



ESSEM

**European Summer School on
Eye Movements (ESSEM)**

9th - 14th September 2024
National and Kapodistrian University of
Athens, Greece

#ESSEM2024

Programme and General Information

Welcome Address

Dear participants,

Welcome to Athens, welcome to ESSEM 2024!

We are delighted to welcome you to the European Summer School on Eye Movements (ESSEM). Following previous instalments of ESSEM in Bonn (2013), Freiburg (2014), Athens (2016), Bonn (2018), Freiburg (2020; online) and Bonn (2022), it is our pleasure to again host ESSEM at the National and Kapodistrian University of Athens, Greece.

ESSEM aims to bring together internationally renowned scientists, postgraduate students and post-docs from all around the world to discuss the methods and neuropsychological bases of eye movements as well as applications of their study in various settings.

This booklet contains the scientific programme of ESSEM as well as other useful information. In addition to the lectures, which are the key component of ESSEM, we would like to highlight the following events and activities.

We start off on Monday at 9am with welcome addresses by Christoph Klein and Nikos Smyrnis! In the evening, we are delighted to welcome participants to an informal wine reception at the meeting hall room next to the meeting auditorium at 6pm.

On Thursday morning, our sponsors SR Research, Tobii and neuroClues will present their eye tracking hardware and software in workshops that will be held in the hall room area next to the meeting auditorium. These workshops will provide all of us with a recent update of the available technologies. Please make sure to attend their stands and feel free to explore their latest innovations!

On Wednesday night, we are pleased to invite all participants and lecturers to a dinner at “Chelona” restaurant.

The poster sessions on Thursday and Friday will provide an important opportunity for students to present their own research and interact with each other as well as lecturers.

Notable events further include the Athens Walking Tour on Saturday afternoon, where Nikos Smyrnis will meet interested participants at the ESSEM location in the central building of the National University of Athens and embark on a walking tour of the city stopping at interesting locations and talking about the city and its long history!

We would also like to point out to you that your feedback and evaluation of the summer school is of great importance to us. We would therefore be most grateful if you could take part in a brief online survey. The details will be sent to your email address.

We are looking forward to an exciting and intellectually stimulating week!



Nikos Smyrnis



Ulrich Ettinger



Christoph Klein

Table of Contents

Welcome Address	1
Table of Contents	3
General Information	4
Organisers	4
Contact and Social Media.....	4
Lecturers	4
Summer School Venue	5
Summer School Office.....	6
Name Badges	6
Certificate of Attendance.....	6
Wireless Internet Access.....	6
Coffee and Lunch Breaks.....	6
Summer School Dinner Party	6
Financial Support	7
Information for Presenters	8
Programme Overview	9
Poster Abstracts	10

General Information

Organisers

Nikos Smyrnis, Department of Psychiatry, National and Kapodistrian University of Athens, Greece (smyrnis@med.uoa.gr)

Ulrich Ettinger, Department of Psychology, University of Bonn, Germany (ulrich.ettinger@uni-bonn.de)

Christoph Klein, Department of Child and Adolescent Psychiatry, University of Freiburg, Germany; Department of Child and Adolescent Psychiatry, University of Cologne, Germany; Department of Psychiatry, National and Kapodistrian University of Athens, Greece (christoph.klein.kjp@uniklinik-freiburg.de)

Contact and Social Media

Email: essem@uni-bonn.de

Web: www.essem.info

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Lecturers

Chrystalina Antoniadou (University of Oxford, UK)

Giuseppe Boccignone (University of Milano, Italy)

Kurt Debono (SR Research Ltd., Canada)

Olaf Dimigen (University of Groningen, NL)

Ulrich Ettinger (University of Bonn, Germany)

Tom Foulsham (University of Essex, UK)

Johanna Kaakinen (University of Turku, Finland)

Kristof Keidel (University of Bonn, Germany)

Alan Kingstone (University of British Columbia, Vancouver, Canada)

Christoph Klein (University of Freiburg, Germany / University of Cologne, Germany / National and Kapodistrian University of Athens, Greece)

Rebekka Lencer (Universität zu Lübeck, Germany)

Giulia Manca (eye square GmbH, Berlin, Germany)

Päivi Majaranta (Tampere University, Finland)

Susana Martinez-Conde (State University of New York, USA)

Sebastian Mathôt (University of Groningen, Netherlands)

Pierre Pouget (INSERM, Paris, France)

Rima-Maria Rahal (Max Planck Institute for Research on Collective Goods, Bonn, Germany / Tilburg University, Netherlands)

Nikolaos Smyrnis (National and Kapodistrian University of Athens, Greece)

Peter Trillenber (University Hospital of Schleswig-Holstein, Campus Lübeck, Germany)

Summer School Venue

ESSEM 2024 will take place in the “Argiriadis” Auditorium of the main building of the National and Kapodistrian University of Athens. The address of the venue is 30 Panepistimiou, Athina 106 79, Greece.

All lectures take place in “Argiriadis” Auditorium. Signs in the main entrance of the building will guide participants to the auditorium which is located on the ground floor.

The poster sessions on Thursday and Friday take place in the hall room next to the “Arigiriadis” Auditorium.

Summer School Office

The summer school organizing office is One to One S.A. (<https://www.onetoone-congress.gr/>). The person responsible for organisational support of ESSEM 2024 is Ms Mara Tsiochantari (mtsiochantari@one2ones.com, tel: +302107254383-85).

Name Badges

In the first meeting day you will receive a name badge. Please be sure to always wear this badge when attending the meeting.

Certificate of Attendance

Along with your summer school documents you will receive a certificate of attendance.

Wireless Internet Access

In the first meeting day you will be notified on how you may gain access to the wireless network in the building.

Coffee and Lunch Breaks

Coffee and lunch are available at the times indicated in the programme in the hall room next to the “Argiriadis” auditorium.

Summer School Dinner Party

The party will take place at “Chelona” restaurant on Wednesday 11th September from 7pm (121 Ermou St., Athens 105 55; <https://chelona.cavanektar.gr/en>).

Financial Support

We are most grateful to SR Research, Tobii Pro and neuroClues for their financial support of ESSEM 2024!



Information for Presenters

The language of presentations at the Summer School is English.

Lecture rooms are equipped with laptop computers and projectors. If you require any further technical devices, flip charts etc. please contact the ESSEM team.

Posters are presented in portrait format (80 cm wide by 200 cm high). Please make sure to put up your posters before the lunch break and to take them down following your poster session.

Students with surnames starting with A-M will present their posters on Thursday, students with surnames starting with N-Z will present their posters on Friday.

If you wish to print your posters in Athens, you may contact the company DOTO, who will be able to print and deliver your posters to the ESSEM 2024 location:

- Mrs Bokia
- Tel: +302105459029
- Email: mbokia@doto.gr; pdimitropoulos@doto.gr

Programme Overview

Time	Monday 9 th Sept: Introduction to Eye Movements	Tuesday 10 th Sept: Neuroscience Methods	Wednesday 11 th Sept: Recording and Analysis	Thursday 12 th Sept: Perception and Cognition	Friday 13 th Sept: Applications (I)	Saturday 14 th Sept: Applications (II)
09:00-09:45	Welcome (U. Ettinger, C. Klein, N. Smyrnis)	fMRI (K. Keidel)	Technical Challenges (K. Debono)	Manufacturer Workshops	Typical and Atypical Development (C. Klein)	HCI (P. Majoranta)
09:45-10:30	Introduction (P. Pouget)					
10:30-11:00	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>
11:00-11:45	Saccades (C. Klein, P. Pouget)	EEG (O. Dimigen)	Markov Models and Lévy Flights (G. Boccignone)	Scenes and Scan Paths (T. Foulsham)	Psychiatry (N. Smyrnis)	Neuromarketing (G. Manca)
11:45-12:30						
12:30-14:00	<i>Lunch</i>	<i>Lunch</i>	<i>Lunch and Manufacturer Stands</i>	<i>Lunch and Poster Session I</i>	<i>Lunch and Poster Session II</i>	<i>Lunch</i>
14:00-14:45	Fixations (S. Martinez-Conde)	Pupillometry (S. Mathôt)	Manufacturer Presentations: Tobii	Social Cognition (A. Kingstone)	Neurology (C. Antoniadis)	Athens Walking Tour
14:45-15:30			Manufacturer Presentations: SR Research			
15:30-16:00	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>	<i>Coffee Break</i>	
16:00-16:45	Smooth Pursuit (R. Lencer, P. Trillenberg)	Animal Studies (P. Pouget)	Manufacturer Presentations: neuroClues	Reading (J. Kaakinen)	Oculomotor Biomarkers in Pharmacology (U. Ettinger)	
16:45-17:30			Recordings in the Field (T. Foulsham)	Decision Behaviour (R. Rahal)		
Evening	18:00 <i>Opening Reception</i>	<i>Free Evening</i>	19:00 <i>Dinner Party</i>	<i>Free Evening</i>	<i>Free Evening</i>	

Poster Abstracts

Sex Differences in Numerosity Perception: A Cognitive Load Analysis Using Eye-Tracking Technology

Julia Bend

Åbo Akademi University, Finland

This study at Åbo Akademi University, led by Julia Bend, investigates sex differences in numerosity perception among adults using a novel approach that employs both numerosity estimation and comparison tasks. Numerosity perception, a fundamental nonverbal numerical ability linked to mathematical competence, varies according to several contextual and perceptual factors. Prior research predominantly focuses on the impact of various irrelevant visual elements and attentional load on numerosity accuracy. Our project extends this research to explore how these factors might affect numerosity perception differently across sexes. To measure cognitive load, our study utilizes eye-tracking technology to record pupil size—a reliable indicator of cognitive load according to Task-Evoked Pupillary Response (TERP). Eye-tracking will allow us to observe the real-time cognitive strain as participants engage in tasks requiring rapid numerosity judgments under varying attentional loads. Participants will complete two sessions: numerosity estimation and numerosity comparison, using a task format that manipulates dot array sizes to elicit cognitive load variations. Preliminary results from a pilot study suggested potential sex differences, with males estimating more accurately compared to females who tended to underestimate numerosity. This research aims to shed light on whether the observed discrepancies in numerosity perception can contribute to understanding broader sex differences in mathematical ability, particularly as they manifest in educational settings and STEM fields. Our findings could inform targeted strategies to address educational disparities and enhance inclusivity in STEM education.

Individual differences in pupil dilation predict task performance in a modified n-back paradigm*Gábor László Bényei**Budapest University of Technology and Economics, Hungary*

Whereas long-standing literature supports that pupil dilation during different tasks correlates with task characteristics (e.g. mental effort, surprise, uncertainty), most of these studies use within-subject designs and less is known about how between-subjects differences in pupil dilation are associated with individual differences in task performance. Our aim was to investigate how pupil dilation during working memory (WM) updating correlates with performance in an auditory n-back task. As pupil size changes represent an aggregate signal of brain arousal, we constructed a special blocked n-back design allowing differentiation of cognitive processes involved in WM updating. Participants were presented with a series of six digits, and they had to indicate during these six-digit blocks, whether one of the digits was the same as the digit presented two before. With this design, processing requirements were different for the first two and subsequent four items, as only encoding and storage was required for the first two, whereas later items also necessitated updating of WM representations. Our results show that the first two items triggered smaller dilation than the subsequent four items - this pattern is in line with the processing requirements supposed in our task, and thus validates our design. We also found that corrected hit rate and reaction time measures in the standard n-back task correlate with pupil response differences in our blocked n-back task, demonstrating that using sophisticated designs separating different cognitive processes, significant correlations can be obtained between individual variability in pupil dilation and task performance.

How objects face and point, and why it matters

Gabriel Brox Wiik & Mikotaj Hernik

UiT – The Arctic University of Norway

Arrows and eyes both face and point, i.e. we perceive them as directional (facing) and they guide our attention in the direction they are facing (pointing). Why and how we see objects like a dartboard as facing is not fully understood (Vestner et al. 2022), and neither is whether objects that face also automatically point like arrows and eyes do. We asked participants (N = 21) to rate the facing directions of 52 objects and found a clear consensus. To assess pointing we use a visual search paradigm where a cueing stimulus is presented centrally, and participants search for a target letter in two arrays presented laterally. The target is in the array that the cue is facing towards (congruent trials) or facing away from (incongruent trials). We expect faster reaction times on congruent trials (cueing effect). Using a 2x2x2 within-subjects design, we investigate the automaticity of the effect, the influence of the implied action direction and the implied user's direction. This is done by manipulating the task (e.g. normal task or activate facing direction representation by asking about facing direction) and choosing objects with implied directional action that is present (e.g. a sledge) or absent (e.g. a chair), as well as implied user's direction consistent (e.g. a chair) or inconsistent (e.g. a monitor) with the object's facing direction. Eye-tracking data will be used to exclude participants not attending sufficiently to the central cue and for exploratory analyses. Data collection is ongoing.

Connectivity in the visuo-motor network during Smooth Pursuit

Yvonne Buschermöhle¹, Jan-Ole Radecke, Tim Erdbrügger, Andreas Sprenger, Till R. Schneider, Rebekka Lencer, Joachim Gross, Carsten H. Wolters

¹University of Münster, Germany

The visuo-motor network enables smooth pursuit eye movements, which are important for the perception of the environment, but limited in many people suffering from schizophrenia. As there is only limited information on the temporal dynamics in this network, we performed an MEG study, aiming to define brain regions, frequency bands and eye measures which show significantly increased connectivity values to cerebral source activity during a smooth pursuit task. We recorded MEG data of 22 healthy participants during a smooth pursuit triangle task and simultaneously tracked the movement of the right eye. Combining an individual singleshell headmodel and preprocessed MEG data, we computed beamformer filters and corresponding timeseries for all sources. We then extracted the main timeseries per atlas parcel (HCP atlas). Based on eyelink data with interpolated saccades, we computed the velocity, acceleration and error between the stimulus and the actual eye-position, such as the absolute value of these measures. The coherences between the source data and the different eye measures were computed and statistically tested against the coherence created by surrogate data. We found significant differences between connectivity values in the actual data and in the surrogate data in occipital areas, but also parietal and motor areas for low frequency conditions (0-7 Hz). However, the atlas parcels showing significant differences and their values vary between (1) tested eye measure and (2) considered data parts (movement to the left or to the right).

Eye Movements Patterns and Performance of a Prosopagnosic Patient during the Recognition of Static and Dynamic Emotional Expressions

Alessia Bussard

University of Fribourg, Switzerland

Prosopagnosia, defined by a deficit in face recognition due to brain lesions, has been a trending topic in the scientific world for the last several years. However, only few studies focused on the processing of emotions by prosopagnosic patients, let alone the processing of dynamic stimuli. Therefore, we conducted this study to fill in the gaps regarding this topic. We examined the eye movements as well as the performances of a prosopagnosic patient (PS), while categorizing static and dynamic emotions. Due to her age (70 y.-o.), we had to compare her data with an age-matched control group of 19 people (AM). Our results showed a dynamic advantage for both groups, with no difference between them, no matter the condition. Regarding their eye fixations, PS and AM both gazed at the inferior part of the face no matter the condition, even though the AM tended to look more at the nose than PS. The results then confirm the ongoing hypothesis that static and dynamic emotions processing are anatomically distinct. Furthermore, our study corroborates the idea that dynamic expressions can be processed outside the fovea, implying that abnormal fixation patterns are still effective in recognizing dynamic expressions.

Interpersonal Eyeblink Synchronization during Real-world Mutual Gaze: A Mobile Eye-tracking Study

Mehtap Cakir

University of Ulm, Germany

Eyeblink synchronization refers to the phenomenon where individuals subconsciously adjust the timing of their eyeblinks to coincide with each other. While previous studies have shown that eyeblink synchronization serves as an important indicator of interest, engagement, and rapport, they often lack ecological validity, relying on videos as stimuli rather than real-world face-to-face interactions. Another limitation of these studies is that they primarily examined eyeblink synchronization within experimental procedures that highly rely on auditory attention and conversational patterns. Addressing these gaps, our study presents the first experimental setup using mobile eye-tracking devices to investigate interpersonal eyeblink synchronization during sustained mutual gazing in dyadic settings. Dyads were instructed to maintain eye contact without verbal communication under three conditions: face-to-face, via a mirror, and self-gazing through a mirror. Participants rated their sense of rapport in each condition. Results revealed varying levels of eyeblink synchronization and perceived rapport across conditions. Notably, face-to-face mutual gazing exhibited higher eyeblink synchronization and perceived rapport compared to mediated interaction through a mirror. These findings underscore the importance of examining eyeblink dynamics in different real-person interaction contexts. This research contributes to our understanding of interpersonal eyeblink synchronization during mutual gaze, shedding light on the complexities of human social interaction.

How we look shapes how we remember: a behavioural and eye tracking study

Celli M., Zangrossi A., Cona G., Corbetta M.

University of Padova, Italy

Visual exploration and visual memory are tightly linked processes. However, there is surprisingly little work addressing the specific role of eye movements in visual memory studies. To date, it is still unclear how the patterns of visual exploration during the encoding phase affect the recall of visual memories later on. In this study, we propose a novel method to investigate the spatial relationship between eye movements while encoding a visual scene and visual memory. In a large cohort of subjects ($n=120$), we collected eye tracking data while participants viewed complex scenes, as well as audio tracks of their free memory recall of five target images. By transforming free recall audio tracks into 2D maps, we show that there is an overlap between what we see (i.e., gaze maps) and what we remember (i.e., memory maps). In summary, we show that 1) gaze maps show a higher similarity with memory maps, as compared with stimulus related maps (i.e., saliency and semantics); 2) the overlap between gaze and memory maps is modulated by visual memory performance and image complexity. These findings suggest that endogenous processes play a crucial role in shaping the recall of visual memory, as opposed to relying solely on stimulus related information.

Exploring the Influence of Mental Imagery and Sensory Processing Sensitivity on Perception: A Pupillometry Approach

Katerina Christodoulou¹, Reshanne Reeder, Emiel Kraemer, Tessa van Leeuwen

Tilburg University, The Netherlands

For understanding the divergent perceptions observed in conditions such as autism and schizophrenia, an opportunity lies in the examination of individual differences. Individual differences in mental imagery and sensory sensitivity have been proposed to influence the balance between top-down and bottom-up weighting in perceptual inference (Reeder et al., 2023). In this study, we aim to study the relationship between individual differences in trait mental imagery and top-down influences on perception while controlling for sensory processing sensitivity (SPS), a trait linked to processing depth and sensitivity to sensory stimuli. We will utilize a novel pupillometry approach (Kay et al., 2022), which has demonstrated a positive correlation between imagery strength and pupil light response (PLR), to objectively measure imagery vividness. Our investigation will focus on how visual imagery influences subsequent perception, particularly in individuals with extreme traits of mental imagery. Additionally, we will explore the influence of SPS on pupil dilation differences to understand its relation to objective imagery strength. We anticipate that pupil size will vary as a function of mental imagery vividness, and we hypothesize that SPS will positively relate to imagery strength. Moreover, we posit that imagery strength may facilitate ambiguous perception. This study aims to offer fresh insights into perception mechanisms, elucidate individual differences' contributions, and enable the disentanglement of confounding factors in perceptual experiments.

Fixation-related potentials and eye movements reveal multiple effects of context across the visual field in natural reading

Allyson Copeland

University of Utah, Salt Lake City, USA

During reading, it is unclear how and when central attention gets allocated across the visual field to extract and integrate semantic features of words. The co-registration of eye-movements with electroencephalography (EEG) allows for the estimation of fixation-related brain potentials (FRPs) in ecologically-valid visual tasks, including reading. While FRP studies have begun charting the time-course of semantic processing, for example showing N400 modulations by plausibility and predictability, no studies have simultaneously examined anterior (linked to predictive processing) and posterior (linked to semantic integrations) post-N400 positivities in natural reading. We recorded simultaneous eye movements and EEG while participants read constraining sentences with expected, unexpected (but plausible), and anomalous target words (e.g., When the power went out the house became dark/cold/half like last time). The eye-tracking results showed readers skipped the target word more often when expected, and spent longer fixating, re-fixated more often, and regressed more often on anomalous targets. When time-locking fixation to the pre-target word, we observed a parafoveal N400 largest to anomalous words, followed by unexpected, and then expected words. The N400 was facilitated when the word was subsequently fixated, suggesting trans-saccadic integration of semantic features. At target fixation, we also observed a late anteriorly distributed positivity to unexpected target words, an effect that was not present at the pre-target word. We did not observe conclusive evidence for a late posteriorly distributed positive component. Collectively, these findings suggest readers can begin accessing semantic information in parafoveal vision, but higher-level

semantic processing requires the orchestration of parafoveal and foveal representations.

Visual and oculomotor disturbances in drug naive Parkinsonism

Solveig J Dalbro

Oslo University Hospital, Norway

Introduction: There is a need for biomarkers in Parkinson disease research. Especially for future drug-trials there is a need for a biomarker that is present early in the disease course since that is when a drug most likely will have the most benefit. A clinical biomarker should measure and quantify disease progression objectively. In this study we aimed to find one or a combination of eye measurement abnormalities that can differentiate healthy controls from drug naive patients with Parkinsonism. Methods: 24 drug naive patients with degenerative parkinsonism and age matched healthy controls were examined with 7 different eye-tracking tasks. The fixation task was to look at a central target for 11sec repeated 4 times with a 4 second break in between. Results: Preliminary results show that the mean fixation duration is significantly shorter in patients than in healthy controls. There is a tendency to differentiate between Parkinson's disease and atypical Parkinsonism, but the sample size is too small to make any conclusions. Discussion: In this ongoing study the fixation task looks promising in differentiating between patients with parkinsonism and healthy controls. There are limitations in the sample size, and the diagnostic accuracy of Parkinson disease vs atypical Parkinsonism this early in the disease course. Future investigations will look at how the fixation duration is influenced by dopaminergic treatment and longitudinal follow up.

Predictive Model of Intrinsic Cognitive Load by Eye Metrics and Bio-signals

Merve Ekin, Krzysztof Krejtz, Izabela Krejtz

SWPS University, Warsaw, Poland

Intrinsic cognitive load is associated with the inherent complexity and the number of elements interacting in a mental task. The aim of this study was to predict the level of intrinsic cognitive load in mental calculations using eye movement and biometric parameters. Cognitive load was assessed using several physiological measures such as the K-coefficient (fixation duration saccadic amplitude), pupil dilation, heart rate, and galvanic skin response. Thirty-four participants (aged 21.18 ± 3.42) performed mental calculations while their physiological data were recorded by the Gazepoint GP3 HD eye tracker with psychophysiology bundle. We also controlled for working memory with a digit span task. As expected, physiological measures changed according to the level of task difficulty. For example, changes in pupil activity were greatest for hard (requiring borrowing or carrying steps during addition or subtraction operations) and long (two-digit) calculations. The results lead to a reliable predictive model of intrinsic cognitive load based on psychophysiological metrics with high discriminative power. The model can be applied to future real-time predictions based on machine learning algorithms in educational settings.

Different goals for oculomotor control and perception

Stephan Fally, Pascal Güntürkün

Vienna University of Economics and Business, Austria

Charities often use extrinsic incentives, such as thank you gifts or lotteries, to attract new donors with the idea that these donors continue giving to unincentivized fundraising campaigns. However, whether donors continue giving after incentives are removed is unclear as prior research offers mixed evidence (Landry et al. 2010, Lacetera et al. 2014, Goette & Stutzer 2020, Haruvy & Popkowski Leszczyc 2022). Research has not yet uncovered the mechanism by which donors react to such changes. We draw on neuroscientific insights to investigate whether donors' attention patterns and visual salience of extrinsic incentives can explain the underlying psychological mechanism and resolve the discrepancy in prior findings. Specifically, we aim to investigate donors' eye gaze when exposed to a temporary extrinsic incentive (more vs. less salient) and expect that withdrawing extrinsic incentives may have negative effects on subsequent donations via a shift in attention away from the cause. We will use a series of behavioral experiments paired with mouse tracking and eye tracking to uncover the decision making process of donors after extrinsic incentives have been removed. By the time of the summer school, I plan to have the final research design and first behavior results ready to present and discuss. This work has important implications for better designing charities' incentive schemes in the long run.

Analyzing Visual Patterns: A Comparative Study on the Similarity of Qajar and Neoclassical Painting Styles Using Eye Tracking Technology

Yasaman Farhangpour

Universita' degli Studi di Milano

The investigation of eye movements is crucial for comprehending how individuals interact with their surroundings, especially within the context of visual art perception. Art interpretation, a culturally significant phenomenon in cognitive sciences, entails identifying visual components and nuanced interpretations of potential meanings a focus of inquiry since the early days of psychological research. In recent decades, the convergence of visual art and eye movements has garnered substantial interest, with eye tracking technologies providing unprecedented opportunities for exploration and verification. This poster delves into understanding how variations in eye movements may influence scene perception, particularly in contrast to traditional, in-person viewing. Focusing on the distinct styles of Qajar art and Italian Neoclassicism, prevalent in two different parts of the world, the study analyzes visual patterns observed in 33 subjects exposed to 50 stimuli divided into two groups. Beyond theoretical aspects in art history books, this research seeks to bridge the gap between conventional inperson experiences and technologically mediated art observation. By surveying differences in Qajar and Italian Neoclassical styles -as two contemporary painting styles-, this study illuminates nuanced ways in which viewers engage with and perceive paintings, offering insights beyond traditional art analysis. The findings contribute to the ongoing discourse in art perception, providing a practical understanding of how technological advancements, specifically eye tracking, enhance our comprehension of the intricate relationships between visual art and human cognition.

Affective consequences of oculomotor-control mechanisms for visual stimuli

Mark J. Fenske, Niyatee Narkar, & Kaya Bartlewski

University of Guelph, Ontario, Canada

Mechanisms of selective attention and motor-response control can determine emotional responses for visual stimuli. Items that are ignored or from which a motor-response is withheld, for example, receive more negative affective ratings than the targets of attention/response. Here we used head-stabilized screen-based eye-tracking to explore similar effects associated with saccadic eye-movements. In a selective-looking task (Exp. 1), shifting gaze away from individual stimuli led to their affective devaluation relative to looked-at stimuli. To test whether the affective status of visual stimuli is specifically altered by oculomotor inhibition, beyond any fluency-related affective enhancement from foveal processing, we examined the affective consequences of suppressing the urge to make an eye movement toward an abrupt-onset stimulus (Exp. 2: anti-saccade task) or in response to a central cue (Exp. 3: oculomotor Go/No-go task). Taken together, our results suggest the mechanisms underlying 'distractor devaluation' and 'No-go devaluation' effects in other selective-attention and motor response control domains may be similar to those determining emotional responses in the oculomotor domain.

Unveiling Deceptive Intentions through Fixations and Pupil Size in a Card Game Scenario

Valentin Foucher

Ulm University, Germany

The potential for eyes to uncover deceptive intentions is well-acknowledged, yet understanding this connection is complicated by various external and internal factors that affect eye behaviour. This complexity occasionally leads to conflicting findings across studies. In our study, we delved into how fixations and pupil movements could serve as indicators of deceptive intentions in a card game scenario. Participants were tasked with selecting a number from a card (ranging from 1 to 6) and then presented with all possible card possibilities. The study tested two levels of deceptive intentions: concealing or faking the chosen number, and compared them to a truthful control condition. Two display layouts were examined: simultaneous presentation of card options and sequential presentation. Our findings revealed that the concealing condition was characterized by more and shorter fixations when multiple cards were displayed on screen, and by fewer but longer fixations when only one card was shown. Fixations also disclosed participants' focus on specific cards in both truthful and faking conditions, while pupil size additionally indicated the selected card in both deceptive conditions. Notably, the two display layouts elicited contrasting fixation patterns for the same deceptive instruction. Our study underscores the importance of distinguishing at least two types of deceptive intentions based on eye movements, while it also reveals the impact of the number of objects in the design on deceptive eye behaviours.

Does an increase in the number of submovements used lead to an increase in cognitive load? An eye tracking study*Jason Friedman**Tel Aviv University, Israel*

When we produce arm movements, we can decompose these movements into a series of temporally overlapping submovements. The number of submovements used in a manual tracking task is a function of the frequency of the movement – when we make high-frequency (i.e., short-duration) movements, we tend to make fewer submovements, whereas when we make low-frequency (i.e., long-duration) movements, we tend to make more submovements. We can observe this if we try to move our hands from the left side of our body to the right side without stopping while taking four seconds – the subsequent movement feels “jerky”, and a kinematic analysis would indeed show that we used multiple submovements. In this project, we ask whether producing more submovements leads to a greater cognitive load. By altering the frequency of the movements in a tracking task on a graphics tablet, we can modulate how many submovements a participant makes. On the one hand, submovements may be largely automatic, so producing more submovements may not increase cognitive load. On the other hand, the need to generate more submovements may lead to increased cognitive load. In this study, we will use eye movements to quantify differences in cognitive load caused by changes in the number of submovements by looking at features related to saccade, fixation, pupil, and blink properties. We will calibrate the system through a series of motor tasks of increasing difficulty (and assumedly cognitive load).

Naturalistic eye movement tasks in Parkinson's disease*Melissa Chloe Gibbs**University of Oxford, UK*

Eye tracking research conducted in laboratory settings has previously highlighted differences in eye movements between individuals with Parkinson's disease and healthy ageing. However, traditional laboratory-based eye movement tasks (e.g., prosaccades, antisaccades, memory-guided saccades) are contrived and thus constrain the ecological relevance of this research. Tasks involving more naturalistic eye movements may offer a more precise understanding of cognitive function. We therefore conducted a systematic review to determine what naturalistic eye movement tasks have revealed regarding oculomotor deficits in Parkinson's disease and their implications for sensorimotor and cognitive processes. We analysed 30 studies that examined eye movements among individuals with Parkinson's disease and healthy controls during naturalistic eye movement tasks (e.g., reading, free viewing, video watching), as well as tasks that were not necessarily naturalistic by nature, but incorporated naturalistic stimuli (e.g., clock matching, sentence-picture matching). Longer fixation durations and reduced saccadic amplitudes were consistently observed in Parkinson's disease relative to healthy controls across various naturalistic eye movement tasks. Nevertheless, the absence of standardisation impedes the interpretation of these findings and potentially contributes to the large number of inconsistencies observed in the literature. We therefore call upon researchers to broaden the existing literature whilst simultaneously working towards the standardisation on naturalistic eye movement tasks.

Insights into Cognition: Analyzing Eye Movements in Neuropsychological Tests

Joan Goset

Universitat Politècnica de Catalunya, Spain

Eye movements have been shown to be altered in neurological disorders such as Alzheimer's disease, Parkinson's disease, etc. Besides common neurological disorders, another emerging concern of cognitive health is the COVID-19 pandemic. Despite the main urgency of the pandemic has finished, the long-term impact of the disease has raised and, in fact, patients with the post-COVID-19 condition (PCC) report a broad spectrum of symptoms, including cognitive impairment. Hence, eye movements might be used as a new biomarker for the assessment of cognition impairment, in particular in PCC patients. To assess cognitive impairment, neuropsychologists often use neuropsychological tests such as the Trail Making Test (TMT) or the Stroop Colour and Word Test (SCWT), and subjects are instructed to connect a set of numbers and letters randomly distributed or to read words as fast as possible. They are commonly scored by the time to completion and errors done. Despite their widespread use, they present some limitations such as the lack of timeliness. In view of this, in this work we investigate the association between functional eye movements measures and cognition performance (assessed using neuropsychological tests) in PCC individuals. In particular, we focus on events and metrics elicited when performing the above-mentioned neuropsychological tests, to make the analysis easier and more objective and reliable, and to study if they can provide further information for an earlier diagnosis. The preliminary results show relations between saccadic and fixational parameters and time to completion, suggesting the potential of eye tracking technology to complement the test.

Pupillometric correlates of post-COVID fatigue

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Fatigue is the most prevalent symptom of post-COVID syndrome, which, in addition to cognitive dysfunction, chemosensory and cardiopulmonary complaints, can include many other neurological and psychiatric complaints and is often accompanied by a variety of vegetative disorders. In addition to immunological and vascular processes, a disruption of brainstem signaling pathways is also discussed as a possible pathomechanism. To date, the degree of severity has depended on subjective assessment, while the neurophysiological equivalents of fatigue have been little studied. Vegetative dysfunction has already been investigated in electrophysiological, neurosonological, electrocardiographic and simple pupillometric studies, with the latter achieving initial success as a prognostic tool in the acute phase. In the post-infectious stage, however, changes in pupillary reactivity were mostly interpreted as a disturbance of peripheral autonomic efferents. Due to the pupillomotor patterns typically occurring in physiological fatigue and drowsiness, it makes sense to systematically investigate a possible central genesis of post-COVID-associated pupillary changes, to correlate them with clinical severity and to expand them methodically. Therefore, in addition to resting diameter and light reflex dynamics, the established pupillographic sleepiness test and chromatic and cognitive pupillometry methods are being used for the first time in post-COVID patients and investigated in patients and healthy controls using questionnaires and scores on severity, chronobiological and depressive changes and a measurement of heart rate variability. A post-COVID-typical pattern could serve as an easily applicable alternative for testing pathophysiological

hypotheses, as a potential prognostic factor or predictive marker in therapy studies.

Beauty in the Eye of the Beholder: Aesthetic Scene Processing in Human- vs. AI-generated Images

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The aesthetics of scene perception can be influenced by a multitude of factors, such as artist attribution (human vs. AI creator), type of image (photograph vs. painting), and eye movement patterns (looking at regions of interest [ROIs] vs. other areas). These three factors have previously been shown to correlate with self-reported measures of aesthetic appreciation, but the cognitive mechanisms underlying such aesthetic experiences remain relatively unexplored, especially with regards to AI-generated stimuli. To address this gap, an eye tracking paradigm is currently being implemented, in which participants (target N=40) viewed photographs and paintings of various scenes, attributed to either a human or AI creator. After each stimulus presentation, the participant rated the image along five aesthetic parameters: liking, beauty, emotional engagement, artificialness, and monetary worth. The preliminary findings will reveal the aesthetic differences in human- vs. AI-generated images, and establish a baseline of free-viewing tendencies for fixation patterns and ROIs within each category of scene stimuli (open vs. closed, natural vs. manmade, human vs. AI). The results will be compared against a guided viewing condition in a future follow-up experiment, to assess the role of self-determination/“free will” in shaping aesthetic processing. Importantly, this research bridges the fields of naturalistic scene perception and aesthetic appreciation, offering an integrated approach in understanding both the cognitive and affective elements of visual processing. It can also elucidate whether AI-generated images are processed by the brain in the same way as human-generated content, or if they are a truly novel stimulus category.

Are you tired of these ecological and environmental claims? The role of eco-fatigue in consumers' behavior

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Introduction: The urgency of sustainable consumption and production has never been more apparent. In the end of 2023, the European Union and Copernicus declared it the year of intense global wildfires, with evidence of extreme floods and record high temperatures underscoring the critical state of our planet (CAMS, 2023). As we approach 2024, the disheartening reality emerges from the 2023 report, confirming that only 12% of the Sustainable Development Goals for 2030 have been achieved (DESA, 2023). Notably, in the report three goals are farther lagging behind which also include "Ensuring responsible consumption and production". Despite over large number of companies have positive intentions for green strategies, governments championing green behavior, and various organizations tirelessly advocating for sustainability, a significant gap persists in consumers' green behavior (Venciute et al., 2023). Drawing on the cognitive fatigue theory as a conceptual foundation, the research implicitly and explicitly explores and confirms the positive connection between eco-fatigue and consumer behavior in services. Additionally, the study aims to define eco-fatigue and comprehend its outcomes for environmentally destructive behavior.

Literature review: Eco-fatigue is rather a new notion and few research articles mentioned studies till now and has an extinct discussion. The meaning of fatigue is exhaustion, tiredness, weariness or lethargy for some action after previously putting continuous efforts into the task (Hockey, 2010). Eco-fatigue can be defined as the "exhaustion from green practices after being actively

engaged into sustainable practices because of certain reasons". There are few previous definitions and opinions regarding eco-fatigue as well. Eco-fatigue can be defined as a sense of being overwhelmed and a belief that personal actions won't impact eventual outcomes for the protection of environment (Woods, 2020). Individuals who perceive their incapability to take on responsibility, low self-confidence, or disappointment met regarding any control on the environmental change happening are affected by such negative green behaviors (Javed et al., 2023). Doherty & Clayton, (2011), contend that conflicting green communications lead individuals to avoid sustainability, resulting in negative intentions, apathy, opposition to sustainable practices, and an increased inclination to choose unsustainable goods. Prior studies emphasize the complexity of sustainable consumer behavior in services compared to products due to intangibility and limited visibility (Martínez, 2015). The service providers of services like tourism are continuously making efforts for to enhance sustainable consumer behavior (Chi et al., 2022). These efforts are aimed at saving the destinations viability and protecting the environment. But the study of Tölkes (2020), confirmed that despite enormous efforts, green communications and awareness, there is a huge intention-behavior gap persists among tourists, posing environmental risks. Such importance facets make it vital to study the factors creating the gap in intention and behavior despite all the efforts. There is also study of Moscardo & Pearce (2018), which explored eco-fatigue as affecting the consumer inclination for sustainable tourist experiences, and suggested that eco-fatigue demands further research to better understand the notion. Additionally, existing studies associates eco-fatigue with eco-anxiety, but there is a need to explore it as an independent phenomenon. The current study addresses the previously mentioned gaps, recognizing the significance of the topic.

Method/Approach: Our study is comprised of four studies. In the first study an online panel was assembled comprising of 150 participants to engage in the Implicit Association Test (IAT). The participants were instructed to categorize the words that were presented in the center of their screen into four categories, i.e., eco-fatigue, eco-active, negative and positive association words. Simultaneously, a survey, focusing on their explicit attitudes, was administered which included statistical analyses including Pearson correlation coefficients, repeated measures MANOVA, and principal component analysis. Furthermore, in the last two studies, experimental approaches were incorporated to substantiate eco-fatigue and its outcomes related to environmentally harmful behaviors.

Results/Findings: The results of IAT confirmed the implicit association of consumers with eco-fatigue. Further, the results of explicit association test solidify the base of the research study. In subsequent studies, we found that there is strong relationship between eco-fatigue and environment harming behaviors.

Discussion and implications: Our research signifies a noteworthy contribution by defining eco-fatigue as an independent entity, distinct from its association with eco-anxiety. This distinction enhances our understanding of the issue's complexity. The alarming prospect of eco-fatigue among consumers potentially leading to environmentally harmful behaviors emphasizes the urgency of addressing this concern. These behaviors in services like tourism and hospitality can lead to overconsumption, waste generation, carbon emissions, habitat disruption, wildlife disturbance, pollution, cultural insensitivity, unsustainable practices, and lack of conservation measures. Addressing these issues is crucial for fostering sustainability in the services industry. For marketers, recognizing the prevailing fatigue resulting from current green marketing and sustainability initiatives is paramount. This realization offers a strategic opportunity to formulate policies and marketing

approaches that mitigate fatigue and reignite consumer enthusiasm for sustainable practices. In the realm of practical implications, our findings underscore the importance of adapting marketing strategies to align with consumers' evolving attitudes and preventing detrimental repercussions on sustainable behavior.

The emotional impact of advertisements on product categorisation

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Perceptual decision-making (PDM) and visual discrimination (VD) tasks are crucial cognitive processes that allow individuals to categorise visual stimuli accurately. Previous research has demonstrated that colour and texture can influence how stimuli are processed, categorised, and perceived in the environment by evoking emotions that affect our behaviour. Also, the emotional valence and arousal of the background context play a crucial role in cognitive processes. Considering this interplay between stimuli and environment, we aimed to investigate how the combination of foreground stimuli and background stimuli influences response time and accuracy. In this study, we examined how varying emotional contexts influence VD and PDM using advertisements. The research aims to provide insights into the emotional mechanisms that underpin product categorisation. By integrating eye-tracking technology within a comprehensive experimental design, we examine how variations in emotional valence and arousal affect the perception of products as either luxury or basic. We recruited 60 participants to categorise the products in the advertisements based on their perceptions. The background stimuli were manipulated regarding valence (low positive/high positive) and arousal (high/low). This ongoing research could significantly impact marketing strategies, particularly for companies selling luxury and basic products. By understanding how different emotional states influence product categorisation, companies could tailor their advertising strategies to evoke the desired emotional response and thus influence how consumers perceive their products.

Exploring the Validity of Eye Movement Paradigms for Measuring Executive Function and Diagnostic Applications

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Executive functions, such as inhibitory control and working memory, are predominantly assessed through traditional paper-pencil and computerized tasks. Recent studies highlight the potential of using saccadic eye movement (EM) tasks for early detection of cognitive decline. EM tasks are advantageous as they are less influenced by motor skills, language abilities, and literacy levels, making them suitable for diverse populations. Additionally, they can be integrated with techniques like EEG or fMRI, offering a more comprehensive understanding of cognitive and neural processes. However, there is limited research exploring the relationship between different saccadic EM tasks under varying conditions and various domains of executive function (EF). The initial phase of my project involved conducting a systematic review to identify effective EF tasks that can differentiate between healthy population and those with memory problems. Out of 9,323 screened studies, 26 papers were reviewed, containing 57 tasks. The findings highlighted the efficiency of tasks like TMT-B and category fluency. The next phase of the study involves examining the relationship between these highly effective EF tasks and saccadic eye movements (prosaccade, antisaccade, and Go/no-go tasks) under various conditions (step, gap, and overlap). Currently, data collection is ongoing, targeting a sample of 67 young adults. Once this phase is complete, the findings will be extended to older adults to validate a comprehensive battery for diagnosing individuals with Alzheimer's Disease (AD) and Mild Cognitive Impairment (MCI).

Readers' Emotional Engagement with War-related Media Content: A Linguistic and Eye-tracking Data Study

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The present research is being carried out within the realms of post-doctoral research internship. It focuses on the emotional responses evoked by Russia's large-scale military actions in Ukraine and aims at identifying and categorizing the emotional responses/emotions in a computer-mediated data sample collected from mass media and social media and through eye-tracking experiments. The eye-tracking data sample will be collected by exposing the subjects (approx. 50) to textual data related to warfare. Measuring cognitive processing of participants will supplement the linguistic analysis. An Eyelink 1000 Plus eye-tracker measuring a person's eye positions and movements and sampling them every millisecond will be used to collect the eye-tracking data, to conduct the qualitative analysis of the individual recordings, and to aggregate the data for the quantitative analysis and visualization. Pupil size has been used as a measure for emotionally toned visual stimulus viewing along with fixations, saccades and regressions (Lim et al. 2020; Child et al. 2020; Filik et al. 2017, De Lemos et al. 2008; Usée et al. 2020). In the eye-tracking experiment, the participants will be subjected to reading texts (headlines, social media posts). The selected areas of interest in the texts will focus on linguistic structures involving war-related meanings. The participants' eye movements (fixations, saccades, fixation durations, gaze duration, etc.) will be measured against control items (war-unrelated counterparts) to learn more about the processing of emotionally toned vs neutral meanings. The subjects will be asked to rate their own emotional response to the stimuli and text on a scale from 1 (negative) to 10 (positive) and indicate the specific emotion evoked. The combination of the results obtained

from linguistic and eye-tracking samples is intended to ensure the scientific validity of the research.

Using Webcam Eye Tracking for Different Gaze Input Methods

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The mouse has been the dominant input method since the invention of PCs, almost unrivalled and no other input type has prevailed. I will evaluate two variants of eye gaze input alternatives, comparing them against the mouse and another dwell-time based eye-only alternative. The results show that in the chosen experimental setting none of the presented input methods outperforms the traditional mouse input which might partly be due to the low accuracy of eye tracking using the webcam. For selection tasks, an input method where eye input can be corrected through mouse input seems to be a promising alternative. In contrast, eye-only input performed worst for selection tasks but for scrolling, it shows the best results in comparison to the novel input methods. Here, manual correction or confirmation seems to be not as necessary as for selection tasks or even disturbing. In general, it can be found that the size of the targets plays an important role and influences the rated usability as well as the performance.

Human-AI interaction in diagnostic decision-making: An eye movement-based investigation

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The increasing use of artificial intelligence (AI)-based decision aids in the field of medicine has warranted a growing body of scientific work investigating the appropriate methods for the effective deployment and integration of the decision aids into existing workflows of decision-making. Generally, we are only able to observe and record the outcome of this decision-making process. However, examining the decision-making process itself can yield insight into the reasoning that results in the particular outcome. In medical imaging-based diagnostics, the viewing behavior can help in understanding the cognitive facets of the decision-making process. A technique that can facilitate this is eye-tracking, which has been widely used to record patterns of visual attention and recognition in a visual search scenario, and gain a more objective measure of visual behavior. In the current study, we employed a head CT-based diagnostic decision-making task aided by an AI-based decision aid, in order to compare the visual behavior of experts (radiologists) and novices (medical students). Participants received two types of AI advice- non-explainable (only diagnostic advice) and explainable (advice with bounding boxes), along with a control condition where they received no AI advice. The aim was to examine the effect of AI advice explainability on the viewing behavior of the two groups, and consequently, their decision making. Previous research has shown that novices may benefit more from explainable advice than experts. To examine this effect in viewing patterns, we analyzed participants' eye movement fixation patterns and pupil diameter while they viewed head CTs and gave diagnoses.

Securing the Gaze: An overview of privacy and security in Eye Information*David-Levente Kovacs**IT University of Copenhagen, Denmark*

Over the past few years, eye tracking technologies have seen significant improvements in efficiency, affordability, and user-friendliness, leading to a more pervasive use of these technologies in a variety of fields. The expansion of eye tracking applications, coupled with the introduction of GDPR, has prompted an increase in research into various Privacy Enhancing Technologies (PETs) aimed at protecting eye information. At present, there's a noticeable gap in comprehensive overviews of the privacy risks associated with modern eye tracking systems. This gap extends to a limited understanding of the specific privacy risks addressed and alleviated by current applications of PETs. The current paper presents an in-depth analysis of the existing literature on eye information privacy, and reveals noteworthy gaps, unexplored research areas and promising future directions. Existing misconceptions, or misleading and flawed approaches will be revealed and cleared. The overview shows us how the existing literature relates to each phase of the data management process and how the methods described in these papers help us achieve GDPR compliance. Finally, the overview also enables us to propose new methods and solutions that not only address current privacy concerns but also anticipate future challenges.

Differentiating Autism Spectrum Disorder and Typically Developing Individuals*Hadar Krasnolob**Ben-Gurion University, Israel*

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that affects 1 in 100 children worldwide and involves social and communicational impairments together with restrictive and repetitive patterns of behavior and interests. One key characteristic of ASD is the presence of atypical eye contact behavior. Research in the field has focused on distinguishing individuals with ASD from typically developing (TD) individuals. The current study utilizes a big-scale data set to investigate the efficacy of two measures: (1) distance from control group mean and (2) correlation with control subjects, in classifying autism and control.

Subjective Uncertainty in Pointing Gestures

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People often communicate with pointing gestures in their daily life. It was previously found that a point does not indicate a specific location but rather a (small) area. We still do not know, which spatial information pointer expect they are conveying with their gestures. We assume pointers scan the target's surrounding that they believe the gesture is covering to find an appropriate target description, so pointers' gaze pattern should represent the area of subjective uncertainty associated with their pointing gesture. We hypothesized that pointers are overconfident concerning their gesture's accuracy and therefore, the fixated area should be smaller than the area in which the observers' interpretation fall. To examine on this, two participants holding either the pointer or observer role were invited to the lab and were seated in front of a big screen. In each trial, the pointer had to point towards one target shape among 179 similar distractor shapes – or depending on condition, could additionally describe it – while the observer had to identify the target shape. To measure subjective uncertainty, eye movements of both, observers' answers and identification confidence were recorded. Unsurprisingly, correct target identification was enormously facilitated, and confidence rating was higher when pointing was accompanied by verbal description. Furthermore, the results support our hypothesis as the fixated area by pointers was smaller than the observers' interpretation area and additionally, both centers significantly differ. Thus, pointers overestimate the accuracy of points and did not consider interpretation biases and situational factors.

Self-owned objects benefit from a more efficient processing in the PPS

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We interact daily with objects that are close to us and that we can manipulate. These proximate objects are located in our peripersonal space (PPS), a space that serve as a motor interface between the body and the environment. PPS is a space underlying the organization of voluntary actions and, as such, objects present in this space can spontaneously activate the motor system, as if the organism were preparing in advance to act on these objects. However, in the PPS, not all objects belong to us and a conflict may emerge between the ownership-based conceptual coding and the sensorimotor coding. To better understand the resolution of this conflict, EMG activity was recorded on the thumbs (flexor pollicis brevis) during a reachability judgement task. Behavioral data showed that reachability judgments were faster for self-owned objects in PPS. The analysis of the EMG activity revealed that more errors were initiated in the PPS for other-owned objects and in the EPS for self-owned objects, and that errors were more quickly and efficiently corrected for self-owned object in the PPS. Overall, the data revealed that reachability judgments were faster in the PPS for self-owned objects, with more efficient inhibition processes in the presence of motor errors. To gain a more comprehensive understanding of the resolution of this conflict, in a second study, participants performed a reachability judgement toward self- and other-owned objects while undergoing fMRI. Altogether, the results of this study enable us to disentangle the neuronal networks involved in conflict resolution in the PPS and in the EPS.

Leveraging Spatio-Temporal Gaze Pattern Analysis to Explore Toddlers' Understanding of Observed Joint Attention

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Prior eye-tracking research on social cognition in early childhood has mainly relied on cumulative measures (e.g., proportion scores), neglecting potentially meaningful spatio-temporal characteristics of children's attention allocation. We address this shortcoming in the context of studying children's ability to infer interpersonal sharedness in observed joint attention interactions. To do so, we compare overt visual attention patterns of 36-month-olds (N=36) in a screen-based eye-tracking experiment (preregistration: <https://osf.io/b67ec>). The study design incorporates three within-subject conditions: joint attention, parallel attention, and control. Participants see two trials per condition, each comprising two phases: sharedness induction and test phase. In the sharedness induction phase, children see videos featuring two actors with the degree of interpersonal jointness manipulated visually and verbally across conditions. In the test phase, we present still images of both actors looking at an object, with distractor objects displayed in the background. Across conditions, the test phase images are conceptually identical and ambiguous in the degree of jointness between the actors, allowing us to tap into children's representation of jointness or non-jointness based on the induction phase. We use sliding window n-grams to extract gaze patterns from character strings representing individual sequences of AOI hits. To explore whether recognizing sharedness is associated with different overt visual behaviors in toddlers, we fit a Bayesian categorical regression model with n-gram identity as a response variable and condition and trial as predictors. As a next step, we plan to adapt this approach to

eye-tracking research with preverbal infants and non-human great apes.

Motor learning: Does execution really matter?*Maxime Martel**Université de Lille, France*

The investigation of contextual saccadic adaptation employs a variation of the double-step paradigm, wherein two directions of intra-saccadic steps are signaled by distinct contexts. This approach enables the simultaneous induction of two distinct saccadic adaptations. Surprisingly, effective contextual adaptation manifests when utilizing spatially relevant cues, but not when the target's color and shape serve as context. Our theoretical understanding of this phenomenon prompted the design of a study aimed at disentangling the respective impacts of movement planning and execution on motor learning in saccades. We examined learning ability across four distinct experiments (n=36), in which a second saccade served as a context to adapt a first one. Full sequence experiments - Participants executed two consecutive saccades towards two simultaneously displayed targets, engaging both planning and execution of the motor movement. Single target + Distractor experiment - Participants faced the same screen display as in the Full sequence experiment but were directed to saccade toward one target, avoiding the second. Execution only experiment – Here we introduced the second target after reaching the first one, thereby preventing sequence planning but not execution. Planning only experiment – Conversely, here participants were instructed to execute two saccades, yet the second target vanished upon reaching the first one, engaging planning and hindering execution of the motor movement. Robust systematic contextual learning was observed in both the full sequence and planning-only experiments, whereas no learning occurred in the other two experiments. These effects on contextual learning underscores the critical role of planning in the motor learning process.

Disentangling the effects of statistical learning on visuospatial center-surround inhibition: an eye-tracking experimental proposal*Andrea Massironi**University of Milano-Bicocca, Italy*

We recently found that statistical learning – the ability to extract and implicitly learn statistical regularities within the visual world to optimize future allocation of visuospatial attention – modulates the center-surround inhibition of the attentional focus - wherein a ring of sustained inhibition circumscribes the center – by transforming it in a monotonical gradient. To do so, we employed a psychophysical task to entirely map the attentional profile, deeming subjects to report the gap orientation of a “C” letter when appearing as a salient target (Baseline Condition) or as a non-salient probe (Probe Condition) at different distances from the salient target. Critically, target spatial probability was manipulated on both conditions to make it appear more frequently proximal to the probe (PD1 position), i.e., the distance generating the inhibitory shadow over the latter. Given the uncertain nature of the target stimulus – target (Baseline Condition) vs. distractor (Probe Condition) – we couldn't firmly speculate about the exact mechanism – distractor filtering (a) vs. attentional focus enlargement (b) – throughout which priority map may have plastically changed. However, eye-tracking methods may be employed to disentangle them. Indeed, based on the above hypotheses, we predict (a) an increment of probe's first saccadic landings – as compared to target PD1 ones – in the Probe Condition along with greater saccadic latencies toward target PD1 in the Baseline condition (b) and equal distribution of probe and target PD1's first saccadic landings in the Probe Condition along with unaltered saccadic latencies toward target PD1 in the Baseline Condition.

Analyzing Atoms of Confusion in Code using FRP*Anna-Maria Maurer**Saarland University, Germany*

Atoms of Confusion are small pieces of code empirically verified in behavioral and qualitative eye-tracking studies to cause misunderstandings in developers. We investigate whether this effect correlates to a cognitive process measurable using EEG, as it is known in linguistics that confusing words or sentence endings elicit a brain response compared to standard words or endings. Since code is normally read in its entirety, we present the code snippets as a unit and apply fixation related potentials: The onset for EEG averaging is the start of fixations near the areas of interest corresponding to the atom location. We contrast the results for confusing and purposefully clarified code to identify brain activation related to confusion. Additionally, we analyze the fixation count and duration inside the areas of interest.

Enhancing Intimate Communication in Dialogue Systems: Exploring Privacy-by-Design Mechanisms and Perceptual Impact through Eye-Tracking

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Background: Language naturalness in dialogue systems, like chatbots, is crucial for transferring social norms and communication patterns to artificial partners. A key aspect to explore is self-disclosure: people share more when other reciprocate personal sharing. The systems leverage this by using obtained information to personalize communication, incorporation frequently used words and creating user profiles. This strengthens bonds and trust, fostering more intimate dialogues. Moreover, the artificiality of the partner provides a sense of security, especially for sensitive topics. However, for intimate communication to thrive, users must feel safe. Thus, the EU AI Act plans the implementation of privacy-by-design mechanisms, safeguarding intimacy, and user autonomy (e.g., privacy right of withdrawal), but also reflect current and future law (e.g., labelling obligation of AI systems), to offer users more self-determination and sovereignty. Objective: Privacy-by-design mechanisms will be implemented into a dialogue system and will undergo testing to assess their impact on perceptions. This entails examining whether participants not only observe but comprehend and perceive the exchange of intimate data and the engagement with an artificial dialogue system during communication. Method Summary: Given the absence of specified labeling requirements for AI systems outlined in the AI Act, several privacy-by-design interventions will be tested. These interventions might include integrating pop-up messages to educate users, either before or during their interaction with the system. To conduct a comprehensive assessment of the visual attention levels directed

towards different pieces of information, eye tracking could be a promising methodological approach.

Deciphering Attentional Biases in Obsessive-Compulsive Disorder: An Eye-Tracking Study with Idiosyncratic Material

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Obsessive-Compulsive Disorder (OCD) is a prevalent psychological disorder characterised by obsessions and compulsions, which are idiosyncratic in nature and vary widely between individuals. Attentional biases are posited to be pivotal in OCD development and maintenance (Salkovskis & McGuire, 2003). However, previous research yielded inconsistent findings regarding vigilance (i.e., orienting response towards threat-related/OCD-relevant stimuli) and maintenance (i.e., difficulty engaging attention away from threat related/ OCD-relevant stimuli) biases in OCD. These inconsistencies may stem from methodological limitations, including implementation of unreliable paradigms like the dot-probe test and the use of generic OCD-related stimuli. To address these gaps, our study employs a free-viewing paradigm coupled with eye-tracking technology (EyeLink 1000) to improve reliability and capture real-time gaze patterns on pictures categorised as negative, neutral, or OCD-related. To assess the idiosyncratic valence and OCD relevance, participants rate each picture on these two categories, allowing analysis of attentional patterns specific to individual symptomatology. In addition to patients with OCD and healthy controls, we include a clinical control group with spider phobia, permitting examination of transdiagnostic specificity. Additionally, measures of attentional control and an acute stress induction are incorporated to test whether these factors moderate the relationship between attentional biases and OCD symptoms. This comprehensive approach promises insights into the nuanced interplay between attentional biases and OCD symptomatology, advancing our understanding of this complex disorder. As data collection is still

ongoing, the research design and/or preliminary results will be presented.

Gaze-SPV: Enhancing Prosthetic Vision for Object Recognition by including Gaze

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Restoring vision to the blind or visually impaired is a highly aspiring goal. Cortical prosthesis offers a promising avenue towards this, but one of the main challenges is to provide effective stimulation to the cortex via the visual prosthesis to enable performance of various tasks. In this study, we aim to enhance the functionality and the quality of the percepts generated by simulated prosthetic vision (SPV). We propose a novel approach to SPV that emphasizes the inclusion of gaze information into the stimulation in order to optimize object recognition performance. Incorporating gaze information is an essential step for future real-life applications. Our proposed method, Gaze-SPV, comprises four deep learning units: an Encoder, the Simulator, the Sighted Unit, and the Blind Unit. These units collaboratively capture stimuli, simulate cortical implant stimulation, and mimic human perception. Training consists of optimizing the Encoder and Blind Unit through perceptual loss and cross-entropy functions. Our results indicate that the stimulation patterns proposed by GAZE-SPV differ importantly from those generated by a system that does not include gaze information. The method is adaptable to include peripheral vision and is more meaningful for recognition of the surrounding environment. In a pilot study we have compared the SPV in healthy observers, leveraging eye-tracking technology to incorporate real-time gaze locations. The preliminary results suggest improved recognition performance with

Gaze-SPV derived stimulation patterns. We conclude that prosthetic vision focussed at object and scene recognition in real-world scenarios may be enhanced by integrating gaze information.

An AI based Classification of Eye Movements

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In this project we employ artificial intelligence (AI) to characterize eye movements and eye movement patterns across diverse datasets. By integrating supervised and un supervised approaches, our goal is to enhance the understanding of eye movement dynamic s and their impact on visual perception. The datasets include observations from lab based EyeLink setups, EyeSeeCam data from unconstrained environments, and recordings from both healthy individuals and patients, providing a comprehensive overview of oculomotor behavior under various conditions. The focus of the project is on identifying oculomotor patterns that could enrich our understanding also of visual perception and potentially offer insights into how these patterns deviate in the presence of neurological conditions. Overall, this study seeks to bridge gaps in our current knowledge by highlighting how eye movements can vary across different contexts and individuals.

Looking for reserve: What can the eye tell us about cognition in older adults?

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Throughout our lives, we master the action of searching, from looking for our caregivers as toddlers to finding our medication when we are old. Aging can affect episodic and working memory abilities (Park and Reuter-Lorenz, 2009) that are important for visual search (Wolfe, 2021). On the other hand, older adults can perform similarly to younger adults in hybrid search tasks when accounting for age-related slowing (Wiegand and Wolfe, 2020). Cognitive reserve (Stern, 2018) suggests that life experiences may protect against cognitive decline. This, combined with their task's demands, could explain part of Wiegand's and Wolfe's results (2020), as some searches are easier to perform than others. Reaction times are higher when people look for targets among distractors of the same category, as compared to distractors of other categories (Shang et al., 2024). To understand how older adults perform in these complex searches, we developed an online hybrid search task. Younger and older participants first learn 2 or 8 items of a given category then look for them among distractors belonging to the same or different categories. Pilot data show that, after accounting for age related slowing, older adults have higher reaction times in conditions when the memory load is high, and when the distractors are from the same category as the target in comparison to younger adults, suggesting impaired top-down inhibition of target-similar distractors. As a next step, we aim to implement eye-tracking in this hybrid search paradigm to unravel the mechanisms underlying age differences, and their relation to protective factors. Such insights could enhance our understanding of how cognitive reserve influences inhibition control and top-down guidance.

Can 'Meaning' Predict Task Dependence of Eye Movements?

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A central question in cognitive psychology is to identify the factors that influence eye movements in real-world scenes and develop models for predicting them. According to cognitive relevance theory, the meaning of a scene region is a central factor in attentional selection. While there have been efforts to find a quantitative measure of scene meaning, criticism has arisen due to the vague and context-free concept of 'meaning', resulting in challenges in establishing a ground truth for ecologically valid predictions. In ongoing work, we examine the recently made claim that meaning can be measured independently of the viewer's task. Since there is evidence that tasks can alter certain parameters of viewing behaviour, we expect that different tasks will require different types of image information and thus will also alter attentional selection. We aim to investigate the ability of meaning maps to predict viewing behaviour in different tasks. We asked participants ($n > 23$) to view 67 indoor scenes in five different tasks. We chose a variety of tasks with semantically different content, including judgments of emotion, style, cleanliness, and room features. Eye movements were recorded using an EyeLink 1000 Plus system. The data will be transformed into fixation density maps. For comparison, meaning maps will be created by means of crowd sourcing ratings. The results will be available in time for the poster presentation at the summer school.

Cognition in Depression (“CODE”-Study) – A pilot study of the cognitive mechanisms during an antisaccade task*Paulina Piwkowski**University of Bonn, Germany*

Major depressive disorder (MDD) is a widely distributed psychiatric disorder which is accompanied by several symptoms affecting cognitive, behavioral and functional capabilities. Especially cognitive deficits have been well documented in patients suffering from MDD. These comprise functions of executive control including top-down regulation, inhibition, shifting and updating. Impairments of these abilities are of high clinical relevance and have been found to be associated with emotional dysregulation, functional disability and the severity of residual symptoms. The Cognition in Depression (“CODE”) study aims to investigate the neural and behavioral alterations in depression patients addressing detailed analysis of the impairments in performance in cognitive tasks. Therefore, 50 depression patients and 50 healthy controls are planned to be invited to take part in fMRI and oculography based paradigms. The current precursor pilot study was implemented without fMRI in order to test the cognitive mechanisms of proactive and reactive control that are expected to be involved in the antisaccade task. Therefore, 20 psychological and physical healthy students were recruited to take part in the eye tracking experiment at the University of Bonn. The task involves the execution of prosaccades and antisaccades in response to different cueing and emotional stimuli (faces). We found significantly higher error rates and latencies for antisaccades compared to prosaccades, especially with incongruent cueing. These results contribute to an overall understanding of the mechanisms involved in proactive and reactive cognitive control in the antisaccade task and are used as a validation for the follow-up depression study which is currently running.

Lorazepam Effects on Eye Movements: fMRI Correlates

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Acting as a positive allosteric modulator of GABA_A receptors, benzodiazepines affect several parameters of saccadic control, including a reduction in saccadic peak velocity and an increase in saccadic latency. Using the advantages of oculography, the antisaccade task is a commonly used paradigm for exploring inhibition, also demonstrating impairments in various parameters due to benzodiazepines. While the neural network underlying saccades and antisaccades is well understood and includes mainly frontal, parietal, occipital and subcortical areas, the neural mechanisms mediating the effects of benzodiazepines on eye movements remain unknown. Additionally, there is limited understanding of the neurotransmitter systems underlying the fundamental perceptual motor and higher cognitive processes involved. To investigate these mechanisms, this study employs a double blind, placebo controlled, cross over design using 1mg lorazepam, a commonly prescribed benzodiazepine. A targeted sample size of 40 healthy participants will be invited to complete an antisaccade task, while BOLD data are collected using a 7T MRI scanner, and eye movement data are simultaneously recorded. On a behavioral level, we aim to replicate findings of increased antisaccade latency and error rate under lorazepam compared to placebo while analysis on a neural level remains explorative. The study is currently ongoing, and N=14 complete datasets have been collected so far. Preliminary results will be presented.

Personalized transcranial direct current stimulation targeting V5 modulates smooth pursuit initiation

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Introduction: Visual area V5 is a core region in the cortical network that maintains smooth pursuit eye movement (SPEM) initiation. SPEM initiation deficits are a robust biomarker for psychosis and are associated with functional changes in V5, e.g. during the so-called step-ramp task. Yet, the exact mechanisms connecting SPEM initiation deficits with functional modulation of V5 remain elusive. **Methods:** To assess SPEM-deficits due to a modulation of V5 in the healthy brain, N = 19 healthy participants completed an eye movement test battery while transcranial direct current stimulation (tDCS) was applied. To control inter-individual anatomical differences and functional variability of the stimulation target, the individual V5 of the right hemisphere was functionally localized (MRI, combined EEG/MEG) and tDCS montages were personalized based on finite-element simulations of the transcranial electric fields and algorithmic optimization. **Results:** Cathodal personalized tDCS targeting the right V5 induced a specific delay of SPEM latencies for ipsiversive step-ramps. These tDCS effects were observed only during the step-ramp task, sensitive to SPEM initiation, but neither during continuous SPEM, nor during anodal or sham tDCS. Furthermore, no tDCS effect on SPEM initiation was observed by application of normative tDCS over V5 or personalized tDCS targeting the right frontal eye field as a spatial control condition. **Conclusion:** Inhibitory personalized tDCS targeting V5 specifically delays SPEM latencies in healthy participants. Although SPEM latency modulation is not associated

with psychosis, delayed latencies were reported in Parkinson's disease and ageing. Furthermore, the presented method of personalized tDCS can be adapted for other research or clinical applications.

Head and scene orientation information influence the ocular motor system*Stephanie Reeves**University of California Berkeley, USA*

When exploring a visual scene, humans make more saccades in the horizontal direction than any other direction. This horizontal saccade bias is well documented despite its unknown origin. In a series of studies, we examined how the saccade direction bias is influenced by head orientation, scene orientation, and task. We found that saccade directions are modulated by the orientation of the head and that this influence depends on scene content. When the scenes viewed are more abstract, saccade directions are generated with respect to the head; while viewing a natural scene, however, saccade directions are generated somewhere in between the head and the scene orientation. We also found that the influence of scene orientation on saccade directions is amplitude dependent, such that the smallest saccades remain horizontal (with respect to the head) while larger saccades are flexibly reoriented and generated in line with the image. Lastly, we found that microsaccades, such as those made while attempting to fixate a dot, are the least flexible and seem strongly oriented to the head regardless of scene orientation. Taken together, our results suggest that there may be two types of saccade direction biases: one that is egocentric and mapped in head (or retinal) coordinates, and another that can be flexibly modified to reorient depending on the image properties at hand.

When to look: Deciphering saccade selection and timing in dynamic environments*Sundararaman Rengarajan**Northeastern University, USA*

Humans actively utilize gaze to interact with and comprehend their surroundings, with the timing of gaze behavior being crucial for responding swiftly and accurately to transient stimuli. This research investigates how individuals synchronize their gaze, specifically saccadic eye movements, with environmental rhythms, facilitating optimal attention allocation and efficient information processing in dynamic settings such as sports, video games, and social interactions. Our study introduces a novel paradigm where saccade targets are determined temporally rather than spatially, requiring participants to identify and fixate on targets appearing at specific frequencies amidst distractors. Utilizing eye-tracking technology, the task is made gaze contingent, allowing immediate recognition of correct target fixation. We aim to delineate how individuals learn to time their gaze, measuring target accuracy and fixation latency to explore the learning curve in gaze timing. Additionally, we will explore how saccades entrain to various visual rhythms, quantifying the temporal dynamics of saccadic synchronization through eye movement data combined with psychophysical measurements. This approach provides insights into the temporal aspects of perception and attention, contrasting with the more commonly studied spatial aspects of gaze deployment. Significantly, this research will extend to compare the gaze timing behavior of neurotypical individuals with those on the autism spectrum, who may exhibit distinct patterns in responding to dynamic stimuli and generating predictive responses. By understanding these temporal dynamics of gaze, we aim to contribute valuable knowledge to the fields of neuroscience and

psychology, enhancing our comprehension of human interaction with dynamic environments.

Effect of gender-fair writing on semantic access in French: an eye-tracking study

Jeanne Rousseau

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In gender-marked languages like French, the generic use of a masculine form for plurals creates a representation bias and leads to alternative gender-fair written practices, like the middle dot (e.g., étudiant-es, meaning students). Previous research has acknowledged social significance of gender-fair writing (Kim et al., 2023; Lindqvist et al. 2019), but few studies have explored its impact on reading comprehension (Gygax & Gestó, 2007; Vergoossen et al., 2020). Gender-fair writing practices may alter the morphological structure of words, which can affect lexical and semantic access during reading (Perfetti & Helder, 2022; Rousseau et al., 2024). We created a semantic decision task using polysemic words for French adults. Participants encounter a sentence containing a polysemantic word whose meaning can only be determined with the help of a target term. This target term necessarily designates a group of individuals (e.g., étudiant-es) and is presented in one of six tested writing forms (feminine/masculine only, iteration, middle dot, brackets, neutral form). To assess comprehension, each sentence is followed by a decision task where participants must select the coherent meaning of the polysemic term. Our aim is to establish whether morphological modifications resulting from gender-fairness affect comprehension. To this end, we will compare reaction times in semantic decision task, as well as fixation times and number of rereads of the target term (saccades) in the sentence across different writing forms. Results of this study are forthcoming and will be discussed in this poster, shedding light on the relationship between reading processes and gender-fair written practices.

Oculomotor control involved in motor skill learning

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Introduction: Implicit motor sequence learning represents a fundamental mechanism by which individuals acquire and refine motor skills without conscious awareness of having learned. This phenomenon underscores the intricate interplay between cognitive and motor systems. While extensive research has elucidated neural substrates and behavioural manifestations of implicit motor sequence learning, investigation of oculomotor behaviour is scarce. Assessment of oculomotor behaviour is valuable in our understanding of how the predictive process unfolds during implicit motor sequence learning. Objectives: In the current study, we investigated the effects implicit motor sequence learning on oculomotor control. Sequence practice was employed over multiple days to allow for assessment of long-term implicit processes underlying learning. We hypothesized that during implicit motor sequence learning using the arm for responses: 1) sequence learning occurs for saccades (as seen by reduced reaction time and increased frequency of predictive saccades), for repeated versus random sequence trials, and 2) implicit sequence learning change in oculomotor behaviour is related to learning related change in arm motor control. Methods & Statistical Analyses: 20 young healthy adults learned a novel motor skill employed using a KINARM robot with integrated eye-tracker. We recorded hand reaction time and saccade reaction time as well as frequency of predictive saccades as participants performed 500 reach trials over 3 consecutive days (20 min per session). Short-term memory of the repeated sequence was tested 24-hour after practice using a retention test. Paired t-tests tested the difference of mean reaction time between repeated and random trials at retention. Correlations tested the relationship

between magnitude of learning for saccades and reaches. Results: Participants made more predictive saccades at retention compared to baseline. Participants were faster to respond to repeated vs. random sequence trials at retention, demonstrating learning of the repeated sequence (mean difference = 6.32, 95% CI [2.04, 10.60], $t(15) = 3.15$, $p = 0.007$; Cohen's $d = 0.81$). Magnitude of learning for saccades was correlated to magnitude of learning for reaches ($r = 0.53$, 95% CI [0.03, 0.82], $t(13) = 2.27$, $p = 0.041$). Conclusions: Overall, these findings show that motor sequence learning occurred for saccades and reaches, and degree of sequence learning is related between oculomotor and manual motor systems.

Restorative potential of Intermediate Environments

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Background: The restorativeness potential of Intermediate Environments (IE) is the focus of this research. IE range from courtyards, arcades, balconies to window-seats, offering retreat to the interior and contact with the exterior. IE includes diverse controllable environmental conditions, adaptable sociability, shelter, and relaxation opportunities. Literature indicates that the restorative benefits of nature dominate Restorative Environments (RE) research, with fewer studies on built settings. With people spending 90% of their time indoors, and predominantly in cities, RE within buildings give opportunity to relieve stress, attention fatigue, and therefore warrants investigation. Methods and results to date: Drawing on insights from a pilot study, a mixed-method case-study approach is adopted. Pilot study findings indicate that views, daylight, and sociability were the main IE characteristics contributing towards restorativeness. Collected data includes participant surveys, semi-structured qualitative interviews, self-reporting, wearable biosensors and eye-tracking recordings, view and light, which is measured with wearable light dosimeters. Based upon the results from pilot studies, an online survey is proposed to investigate specific topics related to view and daylight. Originality of the contribution and next steps: Although similar methodology has been employed in RE research, these are novel methods in the context of IEs; results can demonstrate the value of such methods to inform subsequent IE research. Upon completion of the survey, a final experimental study is proposed to be conducted during different times of the day and sky types, where the effects of daylight variation on restorativeness can be further explored.

Investigating the Impact of Illumination Change on the Accuracy of Head-Mounted Eye Trackers. A Protocol and Initial Results

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Eye trackers have become more affordable and are now being used in real-world environments. However, real-world settings present challenges due to varying levels of illumination, which can affect the reliability of eye-tracking data. Until now, there has been limited research on the impact of lighting conditions on the accuracy of head-mounted eye trackers in real-world scenarios. To address this gap, we developed a protocol to evaluate the accuracy of eye-tracking data under three different illumination levels: Low (Dark), Moderate (Normal), and High (Bright). Using SMI Eye Tracking Glasses, we conducted experiments and found that the lighting level during calibration significantly influenced the accuracy of eye-tracking data. We observed variations of up to 1.15° between different conditions. The most precise gaze estimations were achieved when we calibrated the eye tracker at the same lighting level as the data recording. Our study also found that accuracy variations between fixation targets ranged from 1.77° to 4.05° , strongly influenced by the SMI glasses technology. These results highlight the importance of considering both the illumination conditions during calibration and during data recording, particularly in real-world environments where illumination levels vary. Overall, our study contributes to the limited body of systematic research on the influence of illumination conditions on the accuracy of head-mounted eye trackers in real-world scenarios.

Eye gaze patterns during encoding differentially predict memory accessibility and precision*Iryna Schommartz**Goethe-Universität Frankfurt, Germany*

Eye movements may be functional for formation, retrieval, and reconstruction of memory. Higher dwelling time is related to better memory in adults. Gaze fixations during encoding are related to functional activity in the hippocampus. However, it is unclear whether eye gaze patterns predict subsequent memory over different time delays and to what extent eye gaze patterns predict subsequent memory differentially in children and adults. With this purpose, we tested whether eye-gaze patterns during encoding predict memory performance in 6-to-11-year-old children ($n = 60$) and young adults ($n = 32$) over extended time delays. Our results showed that all eye gaze parameters significantly increased with age in child group and differed between age groups. Higher encoding dwelling time and exploratory eye gaze behavior was related to higher immediate memory accessibility in children. Higher encoding dwelling time was related to higher immediate memory accessibility in young adults. Furthermore, higher encoding dwelling time was related to better memory precision in children over time. Overall, our results showed that developmental changes in eye gaze patterns reflect age-related memory improvement in children.

Adaptive eye movements while playing a continuous interception game

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Justus Liebig University Giessen, Germany

Eye movements are often studied using artificial tasks under highly restricted and repeated conditions. Instead, we used we used a gamified interception task (Pong) and measured eye and head movements using a mobile eye tracker to study more natural behavior. During the game, participants had to hit a moving target (ball) by horizontally controlling a paddle on the lower part of the screen. Every time the automated opponent missed the ball, participants scored a point and vice versa. We tested whether eye, head, and hand movement frequencies were shaped with respect to their next action to potentially optimize interception performance. Additionally, we tested for adaptation of eye, hand, and head movements: i) after missing the target, ii) over time, and iii) with manipulations of paddle size and target speed. Indeed, participants timed their eye, hand, and head movements with respect to their next interception. Whilst they clustered blinks and saccades at times after their own or the opponent's action, they closely pursued the target shortly before intercepting themselves. After misses, participants moved their head more frequently. After long exposure, they pursued the opponent more often. Better game performance correlated with more pursuit eye movements and fewer head movements shortly before intercepting. Together, these results indicate adaptation of eye, head, and hand movements on several levels. Most importantly, eye and head movements were adapted with respect to the next action and this general distribution was stable across all tested levels of adaptation.

Exploring Attention Shifts and Fixation Durations in Media Multitasking: An Eye Tracking Investigation of Varying Task Priorities

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This study investigates the nuanced dynamics of attention allocation within the domain of media multitasking through the lens of eye-tracking technology. Specifically, the research aims to discern whether eye-tracking methodologies can effectively unveil observable shifts in attention and fixation duration corresponding to the manipulation of task priorities during multitasking scenarios. The central question under examination involves the impact of varying task priorities—defined as high (indicative of a prioritized task over another) and low (representing equal priority)—on the visual attentional patterns exhibited by individuals engaged in media multitasking. The study employs a controlled experimental design presenting participants with multimedia tasks requiring concurrent attention. Eye-tracking devices capture and analyze gaze behavior, tracking saccades, fixations, and dwell times during the engagement with tasks of differing priorities. By manipulating task priorities within the multitasking context, the research aims to discern distinctive gaze patterns associated with the allocation of attention between high and low-priority tasks. The anticipated findings seek to elucidate whether individuals demonstrate observable shifts in attention, as manifested through alterations in fixation duration and gaze patterns, in response to the manipulation of task priorities. Insights derived from this investigation hold significant implications for understanding how individuals manage attentional resources during multitasking, shedding light on the role of prioritization in shaping visual attention distribution in complex media environments. Ultimately, this study contributes to a deeper comprehension of attentional mechanisms and multitasking

behaviors, leveraging eye tracking as a pivotal tool in unraveling the subtleties of cognitive processes involved in media engagement.

Eye movement-related eardrum oscillations induced by auditory-guided saccades in different modalities of sound presentation

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The human brain perceives spatial localization based on information provided by different sensory inputs. These senses, like hearing and vision, may already interact in peripheral structures of the nervous system. That can be observed in Eye movement-related eardrum oscillations (EMREOs), low-frequency displacements of the tympanic membrane induced by saccadic eye movements. EMREOs are known to scale in a parametric manner with the amplitude and direction of visually-guided saccades. We have also shown that EMREOs emerge regardless of the sensory modality in which saccades targets are shown. We here ask whether the EMREOs are robust to whether acoustic targets are presented free-field or via headphones. To this end we compared the EMREOs induced by visual targets presented on a screen, auditory targets presented via a loudspeaker array or through in-ear earphones. Recordings of eardrums oscillations proceeded via in-ear microphones, while eye movements were recorded using infrared eye tracking. The results suggest that as well sensory modality of saccadic targets do not affect the amplitude and direction shown in EMREOs as, regarding auditory-guided saccades, different sound presentation modalities also keep similarities. That strengthens the notion that EMREOs are more linked to motor planning or execution than sensory signals.

Interaction of attentional and learning processes during fear acquisition and extinction*Ebru Ecem Tavacioglu**Julius-Maximilians-University Würzburg, Germany*

Threat cues are capable of quickly capturing and holding visual attention. It is however unclear to what degree this bias reflects threat properties or is related to the prediction of reliable outcomes. Furthermore, the process of attentional exploration is shaped by learning, which presumably drives orienting towards more accurate predictors of an event. To explore the impact of fear acquisition and extinction on attentional and learning processes, we created a novel multiple-cue paradigm. First, single visual cues (threat, safety, and ambiguous), that varied in their predictiveness for an aversive electrocutaneous stimulus, were sequentially presented to participants in single-cue displays. In randomly interspersed multiple-cue displays, ambiguous cues were presented together with either threat or safety cues to investigate whether attentional exploration is biased towards the predictive components of the display or driven by the threat value. To investigate the readjustment of expectations, cue-outcome associations were switched in the second half of the experiment (reversal learning). In addition to measures of visual exploration, we acquired trialwise shock expectancy ratings and autonomic data to examine the contribution of attentional processes to aversive learning. In addition to classical inferential statistics, we will also use reinforcement learning models to describe the current data and to analyze whether eye movements are primarily modulated by threat value, outcome predictability or a combination of these aspects.

Non-invasive modulation of post-stroke hemianopia with transcranial Alternating Current Stimulation (tACS)

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Homonymous lateral hemianopia (HLH) is a visual deficit following retro-chiasmal lesions in which conventional visual rehabilitation has shown poor effectiveness. We here present an interim analysis of a pre-clinical randomized cross-over double-blind trial 'HEMIANOTACS', assessing the use of Transcranial Alternating Current Stimulation (tACS) to boost visual perception in patients with HLH after an unilateral stroke. In a cohort of n=10 HLH patients, we assessed effect of 3 tACS conditions, (1)right hemisphere frontal 30Hz tACS on the frontal eye field (FEF), (2)contra-lesional occipito-parietal 10Hz tACS on the intraparietal sulcus (IPS) and (3)sham tACS, tested in 3 independent sessions a week apart. A cohort of matched healthy participants were characterized in parallel for control purposes. After a neurological, anatomical, and neurophysiological baseline characterization, tACS effect was assessed using a kinetic (binocular) and static (monocular) visual field perimetry test prior and after 20minutes of tACS. Statistical group analyses failed thus far to show significant effects of tACS for any of the 3 conditions tested on the 'seen' visual field surface. Nonetheless, individual response patterns suggest increases in surface of the 'seen' field for active tACS compared to the sham condition. Gray and white matter structural MRI assessments showed lesion patterns of the included patients encompassing the superior, middle and inferior occipital

gyri, as well as the optic radiations (OR), the inferior fronto-occipital fasciculus (IFOF) and the inferior longitudinal fasciculus (ILF). Microstructural analyses of the OR revealed lower fractional anisotropy (FA) in hemianopia patients compared to matched healthy controls. At the current stage, our interim analysis attests a large heterogeneity of lesion patterns, spared visual field surface and also the modulatory impact of single tACS active sessions, suggesting a need for treatment customization. The recruitment of further patients allowing reliable cluster assessments of lesion patterns and modulatory effects of HLH will be necessary.

How does the interplay between conjunctive and elemental context representation guide avoidance behavior?*Francesco Tortora**Julius-Maximilians-University of Würzburg, Germany*

Modulating one's behavior according to the environmental information is crucial for survival. The absence of behavioral flexibility underlies the development and maintenance of different psychopathologies, such as anxiety disorders. Animal research supports the importance of the interplay between an elemental and a conjunctive context representation (dual-process theory) in guiding behavior. Notwithstanding the research efforts in this field, it remains unclear how these representations interact to regulate human behavior. To address this issue, healthy participants were subjected to a virtual reality cue-in-context conditioning paradigm divided into three stages. During the first phase (context encoding), participants were invited to actively explore three virtual offices (CXT A, CXT B, CXT C) two minutes each. The contexts were completely different from each other except for two stimuli (two lamps: one yellow and one blue). During the second phase (threat conditioning), participants visited two of the three offices alternately multiple times. In one office, one lamp (e.g., the yellow one) was associated with an unconditioned stimulus (US) while the blue one was not. In the other office, contingencies were reversed. Then, in the behavioral test (third phase), participants actively explored again all the virtual contexts. The gaze behavior, movement trajectories and autonomic responses were recorded along the experiment. We hypothesize to detect the dual contribution of conjunctive and elemental representations during learning construction both behaviorally and physiologically. Notably, we expect an opposite behavioral dissociation in the third phase that would result in an

inverse pattern of threat cue avoidance driven by contextual information.

Eyetracking Enabled Activity Based Adaptive Assistance

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At the ESSEM 2024, I want to present our novel approach to determining the task context of pilots in a multitasking environment. Serial multitasking in pilot supervisory tasks of automated mission systems is characterized by fast switching of attention between task-relevant information. This leads to a highly fragmented pattern of gaze interaction data and makes real-time activity recognition agents challenging to develop. In our recent recognition method, we concatenate observed gaze interactions over time to infer the pilot activity. This reflects the continuous nature of task switching and results in a more meaningful representation of the task context of pilots. Methodologically, we treat tasks from a hierarchical task model as hidden states (e.g. as in Hidden-Markov-Models) that share sequential and hierarchical dependencies. For the inference of the states, we use linear-chain Condition Random Fields (CRFs) which are common classification methods for sequential data. Classification is accomplished in real time by building a series of feature vectors from pilot interactions. The poster will include the motivation of adaptive assistance and background, the conceptual de-sign of the activity recognition agent, and our recent experiments with fighter pilots to validate the model. Our application is the management of a small team of unmanned aerial vehicles from the cockpit of a fast fighter jet. The pilot activity will be used as the basis for real-time workload estimation and task-sensitive adaptive assistance.

Novel approach to assess amblyopia during naturalistic tasks through eye movement analysis

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Amblyopia affects up to 2-4% of the population and is characterized by a usually unilateral loss of vision due to abnormal visual development in early childhood. While decreased visual acuity is its clinical hallmark, other visuospatial functions such as contrast sensitivity, stereopsis, and ocular movements are also compromised. In search for a proper assessment of amblyopia, these dysfunctions are gaining increasing significance, as some of them can be measured objectively, such as eye movements. Conventional oculomotor studies in amblyopia are typically conducted in controlled laboratory settings using remote eye-trackers and presenting visual stimuli on a monitor. So far, no studies measuring objectively eye movements in amblyopia while patients are performing tasks that resemble everyday life activities have been published. For this reason, this project takes a pioneering approach by investigating how the oculomotor deficits of amblyopia manifest in real-world functional activities, offering a more ecologically valid assessment of their visual function. Initially, a protocol for assessing oculomotor performance during the execution of naturalistic tasks was developed and validated. This study aimed to establish the methodology required to accurately measure eye movements in real-world settings using the portable Pupil Core (Pupil Labs) eye-tracker. We identified tasks that mimic daily activities and involve visual functions that are affected in amblyopia, ranging from free movement explorations to eye-hand coordination, and determined the optimal procedure to ensure reliable data collection. Afterwards, the developed protocol was implemented in children with amblyopia and their oculomotor behaviour was compared to that of typically developing children.

Exploring a Novel Hand-Motor Biomarker Across the Dementia Continuum: Integration and Validation in a Cognitive Clinic

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INTRODUCTION: We need accessible tests to aid discrimination of Subjective Cognitive Decline (SCD), Mild Cognitive Impairment (MCI) and dementia. Evidence suggests hand motor function declines in MCI and dementia but it has rarely been evaluated, and never in SCD. We evaluated keyboard tapping tests for discriminating cognitive groups and cognitively healthy controls (HC). **METHODS:** 212 participants (69.0 ± 9.3 years old) with consensus diagnosis of SCD, MCI or dementia, or HC were recruited and completed a 60-second key-tapping test. Regression models, which adjusted for age and sex, included motor features and were compared to null models containing only age and sex using area under ROC curves (AUC). **RESULTS:** Hand tapping motor data improved the classification of individuals with dementia (AUC = 0.89, 95% CI = [0.84, 0.95], $p=0.025$), MCI (AUC = 0.8, 95% CI = [0.73, 0.87], $p=0.002$), and SCD (AUC = 0.75, 95% CI = [0.63, 0.86], $p = 0.004$) compared to cognitively healthy controls. Additionally, motor features aided in distinguishing dementia (AUC = 0.9, 95% CI = [0.84, 0.97], $p = 0.024$) and MCI (AUC = 0.79, 95% CI = [0.67, 0.91], $p = 0.022$) from SCD, though not dementia from MCI ($p = 0.221$). **DISCUSSION:** Motor tests aid stratification of diagnostic cognitive groups. This provides a rapid accessible method to stratification in cognitive clinics. The next step will be to examine eye movements in this cohort to extend our knowledge of motor function in people across the dementia continuum.

Temporal predictions dynamically modulate attentional capture by expected target features during visual search

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During visual search, our attention is guided towards target-like features. This has traditionally been studied using static tasks. However, previous work has highlighted the importance of temporal predictions for guiding attention in dynamic settings. Consider searching for two distinct targets in a dynamic scene where each target has predictable timing. Here, selectively guiding attention towards features of the temporally-anticipated target is more efficient than continuously attending to features of both targets equally. However, it remains unclear if we can exploit temporal regularities to modulate feature-based attention. We investigated this using a novel dynamic visual-search task where participants searched continuously evolving displays for two transiently appearing targets amongst distractors. Stimuli were colour-shape combinations, with the targets sharing neither shape nor colour. Critically, each target most-likely appeared early (early target) or late (late target) during trials. Participants were significantly faster to identify temporally-expected targets than temporally-unexpected targets, consistent with having used temporal predictions. Further aspects of our design allowed us to use continuous eye-tracking measures to investigate if and how these predictions shifted feature-based attention across time. Specifically, distractors could appear at any time during trials and shared their colour with either the early target, the late target, or neither. During target-absent trials, participants were significantly more likely to fixate distractors of early-target colour than late-target colour when distractors appeared early, suggesting these distractors initially captured greatest attention. The opposite was true for distractors that

appeared late. This work therefore provides initial evidence for temporal predictions dynamically modulating feature-based attention during search.

Eye tracking for autobiographical memory detection

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Autobiographical memory refers to our ability to recall personally experienced events. It plays a crucial role in criminal trials, where detecting such memories is essential. Eye movement monitoring has emerged as a valuable tool for probing autobiographical memory. One avenue is studying eye movements to identify recognition of past events, scenes, or faces. Eye movements have shown superiority over traditional behavioral memory detection methods, such as the autobiographical Implicit Association Test or Concealed Information Test. This advantage persists even when participants attempt to conceal their memories by learning an alibi in a mock crime experiment. Furthermore, eye-tracking holds promise as a covert memory detection technique when combined with standard tests. A notable benefit of eye-tracking is its applicability to less structured tasks, like free-viewing. Unlike standard behavioral tests, eye movement analysis doesn't rely on the subject's adherence to specific task instructions, making it more versatile and requiring less compliance. I will outline the findings of three experiments exploring the utilization of eye movements in discerning recognition of autobiographical memories, employing both verbal and visual stimuli.