pops out” and captures gaze. In three experiments, we used 3D rendered images of naturalistic scenes to compare baseline consistent objects with either semantically, syntactically, or both semantically and syntactically inconsistent objects within a scene. In each experiment, a short preview of a scene was followed by a visual search task that only allowed visual input via a small gaze-contingent window. This maximized extrafoveal processing during the preview and minimized the influence of visual inconsistency during later stages of scene viewing. Across all experiments, there was no indication of an effect of inconsistency on initial eye movements. Rather than directly capturing gaze, the semantic inconsistency of an object seems to weaken contextual guidance resulting in impeded search performance and inefficient eye movement control. We conclude that inconsistent objects do not capture gaze from an initial glimpse of a scene.

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Combining top-down information during real world visual search: target template and scene context.

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Eye movements during scene viewing are heavily guided by top-down knowledge. However, there has been little research on how different types of top-down knowledge are combined. Here we used a visual search task in real-world scenes to investigate how two sources of top-down information, target cue specificity and the predictability of a target's location within the scene, are combined to control search. We manipulated the target cue specificity by presenting a word or picture of the target prior to search, and we manipulated location constraint by placing the object in a predictable or unpredictable location in the scene. The results indicate that eye movements are guided by combining top-down knowledge types additively. When scanning for the target, both types of top-down knowledge improved the selection of the next saccade destination and reduced the processing time needed at each fixation. Similarly, both top-down knowledge types reduced the time needed to verify the target. In each case these top-down knowledge types were combined additively to facilitate the search behaviour. The results indicate that future real-world visual search models will have to consider how the visual system integrates different types of top-down knowledge.

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Virtual navigation training and gaze guidance.

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Recent studies suggested that visuo-motor performance may be enhanced by guiding the viewer's gaze to task-relevant locations (e.g., Mars, 2008). In the current study, we present an experimental environment in which viewers are immersed in a virtual tunnel populated with navigation targets and obstacles along the main trajectory, as well as objects, displays, and traffic signs along the tunnel walls. The subjects' task is to accurately and quickly drive across all navigation targets. During navigation, eye movements are recorded, as are data from the controls (joystick, wheel,…). By using ray casting with the currently recorded x-y gaze coordinates and the virtual camera position as point of origin, accurate gaze-contingent manipulation is achieved. On each frame, features in the visual scene are recorded and used in real-time to control gaze-capturing events in the tunnel. This to either optimize tunnel navigation by novices by promoting steering along the optimal path, or to deteriorate expert performance by distracting the expert driver's attention to suboptimal locations such as off-tangent points in bends. Gaze guidance effects were measured in terms of immediate oculomotor and steering responses, and also in terms of increased speed of learning for novices and rate of deterioration for expert drivers.

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Session: Children's reading

Landing position effects in children and adults during text reading.

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It is known that adults generally fixate close to the centre of a word during text reading and that fixating other locations in a word has detrimental consequences for lexical processing. However, children's landing positions have received relatively little attention in the eye-movement literature. The present experiment investigated landing positions in four, six and eight letter words. Twenty children's and twenty adults' eye movements were monitored as they read sentences containing the target words. Results showed that adults and children did not generally differ in their initial landing positions, but while adults' refixations were almost always to the right of their initial fixations, children's refixations were to both the right and left. In addition, both adults and children were more likely to refixate a word if they did not initially fixate the word centre. Results show that while adults and children are similar in their initial fixation positions, adults appear to be more efficient than children in targeting later fixations, thereby decreasing the time they take to process written language. It is probable that this efficiency is something that is developed through experience.

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The ef-fect of syl-la-ble struc-ture and syl-lab-i-fi-ca-tion on 2nd grad-ers' read-ing in a shal-low or-thog-ra-phy.

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In Finnish, hyphenation at syllable level (kah-vi 'cof-fee') is used in 1st and 2nd grade reading instruction in order to promote the use of sublexical units beyond the letter during lexical access. However, it is possible that hyphenation in itself is detrimental to lexical access, since it may disrupt oculomotor processes or syllable integration. To test whether this is the case, we registered 2nd graders' eye movements while they read sentences where words were either concatenated (kahvi) or hyphenated at syllable level (kah-vi). The results showed that 2nd graders processed concatenated words faster than hyphenated words. At the same time, words with a bigram trough (i.e., bigram with lower frequency than preceding and following bigram) around the syllable boundary (kahvi) were read faster than words without a trough (sieni 'mushroom'). This suggests that syllables are used in lexical access by 2nd graders, but also that even though hyphenation may be advantageous in clarifying syllable structure, it indeed disrupts oculomotor processes or syllable integration. Given the shallow orthography of Finnish, the findings are in line with developmental theories of reading that propose the emergence of access codes beyond letter level regardless of the shallowness of orthography (Frith, 1985, Ehri, 1992).

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Session: Visual world

Priming transitivity during sentence comprehension.

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Two visual-world eye-movement studies investigated transitivity priming in comprehension and examined whether this priming is structural or thematic. Experiment 1 showed that as soon as participants heard the verb in target sentences such as "The pedestrian will stop …", they looked more often at the picture of a possible theme (e.g., a policeman) following a transitive (The watchman will stop the intruder) than an intransitive prime sentence (The watchman will stop), suggesting that they anticipated the verb to be transitive. Thus, transitivity priming occurs during comprehension. Experiment 2 investigated whether it is structural (the surface structure of constituents is primed, e.g., whether a verb is followed by an NP) or thematic (the number and type of thematic roles are primed). Transitive primes in which the direct object occurred after the verb (That is the watchman that will stop the intruder) and transitive primes in which the direct object did not follow the verb (That is the intruder that the watchman will stop) equally strongly primed looks to a possible theme (relative to a neutral baseline) as soon as participants heard the verb in the target sentence. We conclude that transitivity priming is independent of surface order and is instead thematic.

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Structural priming in comprehension lasts across intervening trials.

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Most studies suggest that structural priming in comprehension, unlike in production, is heavily lexically dependent (Arai et al., 2007). According to Chang et al.'s implicit learning model (2006, p. 256), lexically-dependent priming is due to an explicit memory mechanism and is therefore very short lasting. This suggests that syntactic priming in comprehension may be a very short-lived effect. In two visual-world eye-movement experiments we investigated the time course of comprehension priming of ditransitive structures. In Experiment 1, prime and target were adjacent (lag 0), while in Experiment 2 the prime was separated from the target by two intervening trials (lag 2). The verb was always the same in prime and target. Analyses of looks to the target entities (e.g., a necklace and a princess when participants heard "The pirate will give …") revealed significant priming effects in both experiments. More importantly, combined analyses suggested that during early processing, priming was as strong at lag 2 as at lag 0. These results are problematic for the view that an explicit memory mechanism underlies lexically-dependent priming. We discuss the implications for theories of structural priming and for the relationship between comprehension and production.

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Local syntactic coherences interfere with anaphora resolution.

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We present two visual world eyetracking experiments to examine interference effects of locally coherent syntactic substructures (Tabor et al., 2004) on reference assignment in pronoun resolution. We hypothesize that the local syntactic context can enable referents as antecedents of pronouns and reflexives that are globally inhibited. The linguistic material consisted of embedded German object relative clauses, followed by pronouns or reflexives. This structure includes local coherences that stretch over the relative clause boundary. The visual stimuli showed pictures of three potential referents mentioned in the sentence. We measured fixations during and after presentation of the anaphoric reference. Since in both experiments the preferred antecedent is the agent of the described action of the locally bound subsequence, we assume that fixations depend rather on the complete situation than on the bare personal reference. The results are in line with empirical evidences criticizing the assumption of a strict structure dependence in anaphora resolution (e.g., Runner, Sussman and Tanenhaus, 2003). Furthermore they strengthen the assumption of the psychological reality of local coherences (Konieczny, 2005).

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Anticipatory eye movements based on contrastive inferences are modulated by the informativeness of the context.

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Sedivy et al. (1999) showed that upon hearing an instruction, such as Click on the tall glass, the probability of fixating the target will begin to increase during the modifier when the visual display contains a contrasting object (i.e. a short glass). This shows that people can rapidly integrate an expectation for modification with the available visual information to anticipate what the target will be. In an eye movement study, we manipulated, within subject, the informativeness of modifiers across two blocks of trials. In an informative block, modifiers were exclusively used to distinguish contrasting objects. In an uninformative block, participants received many trials with an unnecessary modifier. Blocks were counterbalanced across two groups. When participants heard the informative block first, they made anticipatory looks to the target, similar to what Sedivy reported. When participants heard the uninformative block first, they failed to make anticipatory looks. For both groups, there was little change in performance from the first to the second block. These results suggest that participants adapt early in the task to informativeness of the context, and afterwards show little change. These results cast doubt on processing models which assume that contrastive interpretations are available immediately in all contexts.

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Looking at nothing facilitates performance.

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Recent studies have shown that when processing an item, people look at an empty region that item previously occupied. However, few studies have investigated whether looking at the empty region facilitates processing of an item that is associated with the empty space. We addressed this question by investigating the looking at nothing phenomenon in language production and comprehension. Subjects were shown items that were either easy or more difficult to process and had been withdrawn from the screen at the time of processing. We tested whether subjects were more likely to fixate the empty space when the related item was more difficult. Furthermore, we analysed post-hoc whether there is a relationship between looking at the empty region and performance. In the language production experiment, people fixated the empty region more often when it was associated with harder items. We also found a link between looking at the empty position and processing speed. In the language comprehension experiment, subjects did not fixate difficult items more often but response time was shorter when they looked at the empty region. These results imply that looking at nothing serves a functional role by improving speed of processing but has little effect on accuracy.

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Visuolinguistic alignment in face-to-face and mediated communication.

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Against the background of the 'interactive alignment' approach to dialogue (Pickering and Garrod, 2004), we have investigated visuolinguistic aspects of alignment in a series of simultaneous eye tracking studies (two LC EyeGaze systems, full-duplex), contrasting mediated to face-to-face communication. In the studies, participants (n = 20 dyads) had to find the only difference between their respective displays (which were almost identical). In the analysis, alignment-related parameters of the participants' verbal behavior (such as turn assignment, speech rate, and lexical choice) were linked to gaze behavior parameters (such as fixation number, position, and duration). Results so far suggest a distinction between global discourse control which is predominantly strategic, and local discourse control which is primarily automatic. Furthermore, we are optimistic about being able to empirically identify prerequisites of the occurrence of certain alignment phenomena in multimodal conversation and to demonstrate that, under constrained conditions, interlocutors find ways to successfully compensate for any limitations in the semiotic channels available.

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Session: Reading in Japanese and Thai

Active reanalysis during first-pass reading in Japanese.

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The present study used eye-tracking methodology to investigate syntactic processing during the reading of Japanese sentences. Sentences were presented in three conditions such that a noun phrase could have low attachment (embedded verb), high attachment (main verb) or ambiguous attachment (embedded or main verb). Similar to Kamide and Mitchell's (1999) self-paced reading study, preliminary data indicate that total reading times on the main verb were longer in the low attachment than the high and ambiguous attachment conditions, suggesting that the critical noun phrase was attached high to the main verb prior to processing of the main verb. Interestingly, first-pass reading times on the main verb were longer for the low and ambiguous attachment conditions than the high attachment condition. These findings indicate that in both low and ambiguous attachment conditions, the noun phrase was initially attached low at the embedded verb and was revised to high attachment at the main verb, while the attachment preference remained high in the high condition. Overall, the findings suggest that Japanese readers maintain an active search for the optimal attachment site of a phrase throughout sentence reading, by using case markers as well as verb information whenever they become available.
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Reading garden path sentences in the Thai writing system.

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A considerable amount of research has been carried out on the reading of so-called garden path sentences. Eye movement analyses using these types of sentences have been instrumental in illuminating the online syntactic aspects of the reading process. The goal of this study is to examine readers' eye movements during the reading of garden path constructions in Thai, a language and writing system that has received very little attention in psycholinguistic research. This focus is theoretically appealing, as the Thai writing system generally omits spaces between words and rarely uses punctuation. Therefore, word segmentation has to be be based on linguistic cues and, consequently, can be a source of ambiguity for the reader. The experiment described here uses compound nouns to construct garden path sentences based on word segmentation ambiguity. Data from a sample of Thai junior and senior high school students indicate that, despite profound differences between writing systems, the overall impact of sentence level ambiguity is similar to that found for English. The unspaced nature of Thai, however, gives rise to a distinctive pattern of regressions.
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Session: Applications 3

Using eye movement parameters to assess monitoring behavior for flight crew selection.

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The research project Aviator 2030 at the German Aerospace Center (DLR) investigates monitoring behavior and human performance in future air traffic management (ATM) scenarios. Due to the increase in automation, an accurate and efficient monitoring of the automated processes poses a key challenge to future operators in aviation. The Department of Aviation and Space Psychology at DLR is responsible for personnel selection of pilots and air traffic controllers, hence the objective of the presented study is to distinguish between good and bad monitoring operators. We developed a simulation tool that represents future tasks of pilots and controllers. Eye movement parameters act as indicators for the perceptual and cognitive operations while monitoring. Since we premise monitoring automation to predict operators' manual performance, eye movement parameters and manual performance data are combined as measurements. As for eye movement parameters, we hypothesize that good monitoring operators show a target-oriented scanning strategy predicted by the demands of a given scenario. Preliminary results of an experiment with job candidates are presented. Personnel selection based on eye movements is innovative and establishes new approaches of assessing selection profiles in future ATM scenarios.
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Search for multiple types of threat item: Eye-movements reveal a reduction in guidance.

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Visual search for two targets is accompanied by costs in performance compared with two independent single-target searches (Menneer et al., 2007; 2009). This dual-target cost arises from a reduction in guidance for simple colour-shape conjunctions (Stroud et al., submitted). Does this lack of guidance also occur with categorical targets and after practice? Eye-movements were measured across 5000+ trials of visual search of x-ray images of baggage: (1) in single-target search, either for metal-threat items (guns and knives) or for improvised explosive devices (IEDs); and (2) in dual-target search for both metal-threats and IEDs. Colour guidance in the last block was examined. In both types of search, fixations were generally guided to target-colour objects: blue/black in search for metal-threats, and orange/mixed for IEDs. However in dual-target search, fixations were guided to non-target-colour objects more so than in either single-target search. In conclusion, a persistent lack of guidance underpins the dual-target cost, indicating that two target categories cannot be adequately and simultaneously represented.
Supported by the Human Factors Program of the Department of Homeland Security's Transportation Security Laboratory.
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A vision supported healthcare training approach in breast screening.

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The gradual introduction of digital mammography in the UK is providing a wider range of different training opportunities. An experimental investigation was carried out to examine different kinds of training for mammographic interpretation. The visual inspection behaviour of an expert breast screening radiologist were first recorded to inform the training sets. Subsequently, twenty naive observers were familiarised with the appearance of breast cancer in mammographic images and were then split into four experimental groups to undertake different forms of computer-based training. These were: playback of the expert's visual search behaviour, playback of the expert's verbal instruction (along with image presentation); only regions of interest (a portion of the image around a potential abnormality was presented); or the whole mammogram presented with regions of interest highlighted. Both before and after training, each participant was tested and required to identify whether cancer present, locate the cancer and rate their confidence in their decision. Participants' eye-movements were recorded. Comparison of visual search and performance data, pre- and post- training, indicated all the training approaches were found to be feasible to implement but of variable usefulness. Currently we are further developing these approaches for potential implementation in a screening centre using screening personnel.

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Session: Antisaccades

Working memory and antisaccade performance.

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Converging lines of evidence suggest a role for working memory in antisaccade performance – measures of working memory capacity correlate with antisaccade error rate, concurrent secondary tasks that make demands on working memory increase antisaccade error rate, and patients with impaired working memory function also perform poorly on the antisaccade task. Despite this research, the relationship between antisaccade performance and working memory is controversial , and there have been relatively few attempts to provide coherent and detailed accounts as to which working memory processes are presumed to be involved or how exactly they are supposed to modulate antisaccade performance. In a series of experiments we explored the role of different working memory processes in antisaccade performance. Antisaccade errors increased to a greater extent when participants performed a concurrent secondary task that requires the manipulation of spatial information compared to a task presumed to load on more "executive" aspects of working memory function. In addition, antisaccade performance correlated weakly or not at all with measures of working memory capacity or performance on other tasks requiring inhibition of responses or sustained activation of task goals within working memory. The implications of these findings for current models of antisaccade performance are discussed.

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Anxiety impairs attentional control: Evidence from the antisaccade paradigm.

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There is evidence to suggest that anxiety interferes with the efficient recruitment of top-down attentional processes by maximising the effect of stimulus-driven processes; especially in the presence of threat-related material (e.g., Derakshan et al., 2009). Attentional Control Theory (Eysenck, Derakshan, et al., 2007) predicts that anxiety should affect the inhibition and shifting functions of working memory. In an original attempt we investigated this prediction using the mixed antisaccade task. Individuals completed anti- and prosaccades in blocks of 'Single' (repeated) and 'Mixed' (randomly interleaved) trials. High-anxious compared with low-anxious individuals did NOT show the expected switch benefit in antisaccade latency (believed to reflect facilitative effects of Shifting on antisaccade programming; Kristjansson et al, 2001), suggesting that efficient shifting is impaired in anxious individuals. In a novel modification of this paradigm, we examined the effect of threat on task-switching and found that, unlike the low-anxious, the high-anxious individuals exhibited no switch benefit when the central fixation was a threat-related word; no group differences were found with neutral and control non-words. We provide direct support for the notion that anxiety impairs the inhibition and shifting functions involving attentional control. We discuss our findings within the framework of Attentional Control Theory.

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Effects of real-world arrow and eye gaze cues on oculomotor programming.

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Previous work has suggested that eye gaze cues cause automatic orienting of attention, whilst other types of directional cue, e.g. arrows, exert their influence through more cognitive mechanisms. We further investigated this issue by comparing the effect of eye gaze cues with more ecologically relevant arrow stimuli, based on UK road signs. In Experiment 1, 20 participants made pro-saccades to peripheral targets in the presence of non-informative arrow and eye gaze cues, in the form of photographs of a male pair of eyes. The cues were equally likely to be congruent, incongruent or neutral with the target location. Saccadic reaction times, SRTs, were quickest on congruent trials and the effect was equivalent for arrow cues and gaze cues. In Experiment 244, 14 participants made anti-saccades in the presence of the same cues. With arrow cues, incongruent anti-SRTs were quicker than congruent anti-SRTs, but with gaze cues, the reverse was true. Although arrows and gaze cues caused a similar shifts in attention in a pro-saccade task, results from the anti-saccade task are suggestive of a qualitative difference between the way arrows and eyes affect attention. Specifically, arrows may influence saccade programming, whilst gaze cues may facilitate peripheral stimulus onset detection.

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Antisaccades evoked by the presentation of auditory targets.

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Antisaccade is the saccade generated in the direction opposite to a suddenly appearing visual stimulus. In the antisaccade task the reflexive prosaccade toward the visual target must be suppressed and a movement must be generated toward a location in which no target is present. It has been largely demonstrated in the literature that antisaccades have longer latencies and slower velocities than saccades to visual targets. It is still unclear how the different aspects of antisaccade generation contribute to their metrical properties and rather complex experimental protocols have been so far proposed to study antisaccades evoked by visual targets. Saccades can be evoked also by the presentation of auditory targets that provide a position reference signal for the saccadic mechanism. Saccades toward auditory targets are slower than saccades toward visual targets and their latency is strongly dependent on the relative position of the target with respect to the eyes. Auditory targets could therefore be used to further investigate antisaccades generation and the influence of reflexive saccade suppression on the latency and velocity. The aim of this study is that to compare latency, velocity and precision characteristics of antisaccades induced by the presentation of both visual and auditory targets in normal subjects.

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Poster Session A: 12-2pm Monday 24th August 2009

PA1 - Anisotropy of eye movement and Pseudo-Haptic on velocity change of visual target.

Tomoko Yonemura and Taro Maeda

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When we tried a reaching movement using a visual target that reflected our own hand movement, our hand accelerated and sometimes overshot, depending on deceleration of the target. At that same time, it was shown that force perception occurs (Pseudo-Haptic, Le´cuyer et al., 2000; Puscha et al., 2009), and that perceived force in horizontal movement was greater than in vertical movement (Yonemura et al., 2008). While this phenomenon occurs during smooth pursuit eye movement, it is not known which factor in eye movement affects force perceptions. To assess the role of eye movement in pseudo-force perception, we measured eye (EOG), hand (3D motion capture) movement and perceived force during reaching movement. Visual stimuli were a moving dot presented on a monitor and synchronized with the hand. The dot decelerated to a quarter of initial velocities after beginning a hand movement. We compared horizontal and vertical conditions. As a result, we found that the deceleration onset time of the eyes was faster in vertical movement than in horizontal movement. We discuss whether the pseudo force perception was affected by the integrated mechanism of visual and proprioceptive information.

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PA2 - Car drivers' gaze behaviour.

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Nowadays the car driver has to cope with an increasing complex environment. In spite of an information overflow the vehicle driver has to separate relevant from less relevant information in order to navigate his car safely on the road. A good orientation in road traffic is only possible if the attention of the vehicle driver is used for the perception of significant objects and events. The presented investigation of the gaze behaviour during driving identifies objects and other occurrences, which attract car driver's attention. Every subject had to perform two test runs in an urban and rural environment during the day and at night. Gaze direction and gaze duration were logged during the whole test with a remote eye tracking system. 15 subjects between 23 and 64 years of age took part in this investigation. Dwell time on several objects as well as dwell times on six viewing directions, which are "in front left", "in front middle" and "in front right", "rear left", "rear middle" and "rear right", were determined. The gaze behaviour during the day was compared to the gaze behaviour at night. Furthermore the gaze behaviour of several traffic situations were analysed and compared with each other.

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PA3 - Tracking the cultural gaze - acquired acts of looking and learned plots of identities in Austria.

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Cultural and visual studies have recently been concerned with the multiple viewpoints that move beyond the single-perspective of Western rationalism in order to create new places and spaces from which to look and be seen. Such multiple viewpoints have not only been theorised to change the way in which people see themselves, but have also begun to have an impact on host cultures, especially in relation to changes in perceptions and conceptions of 'national' identities. What kind of images 'culturize' a subject and how does this cultural literacy construct a visuality that is able to exclude others and demarcate identities? We created stimuli by combining various cultural theories and adapted them for an eyetracking experiment aimed at visualising 'culturally coded gazes'. The eyetracking data was interpreted with the help of a 4 step analysis: an interdisciplinary approach, applying various theoretical frameworks from semiotics, postcolonial, intercultural, representational and language acquisition theories. Results from our studies show differences and changes in the various perceptions of cultural codes. We intend to use the obtained data to design new visual intercultural training methods to foster the intercultural dialogue in Austria.

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PA4 - Eye movements during concomitant music performance and the text of the score pursuit.

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This research presents experimental results of the music education students' gaze registration during simultaneous listening to music performance and watching the score. It was revealed that while listening to music and score reading, averages of subjects' gaze leading or lagging time are in the range between +0.9 and -0.4 seconds. Analyzing the position of the gaze on eight score staffs it was defined that subjects more often encompassed only limited number of the staffs and jumping from one staff to another is connected with bigger lagging time. Implemented method could be used for music education students to evaluate what qualification they have in music listening and score reading skills.

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PA5 - Eye movements associated with recognition of affect in humans: Implications for the detection of concealed firearm carrying.

Anastassia Blechko, Iain T. Darker, Alastair G. Gale and Kevin J. Purdy

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The timely detection of illegal firearm carrying via CCTV imagery is of great importance. In the previous studies it was argued that when a firearm is concealed, the observers would respond to subtle affective cues (e.g. change in gait or facial expressions) which human surveillance targets inherently produce while carrying a concealed firearm. Such cues were found to be related to dysphoria (i.e. an affective state characterized by hostility, anxiety or depression) experienced by the carrier. An eye tracking study was designed to further investigate these findings with an empirical measure of locus of attention. Experiment participants watched footage of people carrying either a concealed firearm or an innocuous object and estimated their mood, without knowing about the presence of firearm or innocuous object. An analysis of observers' eye movements indicated that certain visual cues were related to a higher level of dysphoria in the surveillance target, correctly attributed to the firearm carriers. Inspection strategies were further assessed in terms of their association with accuracy in mood detection and effective strategies were elucidated.

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PA6 - Eye movements of elderly and young watching animation.

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Nowadays, animation is regarded to be a product of Japanese culture in the world. However, it is not that popular among the elderly. Former research indicates that one of the reasons for it being less popular among the elderly was difficulty in comprehension of the story. In order to confirm this finding an eye tracking study was conducted. A comedy film was shown to six elderly and ten young participants, in animation and in live action, and their eye movements were recorded using the Tobii 2150 eye tracking system. After viewing the films, participants were interviewed about their understanding of the story. Results showed that both the elderly and young participants observed the movements of the main character in the film in live action and in animation. However, in the scenes that had several characters in animation, the elderly focused not only on the main character, but also on the other characters. It is assumed that difficulty in understanding the storyline was caused by the fact that they did not grasp the main character. The essential difficulties faced by the elderly in information perception of animation will be clarified through further investigations using other animated movies.

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PA7 - Characteristics of eye movements during recognition of emotional facial expressions and influence of stimulus repetition.

Ann-Katrin Herbold, Katharina Roth and Henrik Walter

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Recognizing emotional facial expressions is an automated, crucial social skill. Facial expression decoding shows a characteristic triangular shape of eye movements with a majority of fixations to eyes, few to nose, and least fixations to the mouth. Do eye movement patterns change due to different emotional expressions? And are they altered by stimulus repetition? In an explicit emotion recognition task, modified pictures from "Karolinska Directed Emotional Faces" were presented during two sessions one week apart. Faces conveying six different basic emotions and neutral expressions were shown to 40 healthy subjects. Eye movements were recorded during both sessions of emotion recognition. After each face, subjects had to rate the emotion perceived. Eye movement parameters characteristic for seven different emotional categories are described. Furthermore, a comparison between eye movement patterns during first and second stimulus observation will be presented. In order to understand altered eye movement patterns in certain psychiatric and neurological disorders, more needs to be known about this ability in healthy subjects.

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PA8 - Always look on the cloudy side of life – a negativity bias in visual scan paths to natural social scenes and faces.

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Social psychology describes distinct patterns of reactions to interpersonal events and stimuli of different valence. Negative information tends to overweigh positive, negative stimuli tend to evoke more intense affective resonance and cognitive activity. Such differential response patterns are seldom enquired on a physiological level and little is known about possible moderator variables. Therefore, we explored visual scanpaths to image material of social meaning and varying valence, and self-descriptions of social competence and social anxiety in 20 mentally healthy individuals. Social scenes with positive, negative or neutral contact between agents were presented, while eye movements were surveyed. A bias towards negativity became apparent in different characteristics of visual scanpaths, and is presumed to be associated with aspects of social skill and confidence. Pictures with negative features seemed to evoke more and longer fixations in general and to relevant mimic features in particular, longer global visual search and greater pupil diameters compared to pictures of positive valence, indicating higher complexity of visual processing and greater physiological arousal for negative stimuli. Observations also implied that cognitive and behavioural aspects of social anxiety and social competence may be related to gaze behaviour.

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PA9 - Looking at fear and disgust: Neuronal and behavioural differences between two negative emotions.

Katharina Roth, Ann-Katrin Herbold and Henrik Walter

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Fear and disgust are two prominent aversive emotions. Whereas there is a vast amount of research on fear, the number of publications on disgust is relatively small. There is no consensus about the differences between these two emotions or even if there are any. Both of them activate the withdrawal system as a part of adaptive behaviour. Within the dimensional approach of valence and arousal they also belong to the same category. fMRI studies show both common and differential regions activated during processing of fear and disgust (Schäfer et al., 2005). We assume that the difference between fear and disgust mainly depends on the behaviour elicited by the respective emotions. While fear elicits "flight or fight" reaction, confrontation with disgusting objects leads to rejection of the source of emotion. In the present fMRI study behaviour was operationalized by eye movements. While viewing complex disgusting and fearful pictures form the International Affective Picture System (Lang et al., 1999) BOLD signal and eye movements of healthy participants were measured simultaneously. We show that processing of the two negative emotions is associated with different eye movement patterns. Those patterns are further related to different neuronal processing.

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PA10 - Depressive symptoms and attentional control: An antisaccade study.

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Experimental psychopathology research in depression is increasingly adopting an information-processing view in explaining hallmark features of depression, such as negative affect and rumination. In this presentation I will present a study examining if depressive symptoms in general and rumination are related to impairments in attentional control, particularly inhibition and shifting using eye-registration methodology. A sample of 24 healthy and 22 dysphoric undergraduates performed a mixed antisaccade task, a task that allows to examine inhibition as well as shifting problems. Depressive symptoms in general were not related to attentional control impairments, neither on inhibition nor on shifting function. When examining the relationship between rumination and attentional control, high ruminators compared with low ruminators showed impaired inhibition. No effects of rumination were observed on shifting capacity. The results of this study offer new insights into the association between depressive symptoms and attentional control. The findings indicate that a ruminative thinking style, but not dysphoria, is related to inhibitory control deficits. These findings warrant further research on inhibitory control and rumination in the development of depression.

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PA11 - Reversible deactivation of anterior cingulate or lateral prefrontal cortex affects reaction times and performance of pro-saccades and anti-saccades.

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The anterior cingulate cortex (ACC) and lateral prefrontal cortex (PFC) are proposed to play important roles in the cognitive control of action. Clinical studies have shown that patients with lesions of the ACC or PFC are impaired on the anti-saccade task, a well-established test of cognitive control that requires both suppression of an automatic pro-saccade toward a stimulus, and generation of a voluntary anti-saccade away from the stimulus. These frontal cortical areas were deactivated while two monkeys performed a randomly-interleaved anti/pro-saccade task. The ACC or PFC were independently deactivated by pumping chilled methanol through the lumen of stainless steel cooling loops implanted in the cingulate and principal sulci. Cessation of cooling allowed cortical temperature to return rapidly to normal, and thus normal behaviour could be observed both before and immediately following inactivation. Unilateral inactivation of the ACC or PFC increased reaction times of contralateral anti-saccades and increased direction errors towards the ipsilateral side. PFC cooling increased reaction times of contralateral pro-saccades whereas ACC cooling decreased reaction times of ipsilateral pro-saccades. PFC cooling also increased reaction times of ipsilateral anti-saccades. Together these results demonstrate that inactivation of the ACC or PFC has an effect on both pro-saccade and anti-saccade task performance.

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PA12 - Saccades, Alzheimer's disease and arterial spin labelling MRI (ASL-MR): An initial study.

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A saccadic impairment consistently associated with Alzheimer's disease (AD) is an increased antisacccade error rate, which has been found to predict disease severity. Arterial spin labelling MRI (ASL-MR) is a technique enabling the non-invasive acquisition of a quantitative cerebral blood flow measure. ASL-MR in AD has demonstrated a regional hypo-perfusion pattern consistent with established PET data. To date its use in AD has been limited and has not been determined whether hypo-perfusion correlates with saccadic measures and a more comprehensive battery of neuropsychological tests, and ultimately as a marker of disease severity. AD and control subjects undertook reflexive, predictive and antisaccade tasks and had 3T MRI scans including T1 structural and ASL-MR. All completed neuropsychological tests. Principal Component Analysis (PCA), a method of multivariate analysis, detailed perfusion patterns of ASL-MR data as principal component images. The proportion of directionally corrected antisaccade errors appeared to be correlated in a non-linear fashion with the first principal component ASL-MR images as a disease severity marker. This antisaccade correlation was replicated with the MMSE, MoCA and ADAS-cog. ASL-MR is a potentially useful technique to investigate perfusion in AD and shows signs of non-linear correlation with cognitive impairment as indexed by saccadic and neuropsychological measures.

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PA13 - Nystagmus and stress – It's all in the timing!

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Aims: To assess the changes in VA of people with nystagmus when placed under stress. Methods: Stress was created using a TENS machine, and measured via skin conductance; eye movements were measured with infrared eye tracking, and VA was also measured. TENS threshold was measured prior to the stress periods. During these periods subjects were told that the TENS intensity would be double their threshold. VA was measured under four conditions: 1.) Relaxed. 2.) "Task Demand" – Short burst from TENS with incorrect response. 3.) Anticipatory anxiety – Short bursts from TENS at random. 4.) Relaxed. Results: Skin conductance was increased during the periods of stress (p=0.03). During the "Task Demand" period, nystagmus intensity was increased (p=0.01), foveation duration was decreased (p=0.01).VA was not significantly reduced. Response times were increased during the "Task Demand" period (p=0.00). Conclusion: VA is unaffected by stress. Time taken to see things is increased. Wiggins D, Margrain TH, Woodhouse JM, and Erichsen JT (2007) The Impact of Stress on Infantile Nystagmus Syndrome. Invest. Ophthalmol. Vis. Sci. 48: 875-. Wiggins D, Margrain TH, Woodhouse JM, and Erichsen JT (2007) Infantile Nystagmus Adapts to Visual Demand. Invest. Ophthalmol. Vis. Sci. 48: 2089-2094

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PA14 I - ntact inhibition but impaired endpoint accuracy in anti-saccades in visual form agnosia (Patient DF).

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According to Milner and Goodale's (2006) model, areas in the ventral visual stream mediate visual perception and regions in the dorsal visual stream mediate the on-line visual control of action. Strong evidence for this model came from patient DF, who suffered from visual form agnosia after bilateral damage to the ventro-lateral occipital region, sparing V1. It has been repeatedly reported that she is normal in immediate reaching tasks, yet severely impaired when asked to perform pantomime actions. Here we investigated the performance of DF in an anti-saccade task, which requires the inhibition of a stimulus driven response to a target, and instead requires accurate remapping of the eye movement to the mirror side of space. We compared this to a fixation (no-go) and a pro-saccade task, which required an immediate response to a single target. Relative to age matched controls, we found that DF's inhibitory capacity in both the fixation and antisaccade task was within normal range. However, we observed that she was notably impaired in the terminal accuracy of her anti-saccades to both left and right space. The results indicate that DF's intact dorsal steam structures are insufficient for driving anti-saccade performance, suggesting an impairment in offline/allocentric target mapping.

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PA15 - Is volitional saccade initiation impaired in schizophrenia?

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Many patients with schizophrenia display low levels of goal-oriented activity in everyday life. Clinically, this may be interpreted as a fundamental deficit in the wilful initiation of action. Eye movement studies suggested that some neuropsychological performance deficits of schizophrenia patients are correlates of this type of negative symptomatology. In an experimental occulomotor research setting it is possible to isolate the functional aspects of volitional action initiation by comparing the latency of saccades towards sudden onset visual stimuli (prosaccades) with the latency of volitional initiated saccades. In a first study with 30 schizophrenia patients and 30 healthy controls the patients had increased volitional saccade latencies and normal prosaccade latencies. A new study with an equal sample size aims at further elucidating the neuropsychological mechanisms underlying the isolated deficit in volitional saccades. First results suggest that the deficit does not appear if disengagement from the preceding fixation is facilitated by an offset of the fixation stimulus. The proposed impairment in the volitional initiation of action might actually rely on a deficit in disengaging from a preceding activity.

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PA16 - Impaired response inhibition in Obsessive-Compulsive Disorder: evidence from a novel antisaccade task.

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As the antisaccade task is an established tool to investigate executive dysfunction in neuropsychiatric patients, it might help to clarify putative deficits in obsessive-compulsive disorder. However, previous studies revealed diverging results: they either showed increased latencies or enhanced error rates. As the latter could indicate deficits in either the inhibition of reflexive saccades or the initiation of volitional saccades, the present study investigates antisaccades and simple volitional saccades (without inhibitory demands) under different stimulus conditions. Preliminary results suggest normal volitional saccade latencies, but increased antisaccade errors on a condition in that antisaccades were triggered by a change in central stimulation. This change might have facilitated reflexive responding, thereby increasing the inhibitory demands of the antisaccade tasks. The results are therefore discussed in terms of a response inhibiton deficit in obsessive-compulsive disorder.

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PA17 - The relative contributions of concurrent working memory load and preparation time on saccade latencies and error rates.

Donna Berry, Felicity Wolohan, Trevor J. Crawford and Damien Litchfield

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Previous research suggests that latencies and directional errors on the antisaccade task, relative to the prosaccade task, can be modulated by numerous factors, including participants' concurrent working memory load (WML) during the eye movement task and the preparatory period duration preceding the onset of a visual target. In a novel paradigm, concurrent WML was manipulated by presenting participants with one of two task-relevant colour rules (low vs high WML rule) to be mentally processed before a prosaccade or antisaccade could be executed in response to this rule. Alongside this, the duration of the preparatory time (short vs long) was manipulated in a 2x2x2 within-subjects design. Thus, the relative effects of WML and preparatory time upon saccade latencies and error rates were investigated. Results revealed that preparation time significantly reduced antisaccade latencies, to a greater extent than prosaccade latencies, and that increasing WML slowed antisaccade latencies more than prosaccade latencies. Furthermore, preparation duration and WML compounded each other to produce marked effects upon latencies. However, whilst a higher WML resulted in more directional errors, modifying preparation time had no effect upon error rate. These results are discussed with reference to WML theories of antisaccades and parallel prosaccade and antisaccade programming theories.

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PA18 - Visual processing based on anticipated retinotopy.

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We measured the effect of high-contrast masks on target discrimination in both a control condition (no eye movement) and when the mask and target were presented around the time of a saccade. When no eye movements occurred, masks interfered with target identification only when they spatially overlapped with the target. During the 100ms before the eye movement, the effect of masks presented at the same location as the target was reduced, and masks presented in the location corresponding to the anticipated retinotopic position of the target after the impending eye movement interfered with target discrimination, even though there was no actual spatial overlap between the target and mask. A follow-up experiment suggested an analogous reversal of spatial cueing effects when presented in a similar configuration. A reasonable interpretation is that the change in retinotopy expected to occur with the upcoming eye movement shifts the location from which information about the target is being accrued.

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PA19 - Separation and integration in transsaccadic perception.

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Transsaccadic memory is not restricted to coarse, abstract representations but includes considerable visual detail (Deubel, Schneider, and Bridgeman, 1996; Melcher, 2005; Demeyer, De Graef, Wagemans, and Verfaillie, 2009). We report two studies exploring the access to and the contents of such a detailed representation. First, we investigated whether only a postsaccadic blank improves the detection of intrasaccadic object location changes. We observed that improvement is also achieved by changing (task-irrelevant) object shape, suggesting that disrupting transsaccadic stimulus continuity can by itself be a key to unlocking detailed transsaccadic memory. Second, we measured the effect of a presaccadic preview when there is no transsaccadic stimulus separation. Specifically, viewers saccaded to a peripheral shape and chose from a continuum of shapes which ellipse they just glimpsed. We manipulated pre- and postsaccadic shape congruency. When pre- and postviews differed parametrically (ellipses with different aspect ratios) the mean postsaccadic percept shifted towards the preview value while the response distribution remained unimodal, suggesting transsaccadic integration of visual detail.

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PA20 - Parallel changes in saccade metrics and visual localization after saccadic adapatation.

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Saccadic adaptation may result from changes in motor command or in target representation. It induces a shift in the localization of visual stimuli presented before the onset of the saccade. We tested whether saccadic adapation also modifies visual localization during fixation. In contrast to previous studies, which did not find mislocalization during fixation, our experiments were conducted in in the absence of any visual landmarks and separately for inward and outward adaptation. We found strong mislocalization after outward and little after inward adaptation. An analysis of saccadic velocity profiles indicated that outward, but not inward, adaptation was consistent with a change of the saccade target representation. A second experiment used a novel saccade adaptation method which applies a constant postsaccadic visual error. Analysis of velocity profiles suggested that this method evoked target remapping for both inward and outward adaptation. With this method, we found mislocalization after both inward and outward adaptation depending on visual error size. We conclude that changes in saccade metrics are paralleled by changes in visual localization, thus emphasizing the importance of saccade vectors for the representation of space.

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PA21 - Depth of processing and pronoun resolution.

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Two experiments investigated the processing of ambiguous and unambiguous pronouns under deep and shallow processing conditions. Participants read sentences such as 'Paul met John/Mary the other day. His parents were on holiday', in which the pronoun was gender-ambiguous, subject- or object-disambiguated. Sentences were followed by a pronoun-resolving question in Experiment 1 (deep processing) and a non-resolving question in Experiment 2 (shallow processing). In Experiment 1, the ambiguous condition was initially read faster at 'were on' (regression-path) than the unambiguous conditions, whereas during later processing, it was read slower (regression-path at 'holiday' and total times for the first sentence). In Experiment 2, the ambiguous condition was read faster at 'parents' (total times) than the unambiguous conditions. The results are most consistent with Rigalleau et al.'s (2004) model, which claims that under deep processing, early disengagement from the gender-incongruent name is followed by later competition during integration with the context. However, contra Rigalleau et al., disengagement occurred regardless of whether processing was deep or shallow. The findings are harder to explain for other accounts: Competition accounts have difficulty explaining the ambiguity advantage effect in both experiments, whereas reanalysis accounts would need to assume that under deep processing, competition occurs during late processing.

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PA22 - Children's and adults' processing of syntactic ambiguity during reading.

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While there has been a fair amount of research investigating children's syntactic processing during spoken language comprehension, and a wealth of research examining adults' syntactic processing during reading, as yet very little research has focused on syntactic processing during text reading in children. In two experiments, children and adults read sentences containing a temporary syntactic ambiguity while their eye movements were monitored. In Experiment 1, participants read sentences such as, 'The boy poked the elephant with the long stick/trunk from outside the cage' in which the attachment of a prepositional phrase was manipulated. In Experiment 2, participants read sentences such as, 'I think I'll wear the new skirt I bought tomorrow/yesterday. It's really nice' in which the attachment of an adverbial phrase was manipulated. Results showed that adults and children exhibited the same processing preferences, but that children were slightly delayed relative to adults in their detection of initial syntactic misanalysis. It is concluded that children and adults have the same sentence-parsing mechanism in place, but that it operates in a slightly different time course.

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PA23 - Parafoveal-on-foveal effects in reading: What can concurrent ERP and eye movement measures reveal?

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It is controversial whether parafoveal-on-foveal effects in reading are driven by the lexical properties of word n+1 (e.g. predictability) or by low-level factors. Furthermore, the occurrence of parafoveal-on-foveal effects is inconsistent across eye-movement studies. Here, we report a concurrent ERP/eye-tracking experiment, which revealed a parafoveal-on-foveal ERP effect without a concomitant effect in the eye-tracking record. We presented sentences such as "X is the opposite of Y", with X and Y instantiated by antonyms (black-white), related (black-yellow) or unrelated word pairs (black-nice). First fixation durations on the target (Y) were increased for both non-antonym conditions. This pattern was mirrored in an N400 effect time-locked to the first fixation on the target (non-antonyms > antonyms). While the eye movement record showed no parafoveal-on-foveal effects, ERPs time-locked to the last fixation on the pretarget region showed an increased N400 for the unrelated condition. This suggests that the prediction of a specific word preactivates its semantic features and those of semantic neighbors, thus engendering a mismatch (reflected in an N400) when a non-matching word appears parafoveally. Nevertheless, the occurrence of a second N400 on the target suggests that the parafoveal-on-foveal effect does not reflect full lexical access.

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A24 A saccade latency based discriminability metric for parafoveal lowercase letters.

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Gaze contingent displays employing the boundary paradigm mask words in the parafovea to examine the role of spatially distributed processing in reading. A literature review and meta-analysis indicated that mask use is not well defined and inconsistent across studies. For example, "random" masking can include full or partial letter replacement and degrees of similarity between mask and target are often not specified. To address this problem, we developed a new discriminability metric for non-proportional lowercase letters. Using a technique developed by Jacobs et al. (1989), participants were asked to fixate a central lowercase letter, detect which of two parafoveal target letters was identical and then make a saccade to this target. Following Courrieu et al. (2004), targets were embedded with flankers, approximating lateral masking typical for word recognition. Correct primary saccade latencies served as a fine grain processing index of letter discrimination. Results will be presented as a matrix of similarity-dissimilarity for each pair of alphabet letters, offering a new methodological tool for oculomotor reading research. This metric is also an important contribution to the planned extension of the Glenmore model by providing an empirical foundation for a more realistic mechanism of early letter processing across the perceptual span.

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PA25 - The role of higher frequency neighbors as parafoveal previews in reading chinese sentences.

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The present study investigated the parafoveal preview effect of the higher frequency neighbors (HFN) when reading Chinese two-character words in sentences. Three types of possible previews, identical (ID), HFN, and pseudoword (PS) control, were used in the experiment with the boundary technique. One previous English study has shown the facilitative HFN preview effect in first fixation duration and single fixation duration (Williams et al., 2006). Their findings suggested the role of HFN is facilitative to the target word in the earlier stage and the competition is set up in the later stage. However, our results demonstrated the inhibitory effects of the HFN previews and no facilitative effect was found. The targets with the HFN or PS previews were fixated longer than those with the ID previews in all duration measures. The regression rate was higher with the HFN preview than the PS or ID previews. The results indicated, for Chinese words, the competition of the HFN to target words could be built early. This inhibitory effect may hinder the possible benefit from the preview of word neighbors in the early indices.

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PA26 - Saccadic range error depends on saccade type in reading.

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During reading, saccadic eye movements shift words into the centre of the visual field for word processing. Due to random oculomotor errors, saccadic landing positions within words spread nearly normal distributed around the word centre. Furthermore, the mean within-word landing position varies systematically according to the distance of the launch site and the length of the target word (McConkie et al., 1988). Here we present new analyses based on Potsdam Sentence Corpus data showing a strong dependence of both the random and the systematic oculomotor error components on saccade type, i.e., forward saccades, skippings, refixations. Using these results we improved a recently developed oculomotor model (Engbert and Nuthmann, 2008) to estimate the likelihood of mislocated fixations in reading. We discuss the implications for oculomotor principles in computational models of eye-movement control during reading.

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PA27 - Influence of a proof-reading task on reading of compound words.

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We examined how proof-reading instructions influence reading of short and long compound words. Thirty-seven participants read compound words embedded in sentence context while their eye movements were recorded. Participants were instructed to read for comprehension or to look for spelling errors. The spelling errors were transposed or replaced letters; target sentences never included errors. The results replicated earlier findings of Bertram and Hyönä (2003), showing that long compounds elicited shorter first fixation durations but longer gaze durations and more fixations on word than short compounds. The influence of the whole word frequency on first fixation duration was at best weak for long but clearly significant for short compounds. Solid frequency effects were obtained for both short and long compounds on gaze duration and the number of fixations. Proof-reading increased first fixation duration, gaze duration, and the number of fixations on word during first-pass reading. Proof-reading also increased the effects of word length and frequency on gaze duration and the number of fixations. The results indicate that readers are capable of adjusting their eye movement behavior to meet the task demands and that higher level cognitive factors can have an early impact on eye movement control during reading.
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PA28 - Processing transitivity in reading: Effects for lexical and morphological causatives and their intransitive counterparts.

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In Finnish (in)transitivity is mainly categorical and can be realized by either opaque lexico-semantic features (ryösti ‘robbed’ vs. paloi ‘burned’) or transparent morpho-syntactic information (e.g., raunioi-tta-a ‘to ruin’ vs. raunioi-tu-a ‘fall into ruin’). The current study tested whether lexical and/or morphological transitivity information is used immediately during verb processing. In Exp.1 medium-frequency lexical and low-frequency morphological transitive verbs were embedded in sentences and pitted against their intransitive counterparts while readers’ eye fixations were registered. The results showed similar reading patterns across-the-board: transitive verbs were read faster than their intransitive counterparts in the first pass reading and later measures. In Exp.2 both verb types were low frequent, and the results for morphological verbs were replicated. However, lexical verbs did not elicit any immediate effect. Nevertheless, a late effect on word N+2 was found such that reading times were shorter in transitive than in intransitive sentences. This implies that lexically based information can be used only if the lexical frequency of the verb is at least moderate. The results are compatible with models that allow to use both morpho-syntactic and lexical frequency based verb information immediately in parsing; however, their role in parsing strategies is not explicitly incorporated in current parsing models.
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PA29 - Reading visually distinctive words in passages of text.

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Participants read passages of text including critical words that were presented normally, in bold, or in italics. Consistent with the findings of Reingold and Rayner (2006) for single line text, reading times were longer in the bold compared to normal presentation condition for the region following the critical region, but not on the critical region itself, indicating that bold type has a late effect on reading processes as indexed by when the eyes move. Also in line with previous research, eye movement behaviour on text positioned on lines above the critical words was not significantly influenced by the distinctiveness of the critical words. Interestingly though, for fixations prior to the critical words launched from the same line of text, fixations were more likely to be launched from the beginning of the line, rather than the region immediately prior to the critical words, when the critical words were bold compared to normal or italic. These findings indicate that the visual distinctiveness of words later in the text can attract fixations when they are within the same line of text. Reingold, E.M., and Rayner, K. (2006). Examining the word identification stages hypothesised by the E-Z Reader model. Psychological Science, 17, 742-746.

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PA30 - Multiword unit processing in native and proficient non-native speakers of English: an eye-tracking study.

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This study aims investigates multiword unit (MWU) processing. MWUs are not a homogeneous group, having differences in syntax (e.g., I think it's versus I don't think a), flexibility (e.g., Xthe bucket was kicked by him), transparency (at the end of the versus a piece of cake), and literality (she spilled the beans versus he blew his top). Within bilingual speaker processing, MWUs remain largely undescribed from a psycholinguistic perspective. This experiment explores MWU processing in proficient English bilinguals and L1 speakers. The fixations and reading speeds of MWU sentences and control sentences are analysed in a mixed effects model to investigate predictive variables in MWU processing. Fifty students participated in an eye-tracking experiment at an English-speaking university. The stimuli varied randomly in length, frequency, and position of the MWU in the sentence. The corpus-derived stimuli allow better generalisation of the results to non-experimental conditions. The L1 results (Columbus, 2008) show robust differences between reading speeds for different sentence types. In particular, we have found strong facilitation for reading MWUs within the carrier sentences. The L2 study underway is expected to illustrate the MWU processing differences between L2 and L1 English speakers. Such results could inform modelling of language processing.

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PA31 - The eye movement of Chinese elementary students with reading disability on reading causal relationship sentences.

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The objective of this study was to examine eye movement patterns of elementary school children with Reading Disability (RD) when reading Chinese causal relationship sentences with or without causal connectives. Two kinds of causal connectives were separately embedded in 24 sentences, which either with the term Yin-Wei (meaning because), stating effect clauses before cause ones, or with Suo-Yi (meaning so), stating cause clauses before effect ones. The other 24 causal-and-effect relationship sentences without causal connectives were applied as controls. 83 Chinese-speaking students in 5th or 6th grade participated in this study, all with normal or corrected-to-normal vision. The results revealed that the participants showed significant longer total fixation duration (TFD) to the Suo-Yi sentences than paired ones without causal connectives.Besides, both their first fixation duration (FFD) and gaze duration (GD) were marginally longer than controls. However, there was no significant difference between Yin-Wei sentences and paired ones. The result suggested that stating orders of cause and effect clauses affect RD students' eye movement. Such result also showed an implication of sentence meaning integration on reading.

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PA32 - Eye movements and spaced Chinese text reading: Effects of reading skills.

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Unlike English (and other alphabetic systems), Chinese is written without spaces between successive characters and words. Three experiments were conducted to examine whether inserting spaces into Chinese text would be facilitatory for third grade children, and whether any observed spacing effects would be modulated by reading skill. In Experiment 1, four spacing conditions were compared: normal, unspaced text; text with spaces between every character; text with spaces between words; and text with spaces between characters that yielded nonwords. In Experiment 2, highlighting was used to create analogous conditions to Experiment 1 but controlling the spatial extent of sentences. In Experiment 3, the role of reading skill was examined. The pattern of data in all three experiments was very similar. It showed that sentences in a word spaced format were as easy to read for third graders as unspaced text. This is the same effect that has been previously observed with skilled adult readers (Bai et al., 2008). Although word-spaced text was equally easy for good and poor readers, the poor readers were extremely disrupted by the non-word spaced condition. These data suggest that poor readers are more dependent on the visual format of text for initiating normal linguistic processing.

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PA33 - Attempting a theoretical modeling of eye movements in a discrete visual search task.

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A visual search task of finding one black leaf (target) in a white background, among a regular array of similar leaves (distractors), is presented to a subject. Eye movements are recorded using an ASL eye tracker, until the target is seen. These eye movements are compared to those of an ideal searcher, a mathematically determined and computer simulated searcher, using nevertheless the real target discriminating ability of the subject. They are also compared to a simulated random searcher and a restricted memory optimal searcher in an attempt to draw conclusions about the eye's search strategy.
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PA34 - Low-dimensional feature domain learning from visual search.

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The use of visual search for image feature discovery and decision support is a new concept that is driven by the need for an effective framework for recovering both explicit and implicit knowledge that is applied in image understanding. Previous research has shown that it is possible to untangle what appear to be uncorrelated visual search patterns to reveal the underlying strategies. To this end, it is necessary to analyse such visual search patterns in meaningful feature spaces. However, feature space representation is commonly achieved by using a pre-defined feature extraction library, which requires the explicit incorporation of domain specific knowledge and often overlooks factors that are subconsciously applied during visual examination. In this paper, a generic feature domain based low-dimensional embedding scheme is employed. The method includes the use of dimensionality reduction through distance-preserving mappings for defining the feature space. The proposed method has been validated with both laboratory experiments and clinical studies for the assessment of centrilobular emphysema with high-resolution computed tomography (HRCT).We demonstrate how eye movements are useful to unveil features relevant to the visual search and illustrate how they can be used to identify salient regions in the images.
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PA35 - Crowding plays a dual role in visual search.

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Target detection in the visual periphery may be impaired by the presence of flankers, the phenomenon known as crowding. However, in visual search it is still an open question how flankers affect saccadic target selection. For this purpose in our experiments a vertical target Gabor and many tilted distractor Gabors were each accompanied by four flankers. In experiment 1 throughout two blocked conditions the target was either a high or low spatial frequency Gabor, respectively, and flankers were of high or low spatial frequency. As expected the low spatial frequency target was found fastest when accompanied by high spatial frequency flankers. Interestingly the high spatial frequency target was found fastest when accompanied by high spatial frequency flankers. In experiment 2 we elaborated on this counterintuitive finding by varying the proportion of red to green flankers surrounding a red target. This showed a red target was found faster as a greater proportion of its flankers were red, rather than green. This suggests a dual role for flankers: similar flankers impair peripheral target detection, but also attract a higher number of saccades, as more of the target property is present.

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Poster Session B: 6-8pm Monday 24th August 2009

PB1 - The effect of gaze cues on dwell time to print advertisements.

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In addition to revealing important information about our emotional and mental state, our eyes also inform observers of our current focus of attention. Because of the importance of the eye region in our processing of faces, gaze direction is a particularly powerful attentional cue. We used eye tracking to compare viewers' gaze to advertisements (embedded within a magazine) in which the model either looked towards the product being advertised, or looked directly at the viewer. People made more fixations to and spent longer looking at the product when the model in the advert looked at the product compared to when the models' gaze was directed directly at the viewer. Interestingly people also looked towards other areas of the advertisement, and the advertisement as a whole for longer when the model's gaze was directed towards the product. These results suggest that people may find direct eye gaze from models in advertisements somewhat aversive, and have important practical implications for the design of print advertisements containing faces.

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PB2 - Comparison of combined and dwell time based gaze-interaction.

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Using eye-movements to interact with a computing system has been so far primarily utilized to support people with severe motor disabilities, giving them a way to communicate with their environment. In our research we focus on the use of gaze-based interaction in everyday life, i.e. for controlling computer games or desktop applications. To overcome the drawbacks of dwell time based gaze-interaction like e.g. the Midas touch problem (Jacob, 1990), we concentrate on multimodal gaze-based interaction, i.e. the combination of gaze with other modalities (e.g. speech, gestures). In a first study we wanted to find out, if a user will benefit from (1) the combination of gaze for navigation and a mouse click for manipulation, compared to (2) dwell time based gaze-interaction and (3) mouse-interaction. Twelve subjects had to perform a simple searching task resembling a standard working situation on computing systems. The experiment was realized as randomized within-design. The results indicate, regarding reaction times and error rates, that the combined interaction form (1) indeed trumps dwell time based gaze-interaction. Nevertheless mouse-interaction worked best, apparantly due to the design of the searching task. We discuss our findings and further steps of the research, that will focus on the integration of further modalities.

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PB3 - Eye movements and recollective experience in Web search tasks: Is what you see what you get?

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A recent study (Etcheverry et al., in prep.) highlighted the difference in processing requirements between navigation-oriented and content-oriented search in Web pages using the Remember/Know paradigm. The results supported the claim that recollection is a specific marker of the extent to which the readers deeply processed Web elements: a greater proportion of correctly recognized items were given a "Remember" response after being processed in the content-search than in the navigation-search condition. Here, eye movements were recorded while participants completed the two same information search tasks in Web pages sampled from the .fr domain. Content-oriented search was associated with longer fixation duration, higher refixation frequency and smaller saccade length, suggesting a less distributed overt attention during encoding. This narrowing of eye fixations during encoding appears to predict subsequent conscious remembering (Sharot et al., PLoS ONE. 2008; 3(8): e2884). Indeed, participants were also more likely to report conscious experience of recollection of content elements in the subsequent Remember/Know recognition test. The current findings support the claim that eye movement records and recollection can both be used as reliable markers of task-processing demands.

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PB4 - The interaction of encoding mechanisms and decision criteria on eye movements in a visual decision making task.

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The gaze bias effect in decision making research indicates that subjects look longer at the chosen compared to not chosen item (Shimojo, Simion, Shimojo and Scheier, 2003; Glaholt and Reingold, 2009). In the present study, we monitored eye movements during a two-alternative forced choice task with four different decision conditions to investigate the interactive effects of encoding processes and decision criteria on choice tasks. The four decision conditions yielded two comparisons. First, two opposing phrasings were used for a subjective question: "which picture do you like more/less?" where "like more" is more canonical. Second, two opposing phrasings of the same objective question for which neither one is more canonical was used: "which picture is older/newer?" The gaze bias effect interacted with decision condition in the subjective question comparison but not in the objective question comparison. In first-pass time, the gaze bias effect was present in the "like more" condition, but absent in the "like less" condition, and present in both the objective phrasing conditions. In total time, the gaze bias effect was present in all conditions. These data indicate that decision criteria—constrained by question phrasing—influence the way people encode information at early stages of the decision making process.

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PB5 - Comparison of visual attention and eye movement during penalty kick between veteran and novice goal keepers.

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At the moment of penalty kick, effective visual information processing is important for goal keepers. We have investigated the eye movement for predicting a direction of ball on the moment of penalty kick. The stimulus of PK scene were presented in DVD video that were recorded before at real PK situation in a foot ball field. Six male subjects, aged around 20 years, having normal vision and physical and mental condition were done the following experiment. Two of them were not experienced football play (Novice), other two of them have played football more than three years as a field player (Field), the other two have played as a goal keeper more than three years (GK). Eye movements were recorded by the EMR-8 (NAC) head-mounted system. The subjects were asked to predict the direction of a PK. Directions of ball were divided into six positions according to a goal mouth. Prediction of direction was also asked to all subjects. Comparison between Novice and Field, and between Field and GK, the statistical difference of movements were found horizontally or vertically more than 90 percent in the data. Prediction accuracy rates were as follows in better order: Field, GK, then Novice.

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PB6 - LOOK AT THIS! High-school students with high fluid intelligence use shorter fixation durations in a geometric reasoning task.

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Fixation durations are measures of both cognitive processing depth and task difficulty. According to Velichkowsky (1997) and Galley (1999), visual fixations in healthy adults can be categorized into very short, short cognitive and cognitive fixations. However, it is unclear, whether this classification also holds true for people with high fluid intelligence level. Twenty participants with high (hi-IQ) and 12 with average fluid intelligence (ave-IQ) performed a geometric analogical reasoning task with graded difficulty. After training, both groups performed on a stable behavioral level and did not differ in reaction times. However, hi-IQ showed shorter mean fixation durations across all task difficulties. Specifically, with increasing task difficulty their relative amount of short fixations was increased whereas the relative amount of long fixations was decreased compared to ave-IQ. We conclude that while for hi-IQ and ave-IQ fixation durations vary with cognitive processing depth and task difficulty, this variation can be dissociated between groups. Further, when estimating processing depth by fixation durations, prevailing classifications do not account for the performance of high-intelligent individuals. Apparently, they need less time to load content into their cognitive system. Shorter overall fixation durations need to be considered as a complementary aspect when investigating the nature of intelligence.

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PB7 - Properties of the memory recency effect in repeated visual search.

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Visual search often involves searching the same environment more than once for different targets. Here, participants searched the same 10-letter display in two consecutive searches for different target letters. In Experiment 1 manual responses for target letters were faster in the second search than in the first search. Eye movement recordings demonstrated that the time necessary to find the target letter in the second search depended on when that letter was fixated in the previous search: this is a short-term memory recency effect. The effect disappeared, when the letters interchanged their positions between searches, while retaining the spatial layout of the display (Experiment 2). This demonstrates that the memory on which the effect is based is visual and tied to the spatial locations of the search items. In Experiment 3 we introduced a short interval (400 ms or 800 ms, respectively) between the searches. The search benefit was undiminished. This shows that the recency effect is robust to short delays between the searches. Taken together, our research provides a rich picture of the memory processes which support this type of multiple search.

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PB8 - Screening for strabismus: A clinical approach using an eye-tracking system.

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Strabismus is a condition in which the eyes are not properly aligned with each other. The fundamental technique in detecting and measuring strabismus is the cover test. It gives an objective and qualitative measurement of eye alignment, which provides information on the presence, magnitude, directions and frequency of the deviation. However, the test result relies on the interpretation of the examiner and there is no permanent objective recording of the test results, made available to date. This presentation explores the possibilities of combining the cover test with an infra-red eye tracker in providing more objective and quantitative measures that would usefully supplement and extend the qualitative analysis.

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PB9 - Evidence for and against a role of lateral interactions in saccade generation.

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In several models, it is assumed that lateral interactions between neurons of the Superior Colliculus determine when and where the eyes move in two-stimulus visual displays. When a target is presented with a remote distractor, saccade onset is delayed due to long-distance inhibitory connections, but saccade accuracy remains unaffected. Reversely, when two stimuli are displayed in close proximity, short-distance excitatory connections speed up saccade initiation and deviate the eyes towards an intermediate location between the stimuli. The present study was an attempt to estimate the threshold distance at which the distractor effect on saccade latency supposedly reverses and the global effect cancels out. A peripheral target stimulus (singleton) was presented either in isolation or simultaneously with a distractor on the ipsilateral target axis. Both the eccentricity of the distractor and the angular separation between distractor and target were manipulated. Results confirmed a distractor effect on saccade accuracy, but mainly for angular separations less than 5-7° depending on stimulus eccentricity, or short collicular distances. However, the direction and the magnitude of the distractor effect on saccade latency were only slightly affected by distance. Thus, lateral interactions are probably responsible for where, but not when the eyes move in two-stimulus visual displays.

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PB10 - Visual search disorders beyond pure sensory failure: comparison of virtual and real patients with acute homonymous visual field defects.

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Patients with homonymous visual field defects (HVFD) are often disabled during visual exploration of natural environment. Abnormal visual search may be related to the sensory deficit, deficient spatial orientation or compensatory eye movements. We tested whether visual search in HVFD is purely determined by the visual-sensory deficit by comparing nine patients with HVFD due to occipital stroke in an acute stage to nine healthy subjects with gaze-contingent "virtual" homonymous visual field defects (vHVFD) and to nine controls with normal visual fields. Eye movements were recorded while subjects searched for targets among distractors and indicated target detection by clicks. All patients showed longer search durations than vHVFD subjects. This was tightly related to the higher number of fixations and particularly re-fixations. Patients' working memory was intact. Scanpath strategies were similar in patients and vHVFD subjects. For both groups amplitude and frequency of saccades did not differ between the hemifields. In HVFD patients with acute occipital brain lesions, visual input failure does not fully account for abnormal visual search. It might either result from disconnections of the primary visual cortex to associated occipital and temporal brain areas or reflect an early stage of compensatory eye movements which differ from chronic HVFD patients.

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PB11 - Programming of memory-guided saccades in human. EEG study.

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Memory- and visually-guided saccades were studied in 10 healthy subjects by using methods of direct and backward EEG averaging. Increase of duration and memory-guided saccades latency (279±9 ?s) in comparison with visually-guided saccades (199±7 ?s), decrease of amplitude of memory-guided saccades were shown. The decrease of latency peaks of the ERP arising on a signal to start saccade (N1 and P1) and initiation potentials (P-1 and N-1) developing in the last 120 ms before memory-guided saccades was revealed. Potential N1 dominates in the left frontal and frontal-saggital areas before memory-guided saccades. Controlateral domination of potential P1 foci in frontal-parietal areas indicates the inclusion of frontal-parietal network of spatial attention and saccadic control at early stages of saccade programming. Parameters of initiation potentials before memory-guided saccades testify inclusion of main frontal oculomotor areas at initiation stages. The stage of decision-making reflects in topography of potential N2 (80-125 ?s). Its localization in the frontal-parietal areas of the left hemisphere can testify interrelation of decision-making with processes of motor attention and anticipation with movement programming on the basis of the visual information taken from memory. The study was executed at support of the RFBR (08-04- 00308).

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PB12 - Modeling the effects of spatial attention in macaque middle temporal area.

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Spatial selective attention has been shown to modulate the responsiveness of neurons throughout the visual cortex. The effects of attention are generally consistent with a contrast gain model, which implements a multiplicative gain increase by spatial attention. Womelsdorf et al. (Nat. Neurosci., 2006) recently reported non-multiplicative changes of neuronal responses in the medial temporal area (MT), namely a shift and shrinkage of the receptive field (RF). Our study aims at introducing meaningful neuroanatomical constraints in a previous model used to explain the role of feedback signals on feedforward processing (Hamker, Cereb. Cortex., 2005; Hamker et al., PLOS Comp. Biol. 2008). It relies on gain modulated cells, interacting through lateral inhibition, and distributed in visual space according to cortical magnification. These gain modulated cells then excite a pool cell which integrates its inputs through a max function. The pool cell is the level at which the model is compared with the experimental data. This fit to experimental data reveals the shape of the attentional signal in cortical space, the influence of lateral inhibition in shaping the cells' RF. Moreover, we extend the results of Womelsdorf et al. (J Neurosci., 2008) on the relationship between the shift and shrinkage of the RFs.

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PB13 - Individual differences in fixation eye movements: it is true that microsaccades are strictly binocular?

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Microsaccades (MSC) are involuntary and rapid small-amplitude eye movements that contribute to visual perception during fixation, and can be correlated with increases in neuronal firing at all levels of the visual pathway. MSC have been traditionally considered as a binocular phenomenon, but recent studies suggest that MSC can be monocular too. However, because they have smaller amplitude and lower peak velocity, it is not clear whether these monocular movements are playing some role in visual processing or, simply, they must be considered as noise (Martínez Conde et al, 2006, Neuron 49, 297-305). In our study, eye movements of ten observers were recorded, simultaneously in both eyes, during a dichoptic task in which a strict fixation was required. Binocular and monocular MSC were identified in all observers by using an objective algorithm (Engbert and Mengerthaler, 2006, PNAS 103). We observed considerable interindividual differences concerning duration, amplitude, and mean rate of MSC, but, in every case, monocular and binocular MSC shared a strong peak velocity/amplitude correlation (r=.80), that is the key property of MSC (the main sequence). These results suggest that monocular MSC are much more frequent than usually assumed and, besides, they seem not to reflect noise.

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PB14 - Microsaccades during depth tracking.

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We devised a depth-tracking task using stereoscopic displays. Disparity was introduced with a display containing a static fixation point, which visually fused with an oscillating fixation point in the contralateral display. We find gaze trajectories for both eyes oscillating in phase with the oscillating fixation dot, though much weaker in the eye presented with the static fixation dot. Microsaccades occurring simulataneously in both eyes are strongly coupled with respect to their orientations. Microsaccades occuring in one eye only, however, tend to be oriented ipsilaterally, both for the oscillating and the aligned display. The microsaccade rate and mean orientation show oscillations related to the time course of the presented disparity. The possible role of microsaccades for binocular gaze control will be discussed.

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PB15 - Microsaccade detection and characterization using continuous wavelet transform.

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While humans are living in a very dynamic world, to observe the ambient environment they need to perform movements with their eyes. However, even during fixation of stationary scenes, the eyes produce highly dynamic miniature movements. These fixational eye movements consist of three different components, i.e. tremor, drift and microsaccades. All three types generate small random displacements of the retinal image when viewing a stationary scene. In our current research we focus on a reliable characterization and in this course a detection method for microsaccades in a record. Microsaccades represent the most significant component of fixational eye movements occurring in a rate of one to two per second. Our approach introduces a new method to study microsaccade statistics using continuous wavelet transform. From the mathematical point of view, microsaccades can be identified as singularities over a wide range of length scales. A subsequent analysis of the empirical orthonormal functions let us investigate characteristics of local geometries of the eye's trajectory during microsaccades. We identified the principal shape of microsaccades to include an overshoot which gets directly corrected. Analyses done with amplitude-adjusted surrogate data to mimic temporal correlations of fixational eye movements support our results.

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PB16 - Microsaccades may establish the geometric space in visual perception.

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The main purpose of visual perception is to enable action in the physical world. Processing of visual input is done in neuronal circuits where little more than neighbouring relations may be taken for granted. Veridical notions of geometric concepts such as straightness of lines or distance between objects need to be established. Mathematician Felix Klein postulated that each geometry is the study of invariants under certain groups of movements (Erlanger Programm 1872). The euclidean geometry is generated by the euclidean group of motions in space. The translation subgroup is generated by infinitesimally small movements. In visual perception, the nearest physiologically possible realization are microsaccades, which may be thought as generating the group homomorphism from physical translations into the geometry of visual space. If visual geometry is built up at demand, certain phenomena may be better understood. Human vision is able to detect the nonius alignment of straight lines with a hyperacuity down to 5 arcseconds. When the lines are separated by a gap, however, a much larger nonius error of some arcminutes may be observed. The need for continuously refreshing of the metric in visual space may be the reason why microsaccades occur regularly and frequently.

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PB17 - Connection between motor space and perceptual space in saccadic outward adaptation.

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Adaptative shortening of a saccade influences the metrics of other saccades within a spatial window around the adapted target. Within this adapation field visual stimuli presented before an adapted saccade are mislocalized in proportion to the change of the saccade metric. We investigated the saccadic adaptation field and associated mislocalization for saccade lengthening, or outward adaptation. We measured the adaptation field for two different saccade adapations (14° to 20° and 20° to 26°) by testing transfer to 34 different target position in complete darkness with the overlap paradigm. We measured localization judgements by asking subjects to localize a probe flashed before saccade onset. The amount of adaptation transfer differed for different target locations. It increased with increases of the horizontal component of the saccade and decreased with deviation of the saccade direction from that of the adapated saccade. Mislocalization of probes inside the adaptation field was correlated with the amount of adaptation to the probe location. These findings are consistent with the assumption that motor space and perceptual space are linked to each other.

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PB18 - A size-based adaptation for within-object saccades vs. a spatial location-based adaptation for between-object saccades: An asymmetric transfer.

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The absence of saccadic adaptation transfer between different saccade types can be used as an argument for specific neural sites (e.g. reactive vs volitional saccades). Another classification of saccades refers to the distinction based on the action goal, Between-Object (B-O) saccades aiming for an object and Within-Object (W-O) saccades exploring the object. They are coded on different information: object spatial position and size for the B-O and W-O saccades respectively. As previously shown (Collins et al, Brain Research, 2007), the systematic backward displacement of objects during the saccade execution led to adaptation (i.e. the decrease of amplitude) only for B-O saccades. Moreover, the B-O saccadic adaptation did not transfer to W-O saccades, reinforcing the claim that spatial information is not critical in the coding of W-O saccades. Here we found that (1) a systematic intrasaccadic change of the object size (decrease or increase) led to the "adaptation" (decrease or increase of amplitude) of W-O saccades. (2) Interestingly, such an "adaptation" transferred to both W-O and B-O memory-guided saccades. This asymmetric transfer between Within-object and Between-object saccades (W-O transferring to B-O saccades but not the reverse) may suggest specific, but not totally independent neural sites.

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PB19 - Inhibition of a recent distracter: A location or object based effect?

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Crawford et al.(2005) demonstrated that inhibition of a saccadic eye movement at the location of a recent distracter, using coloured targets, occurs, suggesting that visuomotor centres have access to the spatial memory of a distracter. In a current experiment the stimuli were changed to more realistic objects (i.e. ball, bat, hat, wicket) to determine if an object or location is more important for the inhibitory effect of a recent distracter. Participants were presented with a sequence of two displays. In the first the target (i.e. ball) was presented together with two of three possible distracters (bat, hat, wicket), in the second display a lone target (ball) was presented either at the location of the display 1 target, the location of a previous distracter or a new location. There were also conditions where a previous distracter from display 1, or a 'new' distracter not used in display 1, was the lone item. Participants were instructed to fixate the target in display 1 while ignoring the distracters, and to fixate the lone item in display 2. The saccadic reaction time (SRT) to the lone target in display 2 revealed no evidence of an inhibitory effect of a recent distracter when using objects from the same semantic category, in contrast to the study using coloured targets as the stimuli. There was however a significant increase in SRT for the 'new' distracter and previous distracter in comparison to the previous target. These results suggest that when objects are the target of attentional selection spatial location ceases to derive an inhibitory effect on saccadic eye movements.

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PB20 - Effects of acute alcohol intoxication on different levels of visual processing and oculomotor control.

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Although alcohol consumption is known to degrade performance in a variety of tasks, the exact character of alcohol-induced impairments is not well understood. We examined the extent to which acute alcohol intoxication affected basic visual processing and oculomotor control on different levels. The pro-saccade, double-step and two anti-saccade paradigms were used to evaluate alcohol-related effects on the automatic, automated and voluntary processing levels, respectively. Participants' (N=32) performances were measured in separate and counterbalanced "no alcohol" and "alcohol" (mean BrAC 70mg/dl) sessions. Results indicated both general and selective effects of intoxication. A slowing of saccade latencies was found across all tasks. In addition, deficits in adaptive reprogramming of saccades on the basis of new visual information were evident in the double step paradigm, indicating specific impairment due to alcohol on the automated level. Interestingly, findings on the voluntary level showed alcohol effects on the programming on saccade amplitudes, but left inhibitory functioning intact. Taken together, this set of results provides the first theory-driven and detailed account of alcohol-related visuomotor deficits. Theoretical implication and avenues for further research will be discussed.

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PB21 - Vector variations of saccades during mental rotation.

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The present experiment used eye scanpaths to explore the relationship between the encoding phase and judging phase in the process of mental rotation. The stimuli which were composed of one white line and five white squares at random locations were used in a mental rotation task. The participants were asked to determine whether the two images presented in sequence were the same image or not. The two images could differ in the orientation or the content. The displacement variations of fixations and vector variations of saccades were the measures to compare the eye movements between the two images in each trial. The results showed the correlation of eye movements between the encoding and judging phases was higher in the measure of vector variations of saccades than the displacement variations of fixations. We suggest that the relative but not absolute spatial arrangement of parts was represented for an image and used for mental rotation. In addition, the vector variation of saccade is a sensitive index to reflect the mental rotating processing when two images are the same but with different orientation.

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PB22 - A model of the cerebellar mechanism that reduces the variance of saccadic end point.

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Targeting saccades show variations in amplitude and direction. Monkeys showed recovery of saccade accuracy in amplitude some months after the lesion of the oculomotor vermis. However, the variation in amplitude remained large as in the early postlesion period (Takagi et al. 1998, Barash et al. 1999). The cerebellar cortex must have the capability to reduce the variation. Learning speed itself does not solve this problem. Here I propose a model that a Golgi-granule cell system has its ability of pre-filtering to characterize mossy fiber inputs so that Purkinje cells can impinge upon the nuclear activity with proper inhibition to reduce the variation of the saccades. The strength of the inhibition to each pattern of mossy fiber inputs has been learned during former erroneous trials as usual adaptation. The proposed Golgi-granule cell system extends the capability of the feed-forward place-code associative learning of the cerebellum (Fujita, 2005) to cope with the variability of general motor command.

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PB23 - English-German language dominance effects on eye movements during reading.

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How does language dominace affect eye movements during reading? Bilingual or nearly bilingual readers of English and German (half of them English, the other half German as first language) read both 48 English sentences (Reichle et al., 1998; Schilling et al., 1998) and the Potsdam Sentence Corpus (144 German sentences; Kliegl et al., 2004). Eye movement measures were compared using a distributed processing format that also considers effects of neighboring words on measures expressed at the current word. Results were as expected, with reading in the first language invariably reflecting more efficient reading than reading in the second language. Results also replicate the canonical effects of word frequency and predictability and also the inverse effects of predictability of an upcoming word on current fixation duration (longer fixation duration on word n with higher word n+1 predictability) that has been related to memory retrieval (Kliegl et al., 2006). SWIFT simulations of the data are currently underway and results will be available for presentation.

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PB24 - The timecourse of the effect of word frequency on attention in reading.

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The effect of word frequency on attention during reading was investigated using a dual task (Fischer, 1999; The Quarterly Journal of Experimental Psychology, 52A, 649-677). Participants were asked to read single sentences and to discriminate gaze-contingent probes ('\' or '/') that were briefly briefly superimposed on a character. Probes appeared after the eye landed on a critical word with high or low frequency, 6 characters to the right or left of fixation (in the next or previous words respectively), and 40 or 130 ms (Experiment 1) or 10 or 130 ms (Experiment 2) after fixation. There was an effect of word frequency on probe-discrimination accuracy (in Experiment 1) for left probes with temporal offsets of 40 ms and (in Experiment 2) for left and right probes with temporal offsets of 10 ms. Our findings are compatible with load-induced changes in attention (Brand-D'Abrescia and Lavie, 2007; Psychonomic Bulletin and Review, 14, 1153-1157) that occur in reading as early as 10 ms into a fixation but that dissipate on the right (in the next word) by 40 ms. At least lower levels of processing of the next word are unaffected by the frequency of the fixated word 40 ms into a fixation.

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PB25 - Contextual constraint and N + 2 preview effects in reading.

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Extracting linguistic information from locations beyond the currently fixated word is a core component of skilled reading. Recent debate on this topic is focused on the question of whether the acquisition of parafoveal word information occurs in a strictly sequential or limited parallel fashion. One arena of this discussion is the issue of parafoveal processing from word N+2 while fixating word N. The current study adds a new angle to this topic, examining the role of contextual constraint on distant parafoveal processing. Participants read sentences in which N+2 target words were always preceded by the word "the", providing optimal conditions for parafoveal processing. Pairs of target words were selected so that one member was highly predictable and the second was unpredictable. Using saccade contingent display manipulation, preview of N+2 target words was denied while fixating word N, using either a random letter mask or a companion-pair word mask. Significant N+2 preview benefits emerged in the high contextual constraint conditions for both random letter and word masks. There was also a substantial drop in fixation probability for the N+1 word in the letter mask condition. These results provide solid evidence for parallel distributed word processing but also illustrate some of its limitations.

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PB26 - Crossed eye fixations in reading are real.

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We recorded binocular eye movements of adult readers as they read single German sentences. Analyses of horizontal and vertical fixation disparities indicated that the most prevalent type of disparate fixation was crossed (i.e., the left eye was located further to the right than the right eye) while the left eye frequently fixated somewhat above the right eye. Vergence movements during reading fixations led to a reduced disparity at the end of fixation as compared to the start of fixation. The dominance of horizontally crossed over uncrossed fixation disparities is opposite to what has been observed in other studies (e.g., Liversedge et al., 2006). Analyses of monocular contributions to vergence confirmed that the data pattern observed here is not an artefact. Reflecting the prevalence of crossed fixations, the Gaussian distribution of the binocular fixation point peaked 2.6 cm in front of the plane of text. Fixation disparity accumulated during the course of successive saccades and fixations within a line of text, but only to an extent that did not compromise single binocular vision. We conclude that in reading, the version and vergence system interact in a way that is qualitatively similar to what has been observed in simple non-reading tasks.

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PB27 - Usage of statistical cues for word boundary in reading Chinese sentences.

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The present study addressed the question of whether the probability of a Chinese character being used as either word beginning or ending can affect parafoveal word processing. The second character (C2) of the two-character target word embedded in each sentence was either frequently used as a word ending (congruent condition) or beginning (incongruent condition). The character (C3) to the right of the target was a single-character word and C23 could not form another word. With the boundary paradigm, whether the combination C23' was a word or not during pre-target viewing was manipulated in three preview conditions (i.e., identical, ambiguous and control conditions). Gaze durations on the target were shorter in the congruent condition than in the incongruent condition, but an opposite character position congruency effect was observed on pre-target gaze durations. However, there was no significant difference between the ambiguous preview and control conditions. The results suggest that Chinese readers are sensitive to the statistical cues for possible word ending; while whether or not this ending character can be combined with the following character(s) to form another overlapping word is not processed in the parafovea.

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PB28 - Neighbor effects and the L2 stage of E-Z Reader.

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Words with high orthographic relatedness are termed word neighbors (angle, angel; birch, birth). Words such as these can have a late inhibitory effect on eye movements (increased spillover and or second pass time) relative to controls (Johnson, 2009; Perea, Pollatsek, 1998; Pollatsek, Perea, Binder, 1999; Slattery, submitted). We further investigated the time course of these neighbor effects with the boundary change paradigm (Rayner, 1975). Participants read sentences containing a target word (word N) that either had a neighbor, or was a control word. Additionally, the parafoveal preview of the following word (word N+1) was either accurate or not. We predicted a smaller parafoveal preview benefit for neighbor words than for controls. Within E-Z Reader (Pollatsek, Reichle, Rayner, 2006; Reichle, Pollatsek, Fisher, Rayner, 1998; Reichle, Rayner, Pollatsek, 2003) this may be explained by assuming that the duration of the final lexical processing stage (L2) takes longer to complete for neighbor words relative to controls. This explanation has intuitive appeal as neighbor words are likely to activate their own lexical representation as well as the one for their neighbor which would require an additional late decision not required for control words.

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PB29 - The influence of providing word boundary cue on Chinese reading.

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The present study investigated the influence of framed words and non-words on eye movements when reading Chinese text. For Roman scripts, inter-word spaces are the perceptual markers for word boundaries and the spaces help the decision of where the next to-be-fixed word is. For Chinese, word processing is also essential for reading, however, word boundary is ambiguous due to the lacks of both inter-word spaces and obvious lexical markers available for word segmentation. In this experiment, three types of frames were used to create perceptual groupings of word, non-word, and character. One additional condition which framed the whole line of text was used as the baseline. The results showed no significant difference among the four conditions on duration measures. The non-word frame condition, compared with the other three conditions, diminished the preference of the initial landing probability on the end constituent and increased the refixation rates if the eyes initially landed on that position. It indicates that perceptual cues affect the process of saccade targeting when reading Chinese, especially when the cue is invalid for word boundary. The findings suggest that, when reading Chinese, word segmentation occurs during foveal processing and it may also play a role for saccade targeting.

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PB30 - Role of fixation instability when reading continuous text with an artificial macular scotoma.

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Patients with macular scotomas have a much slower reading speed than normally-sighted observers. This decrease is mainly correlated with an increase in the number of fixations needed to read a sentence continuously displayed on a page. It is often assumed that the larger number of fixations results from a detrimental oculo-motor fixation instability due to the absence of visual input from the fovea. The purpose of our study was to test this hypothesis. A gaze-contingent display was used to force normally-sighted observers to read sentences using the lower part of the visual field (minimal eccentricity: 3°). On each trial, observers had to read aloud a one-line sentence displayed on a textured background. In one condition, a spatially uniform grey mask was displayed in real time on the fovea. In the other condition, foveal vision was preserved thus allowing the use of the background texture for gaze stabilization. Results showed no significant difference in reading speed and ocular patterns (fixation duration, saccade frequency, direction and amplitude) between both conditions. This suggests that oculo-motor instability due the absence of foveal stimulation is not a major limiting factor of reading speed in patients with macular scotomas.

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PB31 - Orthographic and phonological information in early word recognition by skilled and less skilled deaf readers of french: Focusing on eye movements.

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A small proportion of profoundly deaf individuals attain expert reading skills and it is important to understand why they become skilled readers and other deaf people do not. Despite the hypothesis that good phonological processing skills during reading are associated with good reading skills in deaf readers (Perfetti & Sandak, 2000), research has not yet provided clear answers as to whether it is the case or not. We investigated skilled and less skilled adult deaf readers' use of phonological codes during early French word recognition using eye movement measures. A group of skilled hearing readers was also included as a means of comparison to existing literature. Given the close mapping of orthographic and phonological information in alphabetical languages, the unique contribution of orthographic codes was also investigated. Results show that orthographic and phonological information was extracted from parafoveal vision to initiate word processing before a word was fixated. Crucially, the same pattern of results was found for the three groups of readers (skilled hearing, skilled deaf and less skilled deaf readers), suggesting that reading difficulties in deaf readers may not be related to their use (or not) of phonological codes during word recognition.

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PB32 - Bilingual processing of homonyms and partial cognates - evidence from synchronized EEG and eye-movement recording.

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Bulgarian-English proficient bilinguals read silently biased English homonyms with two noun meanings embedded in disambiguating sentences. The subordinate (less frequent) meaning of half the homonyms was a cognate in Bulgarian (e.g. "bank" as a river bank is "briag" in Bulgarian, but "bank" as a financial institution is "banka"). The partial cognates (homonyms with a cognate meaning) and homonyms were matched by frequency, length, and predictability among other factors. We report classical eye movement measures (first pass, total time) as well as event-related brain potentials, triggered by the beginning of the first fixation on the target word – this EEG measure is sometimes referred to as Fixation-Related Potential (FRP). Both types of measures show early difference in processing between partial cognates and homonyms, while a dominance effect is found only in the late eye-movement measures (total time). These results are of immediate interest from both theoretical and methodological points of view – the reported effects contribute to the field of bilingual eye-movement research, while the FRP analyses help validate and develop the relatively new methodology of recording synchronized EEG and eye-movements.

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PB33 - Visual information facilitates communication and prediction of others' opinions.

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Several eye-tracking studies have shown that we use visual information to facilitate language processing. For example, to resolve ambiguous statements, to predict upcoming material and to enhance concept retrieval. This poster presents work in progress examining whether optional visual information can facilitate natural communication. The rationale would be that extra visual information helps constrain possible interpretations and provide an extended common ground from which speakers can ground their statements. 48 pairs of participants were asked to discuss eight statements, randomly drawn from a pool of 48 topics. Half of the statements were supplemented by an image illustrating that particular conversation topic. Between statements, participants were asked to rate how well contributed to successful communication, and how well they think their interlocutor contributed to successful communication. After all conversations, the participants were then asked to rate to what extent they agreed with each presented conversation statement, as well as how they think their interlocutor agree with the statements. We predict that interlocutors who were aided by visual information judged the communication to be more successful, as well as being better at predicting their partner's opinions.

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PB34 - What the eye tells about mental model operations: Evidence for a linking between eye-movements, mental model construction, and reasoning – even without visual stimuli.

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In the field of human reasoning there is still an on-going debate on which of the diverse cognitive theories ranging from pure rule-based approaches to mental model can better explain classical behavioral data. We present a series of visual-world eye-movement experiments on spatial relational reasoning to discern these theories A fundamental hypothesis derived from the mental model theory is that relational reasoning strongly relies on a mental model manipulation device responsible for model construction, model inspection and model variation. Participants looked at a empty grid while they listened to a varying number of premises, each introducing a new object. The first object was always aditionally given at the center of the grid while all others were not visually presented. The results suggest a direct linking between this mental model manipulation device and eye-movements, demonstrating that the eye reflect the fundamental operations of model construction - even if there are no visual stimuli. In the second experiment participants were instructed to fixate the centre object during the entire trial, resulting in an effect on reasoning performance.

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PB35 - Lexical processing of compound words in reading Chinese.

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Readers' eye movements were monitored as they read Chinese sentences containing noun-noun compounds using the boundary paradigm (Rayner, 1975). The first constituent of the compound was either low frequency with a highly predictable 2nd constituent or high frequency with an unpredictable 2nd constituent. The preview of the second constituent was also manipulated. There were four preview conditions: identical to the correct form; a semantically related character to the second constituent; a semantically unrelated character to the second constituent; and a pseudo character. There was an invisible boundary between the two constituents. Only when the eyes moved across the boundary, did the preview character change to the identity character. The major findings were: (1) There was a parafoveal-on-foveal preview effect, but only when the second constituent was highly predictable from the first constituent. (2) The preview effect (the difference between the identical and the pseudo-character condition), as measured by gaze duration on the whole compound word, was greater for the highly predictable than less predictable condition. These results support the constraint hypothesis (Hyönä, Pollatsek & Bertram, 2004) for compound word recognition; the former result also lends support for parallel orthographic processing of constituents within compound words.

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PB36 - Eye movements of typically developed and autistic individuals in a false-belief task.

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This study explored eye movements in autistic and typically developed (TD) participants when they viewed a sequence of static images for a theory-of-mind (TOM) task. It also examined social processing as measured by the distribution of attention to people, action-related-objects and background, and initial orienting to faces and joint attention. Autistic participants attended similarly to task-relevant information compared to TD participants regardless of their ability to answer TOM questions following inspection. This suggests that autistic participants who did not demonstrate TOM had difficulty inferring others' false beliefs rather than an inability to visually sample relevant information. The results furthermore revealed that whilst TD participants spent longer looking at people compared to other parts of the scenes, this bias was reduced in autistic participants. We also found subtle reductions in initial orienting to faces and instances of joint attention in autistic compared to TD participants, in line with the wider literature on autism.

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Poster Session C: 6-8pm Tuesday 25th August 2009

PC1 - Eye movements while walking and using a cellular phone.

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Nowadays, many accidents resulting from using a cellular phone while walking are reported. Concentrating on the phone conversation or the phone display may cause lack of attention to one's surroundings. In order to clarify how much attention cellular phone users pay to their surroundings while walking, an eye tracking study was conducted. Ten university students walked along a specific route without calling and mailing, while mailing, or while calling. Their eye movements were recorded using the EMR-8B system. While walking without calling and mailing, participants mainly looked at the front. They also paid attention to important details at each place, such as their feet when climbing stairs and traffic signal at the crosswalk. While walking and calling, it was found that more attention was paid to such detail. However, while walking and mailing, participants looked at their phone display 50–80 percent of the time and did not focus on important surrounding information. Most participants were particularly late in noticing the changing traffic lights, and some even crossed the road without paying heed to the traffic. The results showed that mailing during walking led to participants paying lesser attention to their surroundings. For safety purposes, mailing during walking should be avoided.

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PC2 - Gaze-limb coordination in Parkinson patients driving a simulator.

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Driving a car is an essential everyday coordination task. Symptoms of idiopathic parkinson´s disease (PD) span from narrowed attention with prolonged sensory-motor latencies to tremor, rigidity and slowness of hypometric gaze&limb movements and decreased frequency of lid closures. Using an infrared system permitting free head-eye movements within a driving simulator we recorded eye-head-gaze-coordination together with steering and accelerator/ brake signals from 20 PD (mean age 63.6 , 4 females) and 20 normal age matched subjects. PD patients demonstrated deviations from normal driving: increased gaze latencies & prolonged reaction times for braking; diminished, low amplitude and slow voluntary head movements; inaccurate fixations during driving with consecutive delay of reactions; degraded performance of driving through curves; sometimes neglect of traffic lights and/or other traffic signs; decrease of lid closure frequency with prolonged lid opening; saccadic pursuit eye movements both in the initial test and more so with dynamic fixations while driving; mild paresis of upgaze in 10 out of 20 patients. The special role of head eye coordination together with the narrowing of "attention" as an important part of the disease progress, has so far not been realized by most clinical researchers.

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PC3 - Eye-hand coordination errors during monotonous activity.

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This study was designed to define the characteristics of eye–hand coordination, during a decrease in vigilance. An eye-tracking system (Eyegaze Development System, LC Technologies) provided eye movement measures with a collection rate of 120 Hz. A small circular target moving with low constant velocity (12 mm/sec) on a circular path had a period of 20 sec. Subjects tracked the visual target using a mouse-driven cursor. To test the attention level an additional stimuli was introduced which appeared for 3 seconds with an interval of 15 to 40 sec. When the stimuli appeared, it was required to touch it with the cursor and while touching, click the mouse button. Monotonous characteristics of the test performance induced drowsiness and appearance of errors 25-30 minutes from the beginning of the experiment. The evolution of physiological vigilance level was evaluated using electroencephalography recording. In our analysis, we focused on the pattern of coordination of eye and hand movements during the appearance of errors caused by a decrease in the level of wakefulness. It is shown, that the degradation of tracking performance (errors) was correlated with appearance of the drowsy pattern in EEG. Support: Russian Humanitarian Science Foundation 08-06-00598a

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PC4 - Direction coordination between saccades and arm movements in adaptation to visual target displacement.

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We examined concurrent direction adaptation of targeting saccades and hand movements in a double-step paradigm. For subject group A, two targets appeared in the center of an imagined circle on the monitor vertical screen, then jumped outward in one of eight directions, and jumped again at eye response onset such as to require a change of saccade direction by -10 deg, and of hand pointing direction by +10 deg. For subject group B, the second target jump was -10 deg for both sensorimotor systems. The adaptation session consisted of 30 episodes of 20 double-step trials. In group A, response direction didn't change adaptively for saccades but it changed by about 80% for the hand, and in group B, response direction changed by about 50 % for saccades and about 55% for the hand. These findings suggest that the directional adaptation of targeting saccades and hand movements is not independent, with the hand taking a leading role.

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PC5 - On changes of gaze parameters in scene viewing.

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Previous research has shown that changes in eye movement behaviour over the time course of scene inspection can be described in terms of exponential functions (Unema, Pannasch, Joos, and Velichkovsky, 2005). While fixation durations increase, saccadic amplitudes decline over time. In the present study the same computer rendered interior scenarios as in the above mentioned study were used. Here, we varied the size of images and the inspection time. First of all, the exponential character of changes in gaze behaviour could be replicated. Both inspection time and image size had influences on saccadic amplitudes and fixation durations as measured in absolute values. However, the global changes over time are stable in all conditions. Additionally we investigated the similarity of gaze positions between subjects over time. The results show greater similarity in the beginning of scene inspection than in later phases. Implications for the current debate on saliency influences on eye movement patterns are discussed within the framework of the two visual systems approach.

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PC6 - The role of extra-retinal mechanisms in driving gaze and head movement responses to briefly sampled motion stimuli.

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During smooth pursuit, when a target is extinguished, extra-retinal mechanisms alone drive response continuation. Experiments were conducted to reveal the development of gaze responses made by extra-retinal mechanisms during both head-fixed and head-free pursuit. Subjects were presented with a horizontal step-ramp stimulus, which occurred in pairs of identical velocity; velocity was randomized between pairs. The target stepped left or right then moved in the opposite direction at 5-40deg/sec. In the first of each pair (Short-ramp) the target was visible for only 150ms. In the second of each pair (Initial Extinction), the target reappeared after a randomized interval and was stationary. Its extinction signalled the start of motion, but the target remained invisible for 750ms, then reappeared for the last 200ms of motion. Subjects were required to track the unseen target using the brief visual information obtained in the Short-ramp condition. Subjects were able to assimilate velocity information from the Short-ramp and make anticipatory responses in the Initial Extinction condition that were scaled to the unseen target velocity, thus revealing the underlying extra-retinal drive. Observation of this anticipatory response in head-free pursuit implies that the extra-retinal drive was responsible for suppression of the vestibulo-ocular reflex in addition to facilitating visual tracking.

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PC7 - Semi-automated video analysis in mobile eye tracking for the analysis of urban advertising.

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At the core of our research is the application of computer vision for mobile eye tracking systems which has recently been considered for visual memory augmentation (Roy, Proc. ISWC 2004) and the analysis of scanpath data (Cerf et al., Springer LNAI 5395, 2009). Our study is on the interpretation of eye movement data of about 100 subjects in Austrian public transportation services. We integrated a component for vision based object detection for the semi-automated analysis of huge video and eye movement data for the analysis of pedestrian awareness in urban advertising. We designed a learnable classifier for highly accurate localisation of public electronic displays and propose a strategy for combined manual rejection of false positives. From display detection and the associated broadcasting plan we were able to derive a current content of user awareness and from this a statistical evaluation of eye movements with respect to content categories. The proposed policy for semi-automated object detection automatically covers 63 % of video data with detection accuracy of ca. 98 %. The remaining data are manually evaluated with a minimization with respect to the use of personnel resources so that only 15 % of video data needed full manual interaction.

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PC8 - An eye-tracking study of consumer attention and judgment in e-commerce.

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Customers use salient factors to form an "anchor" that serves as a reference point during decision-making, termed anchoring effect. It has been demonstrated that advertised reference price (ARP) can bias consumers' judgment on the advertised product's sale price. In addition, proper placement can enhance the effect of advertisements. This study also evaluates the effect of advertisement relevancy on attention. Web pages are used to investigate how ARP is acquired and how ARP may influence customers' judgment on the sale prices. With the aid of the eye-tracking instrument, we recorded eye movements from 11 observers who viewed web pages that included anchoring advertisements. Our results showed that location and context relevancy of anchoring advertisements influences people's attention allocation. Such selective attention in turn biases price judgments, indicating the existence of anchoring effect. Our study demonstrates that the eye tracker provides a new perspective to study complex human behavior in e-commerce environment.

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PC9 - Eye movements when using a mobile phone to search on wall maps.

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We report an experiment where subjects had to find hotels on wall maps using a camera phone. When moved over an item, its display showed the camera view plus additional information that was not available on the wall maps, but necessary for selection. Trials varied with regard to number of items and different ways to mark a hotel with the phone. Eye movements were recorded binocularly with a head-mounted Eyelink II eyetracker. We used differences in x-coordinates of left and right eye to determine the plane the subjects looked at, i.e. phone display or wall. In all conditions, average search time, fixation duration and baseline-corrected pupil size increased with item set size indicating higher difficulty and mental workload. 'Good' searchers with less than 5 percent error trials solved the task faster and showed significantly more gaze shifts between mobile display and wall map per minute than 'bad' searchers with more than 10 percent error trials. The difference between these groups in frequency of errors as well as mean fixation time became more pronounced with increasing set size. We therefore conclude that this way of interaction with wall maps is best suited for tasks which involve a low number of items.

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PC10 - OGAMA - open gaze and mouse analyzer.

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Since ECEM'07 were we first introduced OGAMA this application to analyze gaze and mouse movements in parallel has been continuously improved. Major new features include a slide design module along with a recording module to enable sophisticated studies that can be directly recorded and analyzed with OGAMA using e.g. Tobii tracking hardware. This software is intended to be a convenient open source tool for the eyetracking research community. With its ability to provide common analyzing tools like fixation calculation, replay with video export, attention maps, areas of interest, scanpath comparsion, saliency calculation and a wide range of statistical output variables it still needs your feedback and collaboration to become even more valuable. see: Voßkühler et al (2008), Behaviour Research Methods, 40, 1150-1162.

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PC11 - The “main sequence” is sensitive to mental workload in virtual dynamic environments.

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The present investigation aimed at an application of earlier studies on sensitivity and validity of saccadic eye movements to changes in mental workload. Saccadic main sequence (amplitude, velocity and peak velocity) was examined as a diagnostic measure of mental workload in a virtual driving task. To evaluate changes in mental workload we used a multidimensional methodology, including subjective rating, performance in a secondary task and behavioural indices. Eighteen participants, all with driving licence, were tested in the SIRCA driving simulator and eye movements were recorded using the EyeLink II system. As theoretical framework of reference the Wickens' multiple resource model was used. Our analysis revealed that mental workload differed according to our experimental manipulation. Only saccadic peak velocity (PV) was sensitive to these changes: for increasing mental workload a clear decrease in the PV was found. Based on these findings we suggest PV as a future diagnostic index to assess operator’s attentional state in hazardous environments.

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PC12 - Characterizing fixational eye movements using copulas.

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In this work we investigate the correlation structure of binocular fixational eye movement data using the copula. The standard measures proposed in the literature are based on the evaluation of linear correlations only. This approach is valid only in the context of Gaussian processes. Our approach, on the other hand, allows us to investigate the presence of more general dependencies. The application of the copula enables us uncover new types of associations and dependencies between miniature movements of both eyes and/or between horizontal and vertical movement components. Different measures of dependencies based on copulas are investigated.

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PC13 - The time course of disparity-induced vergence eye movements, measured with objective and subjective methods.

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Previous studies have shown that nonius tests can be used as subjective method for measuring vergence eye movement responses by flashing nonius lines for 100 ms at fixed temporal delays (0–400 ms) after a disparity step stimulus presentation in convergent and divergent direction. These subjectively measured vergence responses strongly resemble vergence responses that are objectively measured with eye trackers; both are significantly correlated. However, during the perceptual processing of the nonius offset, the vergence movement is going to proceed so that the nonius test will measure the vergence state at a moment in time "T" later than the moment of nonius onset. Using cross-correlation between subjective and objective response profiles, we found that T was 58.5 +- 28.9 ms and 57.2 +- 16.1 ms (mean, SD) for convergence and divergence responses, respectively, in a group of 10 subjects. In addition, intra-individual T variation is smaller than variation in the group. The results are influenced by the vergence response performance and test procedure. We conclude that the sensory processing of dichoptic nonius lines is completed during the typical 100 ms flash of nonius lines. This information is helpful for the interpretation of subjectively measured vergence step responses with respect to latency and effects of anticipation.

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PC14 - Choice of saccade detection algorithm has a considerable impact on eye tracking measures.

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We compared a saccade detection software provided by a manufacturer of eye-tracking systems with an algorithm developed by Engbert and Kliegl (2003). For the first comparison we took 137 trials from a reading experiment and calculated ten duration measures common in reading research after preprocessing the data with both algorithms respectively. Results: 1.) All standard eye-tracking measures differ significantly by factors up to two due to a tendency of the commercial software to neglect small saccades, leading to mislocated fixations and a much lower total number of fixations. 2.) Early measures like first fixation duration duration are affected the most. 3) Most measures were considerable more dispersed when using the commercial software leading to lower statistical power when doing hypothesis tests. The second comparison looks at the relation of peak velocity and amplitude of saccades which is known to be proportional up to a point where saturation of velocity sets in (Zuber et al. 1965). This relationship was present in the saccades detected by the algorithm by Engbert and Kliegl but much less visible in those detected by the commercial program. Our implementation of the algorithm by Engbert and Kliegl is freely available as a package for GNU-R.

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PC15 - Image processing techniques for measuring eye retraction during blinking.

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Eye blinking is an essential function of the eye that helps to replace the tear film across the corneal surface. This function is controlled by a blinking center that coordinates all actions that happen simultaneously with the eyelid movement. Among them, we focus our attention in the eye retraction. When the blink occurs, the eye retracts about one millimeter. The process is very fast since the blink is completed in 300 ms. In this presentation we propose the use of a fast camera attached to a slit lam to record such movement. The frames are processed and the borders of the different structures of the eye are automatically detected. The images are ordered in a temporal stack which can be resliced thus allowing direct inspection of the variation of any point of the anterior's eye segment. This technique is often used in tomographic images, but no for temporal sequences. The temporal section so obtained allows direct observation and measuring the dynamic changes in the eye during the blinking process.

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PC16 - Characterization of eye movement artifacts in EEG data and the implications for artifact-correction algorithms.

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As eye movements introduce large artifacts to electroencephalographic recordings (EEG), usually subjects are required to fixate. Due to the heterogenous origin of these artifacts there is yet no standard correction method established and the majority of experiments has to comply with these rather restrictive conditions. Here we investigate types, properties and options for correction of different components of eye movement artifacts. By simultaneously recording at high sampling rates eye movements and 64-channel-EEG during a guided eye movement paradigm, we characterize presaccadic spike potentials, transients and offsets caused by changes of the retinal dipole and eyelid-related artifacts. We show that their relative impacts on the EEG signal differ with respect to electrode site, gaze direction, choice of reference and trial alignment. We demonstrate that this poses method-specific challenges to both, regression and independent component analysis based correction techniques. While regression of electrooculogram or eye tracker channels only corrects transients and offset changes, independent component analysis also accounts for eyelid artifacts. However, independent component analysis fails to isolate spike potentials adequately. Overall, none of the investigated methods alone was able to entirely account for all eye artifacts and full correction requires a combination of different approaches.

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PC17 - The time course and direction of the effect of transient stimulus onsets on latencies of voluntary saccades.

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We adapted a well-known dual task paradigm (Deubel, 2008) to investigate the time course of the effects of transient stimulus onsets on pre-saccadic attention shifts and saccadic latencies. The primary task was a speeded saccade and the secondary task was a 2AFC discrimination. A central arrow cue indicated one of four potential saccadic target locations and after 20, 50, 100, or 150 ms (SOA) a discrimination stimulus appeared transiently (80 ms) at the cued location. Participants performed two types of trials: with and without distractors (an additional, simultaneous transient stimulus onset at the three non-target locations). In each block of trials the four SOA conditions were interleaved with trials without any onsets. Consistent with previous studies, longer SOAs were associated with longer saccadic latencies and better discrimination performance in both types of trials. However, relative to the baseline condition in which no onsets occurred, transient stimulus onsets lengthened saccadic latencies in the trials with distractors, while they shortened saccadic latencies in the trials without distractors. The results suggest that the effect of transient stimulus onsets on saccadic latencies involves bottom-up processes and may represent 'attentional capture' when distractors are absent and the 'remote distractor effect' when distractors are present.

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PC18 - non-trained subjects.

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A gap between fixation target offset and saccade target onset encourages the production of express saccades (ES; latency 80-120ms). Some subjects (express saccade makers) produce almost exclusively ES in gap trials, and in overlap trials (fixation target remains present when the saccade target appears), a large proportion (greater than 30 percent) of saccades have latencies in the ES range. This has been suggested to be rare in the absence of pathology and/or extensive training. We exposed 11 naive subjects to gap (duration 200ms), synchronous and overlap trials (2 x 200 trials for each condition, run in separate blocks, targets 10° left/right randomised, randomised fixation time 1s-2s, order of blocks randomised between runs and between subjects). For each subject, the percentage of saccades with latencies of 80ms to 120ms was calculated for all saccades with latencies between 50ms and 500ms. Of 11 subjects, five (all Chinese) exhibited high proportions of ES in both gap (percentage: 74±15; mean±SD) and overlap conditions (41±7) compared with 48±17 and 12±4 respectively for the other six subjects (3 Chinese, 3 Indian). "Express saccade makers" may be more common than previously thought, and this may be related to ethnicity.

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PC19 - Bayesian modeling of double-step saccades.

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Bayesian decision theory was applied to the saccadic eye movements elicited in double-step mode: primary and corrective saccades. Primary saccade performs large amplitude but not precise eye jummp towards new target position and small amplitude corrective sacade brings line if sight precisely on the target. This behavior mach two-step Bayesian decision making process: first with large uncertainty and second, after getting additional information, - more precise. It explains how saccadic eye movements control system performs precise eye jump in the conditions of the noisy visual estimation of the new target position and eye jump errors made by eye globe muscles. Using Bayesian statistics approach two-dimensional scatter of the landing places of the primary saccades was investigated theoretically and experimentally.

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PC20 - The modulation of inhibition of saccadic return by environmental statistics: Is there a role for predictive cues?

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Inhibition of Saccadic Return (ISR) refers to longer fixations that precede eye movements to a previously visited location. ISR is sensitive to the likelihood of a return location becoming behaviourally relevant (Ludwig et al., ECEM 2009). The current experiments explored how this adaptation to the probabilistic structure of the environment evolves. Specifically, we ask whether the internal representation of the likelihood that a return saccade will be required, is shaped by a local mechanism (keeping track of recent instances), learning of the specific features of the experimental context, or both. In several experiments, observers were required to make sequences of two saccadic eye movements that were guided by different cue types (line or arrowhead). The second saccade was directed towards or away from a previously fixated location in the sequence. The different cues co-varied with the probability of a return saccade. Greater ISR was observed when the return probability was low, but this could not be attributed to learning of the mapping between the environmental statistics and the visual nature of the cue. It appears that the adaptation of ISR to the probabilistic structure of the environment is mediated by a local mechanism tracking a short history of recent sequences.

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PC21 - Not sleep but sleep deprivation facilitates visuo-motor learning.

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Sleep improves previously learned perceptual and motor skills. In an oculomotor training experiment, we showed that saccadic reaction times are shortened after a night sleep. Using the pro-saccade gap task, express saccades are performed (latency ~100 ms). The express saccade rate (ESR) can be increased by intensive training. We wanted to determine the impact of sleep and sleep deprivation on learning to perform express saccades. Eye movements of young healthy subjects were recorded before a sleep night resp. sleep deprivation night (test 1), the morning after (test 2) and 24 hours later (test 3). In five groups with ten subjects each we systematically evaluated the impact of sleep, test 1 and 2 as well as additional training after test 1 on the generation of express saccades. Data shows that the ESR is altered if test 2 is followed by sleep deprivation. ESR increase becomes visible after a subsequent sleep night (test 3) and is stable at least over four weeks. Sleep suppresses effectively the increase of ESR. Sleep deprivation obviously changes the brain into a state, in which fast motor reactions can be learned. Subsequent night sleep consolidates the memory traces and induces a plastic alteration of the brain.

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PC22 - Introducing a new psycholinguistic Database for the German language: dlexDB.

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dlexDB is a project funded by the Deutsche Forschungsgemeinschaft (DFG) aiming at establishing a lexical database for psychological and linguistic research. dlexDB is based on the 100-million-word DWDS corpus encompassing a broad variety of written documents across the entire 2oth century. The database provides online speech data in edited and standardized form, ranging from simple type frequency counts as well as morpheme, phoneme, syllable and lemma frequencies to specific linguistic variables such as context diversity, regularity and familiarity. Via the webfrontend searches can even be specified to the level of individual characters. Besides the possibility to search for unigram measures, the project aims at proving norms for n-grams with n = 4. We report a systematic comparison of the predictive validity of fixation durations in reading between norms computed from the dlexDB and from the 5.6 million CELEX corpus. Different orthographic measures are calculated to test for parafovea-on-fovea effects using eye movement data from the Potsdam Sentence Corpus.

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PC23 - Factorizing garden paths.

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Non-canonical word order (scrambling), case ambiguities, non-canonical thematic linking, and passivization are known to evoke sentence processing difficulties. In German, a strong garden path effect is not simply the cumulative result of such difficulties. It only arises when interdependent processing operations that have to apply simultaneously produce conflicting results. This will be shown by factorizing the effects that turn some German 'get'- passive constructions into strong garden paths. This construction allows combining the above-mentioned ‘ingredients’ in single stimulus sentences and to factorize them one by one. The eye movement protocols of 30 subjects (fixation duration within the trigger items, regres-sions from the trigger items to the disambiguating constituents, cumulative dwell time within areas of interest, total amount of regressions) provide the data basis for identifying the factors that produce such a strong garden path effect. In our case, it is the combination of non-canonical word order (scrambling) with non-canonical argument linking (in the German 'get' passive). Any other combination of the factors involved may impede, but does not completely disrupt processing. It has been an aim of this study to identify eye movement signatures for sentences that are judged unacceptable.

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PC24 - Foveal structure and the implications for reading: the productivity of the split fovea approach.

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Over recent years it has been a productive research strategy in the reading of both isolated words and text to explore the implications of the structure of the fovea. This approach is grounded in data suggesting that the vertical division and subsequent contralateral cortical projection found in the rest of the retina extends into the human fovea. However, other researchers have claimed that foveal structure has no implications for reading. We examine all of the specific claims against the foveal spitting approach, involving failure to find particular effects, and review critical new evidence in favour of foveal splitting, including effects involving hemispheric differences, sex differences and binocular disparity behaviours, and the computational modelling of binocular foveation in reading, and conclude that understanding reading requires a theory of foveation that includes a split fovea.

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PC25 - Basic characteristics of eye-movements in good- and bad-reading schoolchildren.

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Thirty three schoolchildren of the first year of education (aged 7,25 years averagely) and twenty seven pupils of the fourth class (aged 10,1 years averagely) participated in the study. From their teachers' experience they were divided into two groups, good-reading and bad-reading. After calibration and training sessions each child read silently a text consisting of two sentences from a video display. Eye-movement registration in reading was carried out by means of video-based eyetracker. Accuracy of registration was 0.45 degree. Each child was studied separately. We found that well-reading pupils of the first year read the text more quickly than the bad-reading ones, the latter had more fixations during reading, their mean duration was longer than in good-reading peers. The bad-reading children had more progressive saccades than the well-reading, but the amplitude of these saccades was greater in well-readers than in bad-readers. The number of regressive saccades and their amplitude in well- and bad-reading children did not differ significantly. We were unable to reveal the above-specified differences either in well- or bad-reading schoolchildren of the fourth year of education. The research is supported by the RFBR grant 08-06-00316 and the RFH grant 09-06-01108.

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PC26 - The contribution of connectives to the reading process, with regard to the complexity of relations and the age of the readers.

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In the experiment we investigate the comprehension of content and epistemic relations in relation to the use of connectives, by means of eye movements. Content relations express relations in the real world: the first part is often a cause or condition for the second part (e.g. You have been running. So you are out of breath). Epistemic relations express relations on the level of thinking: the first part is a premise on the basis of which a conclusion is drawn (You are out of breath. So you have been running). The relations between the two parts can, but need not be made explicit by means of connectives. The main question is whether connectives make the reader process smoother. It is expected that connectives play a greater role for epistemic than for content relations because epistemic relations are more complex. By examining the eye movements during the reading process, we want to find out what exactly connectives contribute to the reading process: do they speed up the reading process and give rise to fewer regressions? The experiment is conducted with 12-13 year olds and an adult group. It is expected that connectives play a greater role for children than for adults.

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PC27 - Two distinct cohorts of initial fixations during visual word recognition and sentence reading.

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Recent findings from eye movement studies in visual word recognition suggest the existence of two distinct cohorts of initial fixations: I.) a cohort of short (~180 ms) first fixations that are followed by saccades that correct for suboptimal initial fixation positions and that is not influenced by the lexical characteristics of the stimulus material, and II.) a cohort of longer first fixations located close to the word center that is sensitive to the stimulus characteristics. In the present study we try to replicate this pattern of results by means of the variable viewing position paradigm (VVPP, that allows to experimentally control the initial fixation position) and to explore the generalizability of this notion for natural reading: During a sentence reading task, initial fixation positions were experimentally varied by shifting whole sentences during the participants' saccadic eye movement towards a target word. The present study's findings support the assumption of two distinct cohorts of initial fixations and, importantly, show that this notion also generalizes to sentence reading.

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PC28 - Effects of sentence position on parafoveal preview.

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Parafoveal preview was examined for sentence-initial, mid-sentence and sentence-final words. Participants read text with identical words, for which the sentence could end in one of three positions. For example, in "Liz ran to the green field nearby along the river she saw some geese" the first sentence could end at "field", "nearby", or "river". The preview of the critical word was correct ("nearby") or incorrect (ntfjcv), and the contingent change boundary technique was used to ensure that the correct version was always presented once the critical word was fixated. First pass reading time measures on the critical word showed significant interactions between position and preview, such that there were effects of sentence position for the incorrect previews, but not the correct previews. It appears that processing of incorrect parafoveal previews is more disruptive when co-occurring with ongoing sentence wrap-up processes in the sentence-final condition. The results will be discussed in relation to models of eye movement control during reading.

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PC29 - Frequency and length effects in bulgarian dyslexic children - evidence from eye movements.

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Seven dyslexic children between 8 and 12 years old were pair-matched with seven control children of the same age and IQ in a sentence reading task. The children read sentences in Bulgarian – a Cyrillic alphabet language with regular orthography while their eye-movements we recorded. Target nouns of varied frequency and length were embedded in the sentences with a neutral preceding context. Using sentences with embedded target words allowed better controlling for confounding factors and successfully varying word length and word frequency as independent factors. We used a task for silent reading with comprehension questions. We argue that this task is more natural than reading aloud, which sometimes can be done without any comprehension. Eye movements revealed highly significant differences in the first-pass fixation duration and in the total time between the dyslexic and the control group. We also find word frequency and word length effects in the eye-movement data for the dyslexic children; as well as interaction for both frequency and length with the group factor.

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PC30 - Eye movement studies of bilingual language processing.

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Using eye movement measures of reading, we recently demonstrated that cross-language activation for French-English bilinguals reading in their L2 is sensitive to sentential semantic constraint (Libben and Titone, 2009, JEP:LMC). Specifically, we observed cognate facilitation and interlingual homograph interference for both early (FFD, GD, skipping) and late (go-past and total reading time) measures of reading in semantically unbiased sentences, but only for early measures in semantically constraining sentences. We now report two new experiments examining L1 reading in English-French bilinguals using the same materials. E1 showed that bilinguals reading in their L1 did not show cognate facilitation or interlingual homograph interference at any stage of reading. E2, which was identical to E1 except French filler sentences were randomly inserted to boost L2 activation, showed the same absence of effects for early measures. Late measures, however, showed cognate facilitation and interlingual homograph interference in low constraint sentences, and, interestingly, interference for both cognates and interlingual homographs in high constraint sentences. Post-hoc analyses revealed that cross-language phonological overlap modulated cognate and interlingual homograph effects. These results are compatible with bilingual language processing models (BIA+), distributed memory models of word representation, and suggest an important role of phonology in bilingual reading.

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PC31 - The influence of random luminance variation of words on parafoveal preview.

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With the goal of developing a paradigm for the co-registration of EEG and eye movements, this paper explores the influence of the pattern of word luminance variation on regular reading. A parafoveal preview study was undertaken as a preliminary investigation to evaluate the impact of dynamic luminance variation. We used a gaze-contingent boundary paradigm to manipulate both the luminance variation and the type of preview. The experiment involved two crossed conditions: (1) readers obtained either a valid or incorrect preview of the target word; (2) the target word was flickered with a different random pattern of luminance variation from the rest of sentence, but when the boundary was crossed it flickered with the same pattern. The experimental results demonstrate that changes in the relative variation of word luminance reduces parafoveal preview benefit in reading.

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PC32 - Reading resumption after interruptions: Using eye movements to study the costs of interruptions during reading.

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People are frequently interrupted during office work. Interruptions during reading are particularly consequential because of the long warm-up time often needed to return to a text. An experiment is presented that evaluated the consequences of interruptions on normal reading. People read paragraphs of text while their eye movements were recorded. Contingent upon the readers' eyes entering an invisible window of the text, an interruption occurred: the text disappeared and readers received a 60 second verbal message. The verbal message was either delivered immediately after the text disappeared or following a delay of 3 seconds to allow time for consolidation. Various eye movement and behavioural parameters are discussed to evaluate readers' efficiency in resuming text reading after the interruption.

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PC33 - Local syntactic coherence interpretation and its interaction with prosody: Evidence from two visual-world studies.

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Two visual-world experiments provide evidence that locally coherent, but globally incoherent sequences are being processed and interpreted semantically, (1) within dative relative clauses and (2) crossing clause boundaries of embedded relative clauses. In both experiments German spoken sentences with and without embedded locally coherent sequences were presented while visual stimuli with scenes depicting global contents of the sentence, as well as the content of the locally coherent sequence (LC) were displayed. In experiment (1), averaged fixation proportions were significantly higher on the LC-scene when the target sentence contained a local coherence. In experiment 2 local coherences ranged over clause boundaries. Fixation proportions on LC differed significantly only when the locally coherent sequence was spliced in from spoken main clauses. The results provide further insights in the processing of locally coherent sequences, showing that prosodic cues can prohibit their interpretation, but can also overwrite strong global syntactic cues. We take these results as evidence for dynamical accounts of language processing that interactively integrate information sources from all modalities.

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PC34 - Psychological word: basic primary unit of information in Chinese reading.

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Native Chinese speakers often do not agree on how to divide the continuous string of characters within a sentence into words. We propose that Chinese people segment text into words according to complex cognitive representations: “psychological words” (e.g., representing the phrase “economic development” as a single word). Two studies were conducted. First, we explored the effect of grammar skill on Chinese word segmentation. The results suggested that: (1) there were great inconsistencies between readers in parsing the sentences into words; (2) these discrepancies decreased as grammar skill increased; (3) readers tended to segment multiple words as being one word. Secondly, we explored whether psychological words were easier than dictionary-defined words to be processed. We used a highlighting manipulation to create four conditions: normal text, text with highlighting used to mark words, text with highlighting to mark psychological words, and text with highlighting that yielded nonwords. Only the target words were highlighted. The results showed that psychological words were more easily processed than either words or nonwords. Compared to the normal (unhighlighted) text condition, both the nonword and word conditions caused some disruption to Chinese reading when highlighted.

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PC35 - Twisting your words: Reading tilted text.

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We measured participants' eye movements as they read sentences containing a word frequency manipulation, in which the individual letters were tilted. We anticipated that letter rotations would disrupt letter encoding, and in turn lexical identification. Both direction and angle of rotation were manipulated (letters rotated all left, all right, or alternately left and right; 30 or 60 degrees). For direction, alternating letter directions were significantly more disruptive than consistent (left or right) rotations. For magnitude, rotations of 60 degrees were the most disruptive, with 30 degree rotations leading to a relatively small effect compared to upright text. There were significant interactions between direction and magnitude, with the greatest disruption from 60 degree alternating text. We also found significant interactions between frequency and letter rotation - the frequency effect was more pronounced when reading alternating tilted text than consistent rotations, and for larger magnitude rotations. We conclude that degradation of overall word shape, and (perhaps) of the individual letters of the word disrupt letter encoding and subsequent lexical identification.

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Poster Session D: 12-2pm Wednesday 26th August 2009

PD1 - Anti-saccades do not benefit from attentional diversion.

David R. Evens, Iain D. Gilchrist and Casimir J. H. Ludwig

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Kristjansson, Chen and Nakayama (2001, Nature Neuroscience, 4, 1037-1042) reported the surprising finding that anti-saccade performance was improved by diverting attention away from the primary saccade task by a concurrent visual discrimination task. Correct anti-saccade latency was reduced compared to conditions in which the discrimination occurred after the saccade target. Most importantly, for these early discriminations saccade latency was shorter compared to the single-task condition with no visual discrimination task. In a number of experiments, we failed to replicate these findings with naïve observers. Our results show a reduction in anti-saccade latency when the discrimination target occurred before the imperative stimulus in both single and dual-task conditions. These results are consistent with the known properties of the oculomotor system. A discrimination target that appears before the imperative stimulus may act as a warning signal and shorten saccade latency. A discrimination target that appears around the onset of the imperative stimulus may capture visual attention and interfere with saccade programming, prolonging latency. We suggest that observers in Kristjansson et al. (2001) may have learned, through extensive practice, to ignore the discrimination target under single-task conditions, counter-acting both warning and interference effects under these conditions.

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PD2 - Comparing the benefits of overt and covert attention.

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Eye movements point the fovea at a region of interest and this delivers a processing advantage. However, it is also possible to enhance processing using covert attention when the eyes don't move. We report two experiments in which we compare the magnitude of these processing advantages. In the first experiment we measured reaction time in an orientation discrimination task. The target was either preceded by a peripheral cue to measure the effects of covert attention, or performance was compared at fixation and in the periphery to measure the benefits of overt attention. Overt attention delivered about double the benefit of covert attention. In the second experiment we measured orientation discrimination thresholds. As before there was a reliable benefit of overt attention, but for this task we found no systematic benefits for covert attention. The results show that benefits delivered by covert attention are not stable across all tasks and illustrate the relative magnitude of these effects. This suggests that selection in vision is likely to be driven by overt attention and supports models in which covert spatial attention either subserves, or is part of, the eye movements system.

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PD3 - The allocation of attention during antisaccades.

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The allocation of attention during the preparation of pro- and antisaccades was studied in a dual task paradigm. As the primary task, subjects were instructed to make a saccade at the location opposite the salient cue (anti-saccade task) or at the location of the salient cue (pro-saccade task) in a gap protocol. Sixty milliseconds after the presentation of the peripheral cues, a target or a distractor were presented at the pre-cued locations during 70ms. The secondary task was the discrimination of an oblique line located either at the saccade goal or at the opposite location. The data demonstrate that discrimination at the position of the direction errors in the antisaccade task was not significantly enhanced as it was at the same location targeted by pro-saccades. Another important finding was that discrimination at the location of the antisaccade goal is superior to the opposite location only when the saccadic movement was made in a different direction than the preceding trial. When the direction of automatic orienting and voluntary attention are dissociated, the allocation of attention at the location where the eyes is about to land depends critically of the details of the action.

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PD4 - The impact of feature-based attention on the metric of feature space.

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Attending to a specific feature, such as the direction of motion, results in an increase of the bottom-up driven activity of neurons if their tuning characteristics match with the attended feature, even if they are located outside the focus of spatial attention. Thus, depending on the task at hand, global feature-based attention may play a crucial role in the selection of eye movements by rendering important features more ‘salient’. In this study we will provide for the first time psychophysical evidence that feature-based attention does not simply result in a more active representation of relevant features, but that feature-based attention is able to dynamically alter the metric of the underlying feature space. While subjects attended to the direction of a random-dot kinematogram (RDK) presented in one hemisphere, another RDK was presented in the opposite hemisphere. After a certain time, subjects indicated the direction of the perceived motion aftereffect of the unattended RDK. Directions closer to the attended direction are attracted while directions farther away are repelled resulting in an effective expansion of the feature space between these directions. A model with a net attentional center-surround gain effect on the population response is able to account for our results.

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PD5 - How automatic is gaze cueing?

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It is thought that observing someone's gaze automatically directs your own attention in the same direction. Here, we report findings of three experiments investigating whether such 'automatic' shifts of attention are restricted to eye-gaze only or whether they also occur for other directional cues, such as arrows. To this end, the effects of gaze cues, arrows, and sudden peripheral onsets were compared. Three different measures were used: (1) microsaccade frequency, (2) saccade trajectory deviation, and (3) response times. The findings suggest that shifts induced by sudden peripheral onsets (that are usually regarded as triggering an automatic shift of attention) are different from those induced by gaze-cues and arrow-cues. In particular, the pattern of observed micro saccade rates were different for peripheral onsets compared to gaze and arrow cues. Saccade trajectory deviation was also greater for peripheral distractors than for gaze-cues and arrows. Reaction times to peripheral targets were similarly influenced by arrow and gaze cues, again showing similarities in the shift of attention produced by these types of cues. The results suggest that both biologically relevant and symbolic cues can shift attention, but that the nature of these attention shifts appears to be different to that induced by a sudden peripheral onsets.

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PD6 - Effects of Attentional Control on Prosaccades and Antisaccades.

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The control of attention is necessary for correlated mental actions such as inhibition, updating, and time sharing. In the current study the antisaccade task was conducted to examine whether attentional control influenced the programming and generation of prosaccades and antisaccades. We varied target eccentricity (2.5° or 7.5°) in two attentional control levels (high or low). Correct saccade latency findings showed that participants in the high attentional control condition made faster antisaccades compared to the low attentional control condition, but not for the prosaccade task. This suggests that the level of attentional control influenced the inhibition latency without affecting the generation latency. Directional error findings in the antisaccade task showed that the participants made less directional errors in the high attentional control condition compared to the low attentional control condition further demonstrating that control of attention could facilitate the saccade response when inhibitory control of prepotent responses was required. Attentional control was independent of target eccentricity. In both levels of attentional control, the programming of the saccade to the far target was more rapid than for the near target.

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PD7 - Selection-for-action studied with the Illusory Line Motion effect.

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Illusory line motion (ILM) has been shown to occur when a static line is presented with one end next to a previously stimulated location - the line then appears to be drawn away from the site of stimulation. It has been suggested that this is because of the allocation of attention to the stimulated site. Indeed, many studies have confirmed that automatic shifts of attention due to peripheral cues induce perception of ILM. However, it has recently been disputed whether voluntary shifts of attention also cause ILM (Christie and Klein, 2005). We addressed the question of whether ILM can be induced by action-related, endogenous shifts of attention. ILM was examined when voluntary, goal-directed eye or hand movements were prepared in response to symbolic movement cues. Subjects performed manual pointing or saccadic eye movements, respectively, to a target location specified by the pitch of an acoustical go-signal. Both conditions were found to induce ILM. The results are in contrast to the conjecture of Christie and Klein (2005) and demonstrate that ILM occurs also with purely voluntary, action-related attention shifts. The findings provide further support for an attention-based explanation of ILM and recommend the illusion for studying attentional deployment in dynamical situations.

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PD8 - Does saccadic adaptation shift the presaccadic attention focus?

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There is a controversy about the effect of saccadic gain adaptation on the presaccadic attention focus. Some studies showed a concomitant shift of attention with saccade adaptation (Doré-Mazars & Collins, ECEM 2007) whereas others showed that the attention focus remained on the visual target whatever the adapted state of the saccade (Deubel, ECEM 2007). We propose that the discrepancy originates from competition between visual and motor selection processes. When the peripheral saccade target is salient, visual selection processes could determine the orientation of attention. With weak salience, motor selection could determine the attention focus. The present study examined the location of the attention focus with a discrimination task while subjects prepared a saccade to a visual target. In separate sessions, the saccade target was defined by a peripheral or central cue and its location held constant or varied. Preliminary results suggest that when the ST is not salient but constant and selected endogenously, the attention focus shifts with saccadic adaptation. Such an effect of adaptation was not seen with peripheral cues. The implications of these results will be discussed.

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PD9 - Processing numbers influences eye position and saccadic responses.

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Seeing smaller digits (1, 2) improves visual target detection in the left visual field while seeing larger digits (8, 9) provides similar facilitation in the right visual field (Fischer et al. 2003; 2004). Two new experiments further explored the relationship between number processing and spatial biases. In Experiment 1, participants listened to number names while fixating a central cross. Eye position drifts reflected spontaneous magnitude processing with consistent shifts to the left after hearing a small number and to the right – after hearing a larger number. In Experiment 2, participants saccaded to lateral visual targets that appeared at variable delays after auditorily presented number names. A similar facilitation pattern was observed with leftward saccades initiated faster after hearing smaller numbers but only after longer (1200 ms) delays. Together, these results support the existence of largely non-abstract number representations and clarify the role of covert and overt attention in number processing.

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PD10 - An integrated system for EOG signals conditioning, A/D conversion and wireless transmission.

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Among the many techniques available to record eye movements, electrooculography (EOG) presents exclusive performances. A wide range of movement can be measured; eye-closed recording is possible; head movement does not affect EOG that represents therefore the most suitable recording technique for eye-head coordination studies. Moreover EOG is easy to use, cheap and very comfortable. But EOG presents all the problems typical of biological signals detected through superficial electrodes, such as noise and drift. In order to reduce the effect of noise an integrated system for EOG signal processing has been developed and tested. A small box, positioned very close to the subject, receives the input from electrodes and other transducer i.e. a potentiometer. The electronic circuit includes pre-amplifier, low-pass and high-pass filters, and amplifier, whose parameters are set up through commands transmitted wireless from a PC. This approach makes the device very flexible to adapt to signal properties. The SW can also remove the drift. After conditioning the signal is A/D converted and data are transmitted wireless to the PC to be stored. Having the signal processed within this device and A/D converted before transmission has improved significantly the signal to noise ratio allowing high quality recording of EOG signals.

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PD11 - Comparing Visagraph III to EyeLink 2k: How does a "low cost" eye tracker measure up to state of the art technology?

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The Visagraph is a low-cost eye movement recording device that is part of a reading intervention system currently used by thousands of schools, clinics, and vision specialist to assess silent reading fluency efficiency. Although the Visagraph evolved through several generations over the last decades it was never tested against a high end eye tracker with established validity and reliability. In this study the Visagraph III, the most current, browser-based version of this device was compared to the desktop version of the EyeLink2K. Participants were tracked simultaneously with both systems while reading a series of paragraphs silently for comprehension. This experimental design allowed for a detailed comparison of critical eye-movement parameters. Results showed that the Visagraph produced accurate data for fixation durations, number of fixations per page and reading rate (WPM). More detailed analyses revealed room for improvement with respect to assignment of vertical fixation positions and the determination of regressive eye movements. Found discrepancies were partly caused by differences in sampling rates and different saccade classification algorithms. Further implications for soft- and hardware development will be discussed.

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PD12 - The use of monocular eye movement calibrations for measuring the individual heterophoria.

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When calibrating eye movement recording systems, one assumes that the fixated calibration point is projected onto the centre of the foveola. This might not be true if calibration targets are viewed binocularly and the subject tested has a fixation disparity: due to this vergence error, the fixation point is projected lateral to the centre of the foveola. Such a fixation disparity remains undetected with binocular calibrations, thus many studies use monocular targets to calibrate the right and left eye separately. We show that monocular calibrations can be used for a further purpose: the vergence angle between the fixating and the non-fixating eye represents a fusion-free resting state of vergence (known as heterophoria in ophthalmology), which depends on tonic vergence and accommodation. From monocular calibrations with EyeLink II, we objectively measured reliable individual heterophoria values covering a range of 6 deg with an average intra-individual standard deviation of 0.5 deg. Further, objective heterophoria was correlated with objective fixation disparity (r=0.8, n=18); this finding corresponds to previous subjective results found with dichoptic nonius lines. Thus, heterophoria measured during monocular calibrations can be useful as an individual vergence parameter that is able to explain inter-individual variance in binocular coordination.

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PB13 - Assessment of reliability of binocular eye movement measurements using video eye-tracking.

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The calibration of eye movement measurements using binocular targets may be adversely affected by a fixation disparity. Therefore, we generally use a monocular calibration routine either with shutter glasses or at a mirror stereoscope. In order to optimize the calibration procedure for high precision and reliability of vergence measurements, we conducted an experiment using Eyelink II equipment at a mirror stereoscope. Monocular and binocular presentations of calibration targets were interleaved in two different ways: 1) Blockwise interleave: monocular calibration blocks were made before and after a binocular test phase comprising two binocular calibration blocks; 2) Targetwise interleave: two blocks were made up of a random series of binocular and left and right eye monocular presentations of all targets. In the second way, it is expected that the fixation disparity in the binocular presentations is estimated with better reliability than in the first. The quantitative results of 20 subjects and 2 replications suggest that using a mixed calibration strategy may be advantageous, where most calibration targets are displayed binocularly and only a subset monocularly, because less presentations are needed without deteriorating the information regarding fixation disparity.

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PD14 - Analysis of fixational eye movements through structured illumination of the cornea.

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Eye micromovements are produced in a wide range of frequency going from 1 Hz to 100 Hz. Capturing these movements require fast devices working at very high sampling rates. Standard eye trackers register these movements through pupil tracking, limbus tracking or iris recognition while other measure reflections from the cornea. All these systems can accurately measure large amplitude eye movements but they are not well suited for fine and accurate measurements of small fixation eye movements and other invasive methods are used instead. Our work consists of projecting a structured pattern on the cornea. Eye displacements produce deformations in the pattern that can be studied to determine the main characteristics of the eye movement. During the measurement a ring of LEDs is projected on the cornea. The sequence of images is captured with a high speed camera (250 fps). Each image of the ring reflected from the cornea is fitted to an ellipse, and temporal variation of its geometrical characteristics is analyzed. To reduce the head movement, a rigid head rest and a bite bar were applied. Presented method of eye tracking is simple and accurate and does not require any specifically designed material.

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PD15 - Does the distractor effect allow identifying different modes of processing?

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In view of a variety of everyday tasks, it is highly implausible that all visual fixations fulfil the same role. Henderson and Pierce (2008) recently proposed a mixed control model for fixations, based on the identification of two distinct fixation populations. Earlier we demonstrated that characteristics of fixation duration and amplitude of related saccades is correlated with ambient vs. focal modes of visual processing (Velichkovsky, Joos, Helmert, and Pannasch, 2005). The distractor effect describes the influence of sudden (visual) onsets on the saccadic latency (e.g. Walker, Deubel, Schneider, and Findlay, 1997) but has also been found as prolongation of fixations in free visual exploration (e.g. Graupner, Velichkovsky, Pannasch, and Marx, 2007). In a series of experiments, we investigated parameters of distractors (modality, motion, delay and duration) in relation to amplitudes of the preceding saccade. Our main result is that distractors have significantly less influence on fixation duration if the amplitude of the previous saccade exceeds the parafoveal range (5 deg). These findings suggest an explanation in terms of a shifting balance of at least two modes of visual processing during a free viewing of meaningful visual images.

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PD16 - Saccadic latency versus eccentricity for targets scaled by an estimate of the cortical magnification factor.

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The saccadic latency-eccentricity function is bowl-shaped with a central latency peak, a minimum plateau to around 15 degrees, and an increase in latency towards the periphery (e.g. Kalesnykas and Hallett, 1994). A recent computational model of the eye movement system (Chambers, 2006) has suggested that the peripheral increase may be due to a reduction in saliency caused by diminished neural representation of targets in peripheral vision. We hypothesised that this diminished representation could be counteracted by scaling the targets according to the 'cortical magnification factor' of Rovamo and Virsu (1979). Using a target-elicited saccade paradigm, ten subjects were shown scaled and unscaled Gaussian targets over a horizontal range of ±40 degrees using a custom-built immersive dome. If size-scaling counteracts diminished target representation then saccadic latencies to peripheral targets should be faster compared to targets that are not scaled. Contrary to this prediction it was found that saccadic latencies increased at an equal rate for peripheral targets regardless of whether targets were size-scaled or not. This suggests that peripheral increases in saccadic latency cannot be removed by increased spatial representation of targets. We interpret these results in terms of architectural and stimulus-related constraints on the eye movement system.

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PD17 - Anticipating changes in direction during ocular pursuit of target motion with irregular periodicity – the influence of stimulus history.

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Prediction is so pervasive a feature of human ocular pursuit that the generation of expectations regarding future target motion cannot easily be eliminated by randomising stimulus parameters. We have investigated this seemingly inappropriate prediction of temporally randomised events using alternating constant velocity stimuli, presented either as discrete pairs of ramps or as a continuous irregular triangular waveform. We conclude that expectations are generated using stored information about recent ramp timings and that this stimulus history information is used to constantly adjust the time at which pursuit begins to decelerate in anticipation of a reversal in target direction. This deceleration was quantified using T90, the time at which smooth eye velocity fell below 90 percent of its peak. Regression analyses on T90 revealed that the quantitative effects of prior stimuli are strongest for the previous two or three ramps in a trial and progressively diminish thereafter. This quantitative association with past stimuli allows a running average of anticipatory timing to be estimated. We propose that this strategy is employed in order to minimise error amid temporal uncertainty. Whilst such a strategy has clear benefits, it does result in the seemingly inappropriate prediction of events which are, in fact, temporally randomised.

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PD18 - Effects of target onsets and offsets on antisaccade performance.

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This study investigated prosaccades and antisaccades to target onsets and offsets by manipulating the prepotent inhibition of the target, independently of working memory. The displays consisted of a fixation point together with a peripheral stimulus; in the corresponding ‘ONSET’ condition (high prepotency) an additional peripheral stimulus was presented as the target for a prosaccade or antisaccade. In the ‘OFFSET’ conditions (low prepotency) the peripheral target was removed, thus prosaccades or antisaccades were directed to an absent target. On control trials, participants generated prosaccades and antisaccades in a standard single target display. Antisaccade errors were significantly reduced in the ‘OFFSET’ condition in comparison to both the control antisaccade (7 percent) and the ‘ONSET’ antisaccade (3 percent) conditions respectively, ($F(2,28) = 9.24$, $p = .004$, effect size $= .40$). Remarkably antisaccade OFFSET errors (1.01 percent) were reduced to the level of prosaccade error rates (0.8 percent). These results demonstrate that target offsets do not produce the usual disadvantage of executing correct antisaccades compared to prosaccades. Since working memory involvement remained constant across conditions, the results suggest this may not be the critical factor in antisaccade performance.

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PD19 - Predicting saccade length in the L2 reading of English passages: A pilot study using mixed-effect modelling.

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The ultimate purpose of this project is to characterize the relationship between proficiency in English and saccade length during normal reading among second-language (L2) readers of English from specific first-language (L1) backgrounds. There is reason to suspect that native readers of certain writing systems will at least initially show saccade-length transfer effects. For instance, based on the perceptual span alone, native readers of Chinese should at least initially show shorter saccades while reading English compared to natives readers of, say, Vietnamese or Japanese (Inhoff and Liu, 1998). However, at some level of English reading proficiency, one would also expect the saccades of all nonnative readers to begin approximate those of native English readers. The approach to analysis will be mixed-effect modeling. Relevant predictors will include both participant background variables (e.g., English reading proficiency, L1 writing system type) and stimulus-item variables, which are naturally nested (e.g., word variables, sentence variables, passage variables). Although this project is in the initial stages of development, pilot data and pilot analyses will be presented, and advice sought for the optimal modeling approach.

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PD20 - The eye movement patterns in reading emotional passage under different emotional music and question types.

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The aim of the present study is to examine the eye movement patterns when participants read emotional passage under different emotional music. In order to see whether different reading goals may moderate the interaction effects of emotional passage and emotional music, different type of questions were asked at the end of each passage. Therefore, three variables were manipulated, namely, emotional passage (positive vs. negative), emotional music (positive vs. negative), and question type (gist vs. detail). It was identified as an inconsistent condition when the emotionality between passage and music were different from each other and a consistent condition when they were the same. Results showed that, under detail question condition, the total reading time and gaze duration were shorter, skip rate was higher, and the number of fixations was fewer in the inconsistent conditions than those in the consistent conditions. However, there was no difference between consistent and inconsistent conditions under gist question condition.

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PD21 - Reading Dr. Seuss: Rhyme helps, then hurts, processing.

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Although rhyme is important in language and reading development (Bradley and Bryant, 1983), and speech recognition (Allopenna et al., 1998), whether and how rhyme affects on-line reading in adults is unexplored. We report an eye-tracking experiment that compared rhyming to non-rhyming versions of 4-line text fragments taken from Dr. Seuss. The focus was on reading times on the last words of lines 2 and 4. Any fool would get out! So I've packed up my things/clothes and I'm off to my granddaddy's, out in Palm Springs. "Take cover!" he yelled. "Use my house if you wish/want." Then the chap in the slicker splashed off like a fish. Rhyming produced shorter gaze durations on the target words, consistent with phonological priming (Kinoshita and Lupker, 2003). Second-pass measures, however, indicated inhibition for the rhyming words. This latter effect could either indicate (a) later, deliberate, evaluation and/or appreciation of the rhyme, or (b) initial superficial processing of the rhyme word, with a quick encoding of the rhyme at the expense of a good understanding of the meaning of the word. In the latter case, the rhyming word would need greater re-processing effort. Additional analyses lend support for the latter hypothesis.

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PD22 - How does the reading span task impact eye guidance during reading.

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In the reading-span task two tasks compete: Participants read sets of four to seven sentences and performed a memory task including selection, encoding and maintainance of relevant information (i.e., the last words of sentences). In two experiments we examined the effect of working memory load (increasing of the number of sentences within one set) on eye movements. Experiment 1 revealed a specific task strategy: The number of fixations on the to-be-remembered words was surprisingly high, and reading often started with the sentence-final word. In Experiment 2 a visual mask excluded application of such a strategy. This resulted in shorter sentence-processing times compared to Experiment 1, even though memory accuracy remained high. Both experiments demonstrated effects of load on gaze durations of target words. Experiment 2 also included older participants to increase the variance in memory span. Surprisingly, there were no effects of WM span and age on eye movements, but during the first sentence within a set (no WM load). The lack of evidence for individual differences suggests that reading is a highly automatized process and does not interfere with executive control processes in WM.

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PD23 - Accuracy of word recognition as a function of font type and luminance.

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The aim of this study was to determine whether the type of font (serif vs. sans serif) affected word recognition rates under varying conditions of text visibility. Subjects were required to fixate a central point on a computer display after which a word was presented randomly on one or other side of this point in either a serif or sans serif font. The subject's task was to say the word as quickly as possible. The luminance level of the display was systematically varied across font and word-position conditions. Results showed that recognition performance was more accurate for words presented in the right visual field and that sans-serif fonts gave rise to superior recognition performance under all experimental conditions.

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PD24 - Individual differences in reading behavior - clustering eye movement data from a relational database.

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This paper presents result of a study of individual differences in newspaper reading by means of clustering eye movement data from a large population of newspaper readers. Eye-tracking data and stimuli from four newspaper reading experiments were coded and entered into a relational database. The stimuli were analyzed into 15 different newspaper objects types. 30 eye movement measures reflecting cognitive functions involved in newspaper reading were calculated from the database. Participants' scores on these eye movement measures were clustered using a two-step clustering algorithm. Three distinct clusters emerged from the cluster analysis. Using the distribution of age group and gender in the clusters, the clusters are interpreted in terms of reader types with distinct individual reading styles. The concept of reading consistency is developed and analyzed. Suggestions are made about the application of the research results and the research methods in the field of pedagogic literature.

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PD25 - The influence of highlighting and word length on eye movements during reading.

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An interesting issue in eye movements during reading is how non-foveal information affects saccadic targeting and fixation durations. Highlighting is often used by people to emphasise information in text; however, to date, its influence on reading has not been examined. We investigated the influence of highlighting of long and short words on eye movements during reading. In our sentences, a target word that was either 4 or 8 letters long was highlighted, with four highlighting conditions: whole word, first half, second half, no highlighting. There were significant effects of highlighting and word length on reading times on the critical word (but not on the pre and post critical regions). However, for first pass measures, the highlighting effect was that the partial highlight conditions had longer reading times than the non-highlighted words, with little effect from highlighting the whole word. In contrast, regressions to the target word increased under all highlighting conditions. Thus, it appears that highlighting does not draw attention to a region, but holds initial attention once fixated. Furthermore, highlighting directs attention back to a region during re-reading. We consider these preliminary findings of potential theoretical significance to accounts of discourse salience in relation to reading and re-reading text.

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PD26 - Reading Information Graphics: The Role of Spatial Contiguity and Dual Attentional Guidance.

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In a naturalistic newspaper reading study, two pairs of information graphics have been designed to study the effects of a) the spatial contiguity principle and b) the dual scripting principle by means of eye tracking measurements. Our data clearly show that different spatial layouts have a significant effect on readers' eye movement behaviour. An integrated format with spatial contiguity between text and illustrations facilitates integration. Reading of information graphics is moreover significantly enhanced by a serial format, resulting from dual attentional guidance. The dual scripting principle is associated with a bottom-up guidance through the spatial layout of the presentation, suggesting a specific reading path, and with a top-down guidance through the conceptual pre-processing of the contents, facilitating information processing and semantic integration of the material. The integrated and serial formats not only attract readers' initial attention, but also sustain the readers' interest, thereby promoting a longer and deeper processing of the complex material. The results are an important contribution to the study of the cognitive processes involved in text-picture integration and offer relevant insights about attentional guidance in printed media, computer-based instructional materials, and textbook design.

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PD27- The role of reading proficiency and word length in compound processing.

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In the present study, the role of morphology in reading development was examined. In the first experiment, the participants were Finnish 2nd, 4th, and 6th graders and adults, who read either a relatively short hyphenated (ulko-ovi) or a concatenated (autopeli 'racing game') 7-9-letter compound. We hypothesized that the role of hyphenation changes from beneficial to disruptive as reading skill develops. More specifically, we hypothesized that for low-proficiency readers relatively short 7-9 letter compounds are too long to access holistically and hyphenation aids in breaking down compounds into more digestible pieces, whereas for more proficient readers hyphens may interfere with holistic access. The results showed that proficient 2nd graders and older children and adults were faster in reading concatenated compounds than hyphenated ones, but that for less proficient 2nd graders it was the other way around. In the second experiment we found that adults actually benefit from hyphenation in compounds that are too long to be dealt with in one single fixation (yllätystulos 'surprise result' eliciting longer gaze durations than musiikki-ilta 'music evening'). Taken together, the results suggest that the use of morphological units in reading compounds is not categorical but depends on factors such as reading proficiency and word length.

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D28 - Is the word-predictability effect modulated by parafoveal preview information?

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This study investigates the question of whether word-predictability effects are modulated by parafoveal preview information. Eye-movements were recorded while participants read sentences for comprehension. Embedded in each sentence was a target word that was either unpredictable, low-medium, medium-high or highly predictable depending on the preceding sentence context. Using an eye-movement contingent procedure, the target was either available for parafoveal preview or masked, using a pixel scrambling manipulation. When preview was available, the results were comparable with those reported by Paul, Kennedy and Murray (2008), with a near linear relationship between target word-predictability and target word-processing time. This effect was not modulated by the availability of prior parafoveal preview. However, gaze on the preceding word showed an interaction between upcoming target word predictability and parafoveal preview. This latter result suggests that "early" effects of word-predictability may be attributable to a combination of top-down and bottom-up processing and it does not appear to be compatible with current serial-sequential models of eye-movement control. Reference: Paul, S-A.S., Kennedy, A., and Murray, W.S. (2008). Exploring the word-predictability effect. Paper presented at The British Psychological Society, Scotland Annual Conference, November, Clydebank.

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D29 - Lexical and post-lexical complexity effects on eye movements in reading.

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E-Z Reader 10 (Reichle, Warren, & McConnell, 2009) provides a new framework for thinking about the ways that lexical and post-lexical processing jointly affect eye-movement control in reading. In this poster we present data from an experiment that was designed to test E-Z Reader 10[1]s predictions about interactions between post-lexical and lexical processing by manipulating syntactic complexity at word n and lexical frequency on the following word (n+1). At word n, effects of syntactic complexity were apparent in all measures (interestingly, even in early measures like first fixation and single fixation duration). These effects spilled over into a few measures on word n+1 and even n+2. Lexical frequency effects showed a similar pattern: all measures on word n+1 showed frequency effects, which spilled over onto the next word. Interestingly, the numerical pattern of first pass regressions out on word n was consistent with E-Z Reader 10[1]s prediction that when post-lexical processing on word n is more difficult, faster lexical processing on word n+1 may actually lead to more regressions from word n. E-Z Reader 10 simulations of this data will be discussed.

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PD30 - Effects of the Stroke removal on the Chinese Sentence Reading: Evidence from eye movements.

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We explored the effect of removing individual strokes from Chinese characters on eye movements during sentence reading to examine the role of orthographic processing in Chinese character recognition. We manipulated both removal type (beginning stroke, end stroke, or configuration-retaining stroke removal) and removal percentage (15%, 30%, and 50% of strokes) of the Chinese characters. The results showed that: (1) the characters with 50% removal caused most disruption to eye movement behavior, the characters with 30% removal had a smaller effect, but the characters with 15% removal did not disrupt reading; (2) characters with the beginning stroke removed were more disruptive to reading than those with end strokes removed. Characters with strokes removed that maintained the overall configuration of the character were the easiest to read. The results suggest that when only a small number of strokes were deleted, or the overall shape of the character was maintained, readers used holistic processing to identify the Chinese words. However, when more strokes were removed, or stroke removal destroyed the overall configuration, readers were inclined to process local features of the incomplete character. A role for feature analysis is also suggested in relation to the finding that beginning strokes were more important than end strokes in character identification.

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PD- 31 Two searches, two memories? What memory mechanisms are involved in repeated visual search?

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In a repeated visual search task Körner and Gilchrist (2007) had participant search the same 10-letter display twice for different targets. Participants found the target faster in the second search when the target had recently been inspected in the first search. In Experiment 1 we showed that items were found faster not only when they had been inspected previously but also when they had not been fixated. Additionally, participants preferred to search within the set of previously non-inspected letters during the second search. These results suggest that different memory mechanisms are involved in repeated visual search: An automatic mechanism guides search away from old items and towards new items, whereas a more active mechanism can guide search back to old items if required. In Experiment 2 we investigated the possibility that the automatic process is based on Inhibition of Return (IOR). We instructed the subjects to interrupt their search and saccade to a probed item, as soon as it was highlighted. This item had either been inspected earlier on or not. We measured the latency of the saccade that was directed towards the probed item. Results suggest that IOR can serve as a guiding mechanism in repeated visual search.

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PD – 32 The characteristic eye movements in counting the objects in a line.

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When we count objects in the same color and size in a line, the counting work is difficult and the eye movement is very important. We have studied the eye movement for accurate enumeration during those objects counting. Thirteen subjects (6 male and 7 female), aged 21 to 78 years, had normal vision and physical and mental condition. In this experiment, the stimuli displayed on the touch panel screen were five to nine graphic apple figures in a line arrangement. Eye movements were recorded by the EMR-8(NAC) head-mounted system. The subjects were requested to count and to answer how many objects were presented. Their performances were almost good and their answers were correct in those stimuli. Their gazes did not shift from one to another all each objects but were on some points of those objects by using saccades. For counting, they used saccades to jump over one or two objects. These results show that their accuracy needs to catch the marked object in the present ones to prevent double counting or miscounting and their saccade amplitudes were within a range of 3 times of the object's size.

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PD – 33 Can a specific typeface express certain taste?

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In order to confirm whether a certain taste can be expressed by a specific typeface, eye movements while looking at food menus were analyzed. Using four typefaces selected by a preliminary test, several menus consisting of fictitious foods were used as stimuli. Thirty-four university students, as participants, were informed that each typeface expressed any of the four basic tastes and asked to choose the food that was likely to taste like the indicated taste. Later, they were asked the reason for their choice. For the sweet taste, 76.4 percent of the participants chose the “Himaji” typeface without hesitation. The average decision duration was shorter than that for the other tastes, and the average gaze rate was 44.9 percent. Most participants said that a “sweet” typeface was easiest to choose. With regard to other tastes, fixations were rather distributed on several typefaces. The average gaze rates on the “most likely” typeface for each taste, determined by the preliminary test, were 27.8 percent for salty taste; 36 percent, sour taste; and 32.3 percent, bitter taste. It is concluded that the expression of taste by certain typefaces is effective for the sweet taste, but not effective for the salty, sour, and bitter tastes.

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PD – 34 Looking through the eyes of art – viewing paintings in art galleries and in laboratory settings.

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In this study we compare the way people perceive paintings in their "natural environment" (art galleries) or in laboratory settings. We recorded eye movements of people who viewed paintings in an art exhibition in the National Gallery for Foreign Art in Sofia, Bulgaria. The participants’ eye movements were recorded with a ASL MobileEye wearable eye tracker, while walking around the exhibition. We compared these data with the eye movements from people observing the same paintings in laboratory conditions, on the screen of a Tobii 1750 remote eye tracker. In both conditions, the participants spent as much time as they wished looking at each painting. After seeing all of the paintings, the participants rated each of them for liking. As expected, mean viewing time for a painting in natural settings was more than two times longer than in the

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lab. We analysed the subjective ratings and the degree to which they can predict the time people spend viewing each painting. The average correlation between viewing time and subjective rating was much higher for galleries (r = 0.5) than for the laboratory (r = 0.34). Scanpaths from the laboratory and the gallery were also compared and the differences are discussed in detail.

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PD – 35 No news is bad news – guiding attention in TV newsrooms.

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Most TV news programmes share a common newsroom setting: they show a news presenter and a photographic snapshot, complemented by a text caption. As we need to process this information rapidly before the programme proceeds, it is essential to optimise the visual structure of the setting so that relevant news contents are being understood and remembered. In the present study, we investigated how variations of individual newsroom elements affect the recall of semantic details of TV news. Oculomotor data and recall rates (correctness) of 20 subjects were recorded while they viewed static scenes of different newsroom settings. Results show, for example, that the presenter becomes the centre of attention when located on the left. Scene elements with relevance to news content, however, are attended to less and cannot be remembered well. With the presenter on the right, these latter scene elements move into the focus of attention and can be remember better. Data also indicate that visual neglect of textual elements (or their absence) also considerably impairs the recall of relevant semantic content of news reports. Findings could be used to optimise the visual structure of newsroom settings and may improve the recall of essential news details.

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