



# Forum Annuel de GDR Vision

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# Table of Contents

<b>Oral Session 1: Vision in Real-World and Ecological Conditions</b>	<b>5</b>
Do lighting conditions impact mental workload while driving?, Lara Désiré [et al.] . . . . .	6
Applying Principles of Sensorimotor Learning to Robot Assisted Surgery, Uma Navare [et al.] . . . . .	8
Central visual information improves peripheral scene visibility, Clara Carrez-Corral [et al.] . . . . .	10
<b>Oral Session 2: Oculomotor Behaviour</b>	<b>12</b>
Motion Direction Representations in Fixational Eye Movements, Mert Can [et al.] . . . . .	13
Hierarchical Classification of Eye Movements using Ensemble and Deep Learning with Multi-Label Vergence Detection, Hanae Hammani [et al.] . . . . .	14
<b>Oral Session 3: Quantity &amp; Numerosity</b>	<b>16</b>
Perception of quantity is modulated by segmentation for line stimuli, Arash Sahraie [et al.] . . . . .	17
Redundancy masking underlies underestimation and the radial-tangential anisotropy in numerosity perception, Li L-Miao [et al.] . . . . .	18
Feature enhancement in peripheral vision explained by redundancy masking, density perception and the compression of visual space, Bilge Sayim [et al.] . . . . .	20
<b>Oral Session 4: Multimodal Approaches for Exploring Vision</b>	<b>22</b>
Testing the quantum nature of color perception through hue cancelation experiments, Edoardo Provenzi . . . . .	23

Cortical Traveling Waves in Visual Search: a TMS-EEG study, Yue Kong [et al.] . . . . .	25
<b>Oral Session 5: Perception of Faces</b>	<b>27</b>
Preserved Human Face Categorization in Temporal Lobe Epilepsy revealed by periodic visual stimulation and electroencephalography, Maroua Melki [et al.] . . . . .	28
Human face categorization is radially-biased: Fast periodic visual stimulation evidence, Marius Grandjean [et al.]	30
Horizontal image compression significantly impairs human face identity recognition, Alexandros Venetis [et al.] . . .	32
Is the Other-”Race” Effect Really About ”race”? Evidence Supporting a Familiarity- and Cognitive Capacities-Based Account, Quentin Sénant [et al.] . . . . .	33
Pupil responses in rest and reactivity paradigms, Vivien Rabadan [et al.] . . . . .	35
<b>Posters</b>	<b>37</b>
<i>Poster 1: An Active Inference Modelling of Visual Exploration and Decision Making in a Football Task, Guillaume Hacques [et al.] . . . . .</i>	<i>38</i>
<i>Poster 2: Crossing a moving gap: how the visual dynamic of the gap affects pedestrian approach speed?, Martin Bossard [et al.] . . . . .</i>	<i>40</i>
<i>Poster 3: A novel method combining motion capture, eye tracking and 3D modeling to characterize human visuospatial behavior in complex real environments., Youri Marquise [et al.] . . . . .</i>	<i>42</i>
<i>Poster 4: Visual history shapes perceptual choice and smooth pursuit during ambiguous 3D motion, Liubov Ardasheva [et al.] . . . . .</i>	<i>44</i>
<i>Poster 5: Does Working Memory Load Dictate Foraging Strategy?, Maha Haggouch [et al.] . . . . .</i>	<i>45</i>
<i>Poster 6: Investigating the learning of statistical regularities during visual foraging, Ali Batikh [et al.] . . . . .</i>	<i>47</i>
<i>Poster 7: A Model of Rhythmic Visual Attention, André Zarza Tapia [et al.] . . . . .</i>	<i>49</i>
<i>Poster 8: Links Between Eye Movements and the Updating of Ensemble Representations, Thomas Chaptal [et al.]</i>	<i>51</i>

<i>Poster 9: Dissociable Internal Models for Perceptual Decisions and Eye Movements, Saleha Siddiqui [et al.] . . . .</i>	53
<i>Poster 10: Peripheral scene context modulates the temporal dynamics of saccadic choice, Eva Aprile [et al.] . . . .</i>	55
<i>Poster 11: Timing pre-saccadic attention : Temporal dynamics of the Size-Eccentricity Effect’s compensation, Jad Laaboudi [et al.] . . . . .</i>	57
<i>Poster 12: On the missing link between perceptual decision-making and saccade initiation, Vanessa Carneiro Morita [et al.] . . . . .</i>	59
<i>Poster 13: Sensory attenuation of auditory pitch: reduced perceptual sensitivity of tones triggered by keypresses, but not by ocular saccades, Lilian Nguyen [et al.] . . . . .</i>	61
<i>Poster 14: Predictable Vertical Eye Movements in Binaural Monopolar Galvanic Vestibular Stimulation, Alba Langlade [et al.] . . . . .</i>	63
<i>Poster 16: Central–peripheral interactions in scene recognition across the adult lifespan, Pauline Olivier [et al.] . . . . .</i>	67
<i>Poster 17: Disentangling redundancy masking and visual resolution in foveal vision, Y. Emre Turkmen [et al.] . . . . .</i>	69
<i>Poster 18: Does flow-parsing play a role in Time-To-Contact estimation?, Loïc Chomienne [et al.] . . . . .</i>	71
<i>Poster 19: Perceived time of visual events is affected by spatiotemporal grouping, Ljubica Jovanovic [et al.] . . . . .</i>	73
<i>Poster 20: Effect of flash presentations on brightness induction, Frédéric Devinck . . . . .</i>	75
<i>Poster 21: Effect of orientation on accumulative size for line stimuli, Milo Toumine . . . . .</i>	77
<i>Poster 22: A Comparative Analysis of Methods of Confidence Reporting, Elaine Casey [et al.] . . . . .</i>	78
<i>Poster 23: The neural basis of the general metacognitive mechanism, Tarryn Balsdon [et al.] . . . . .</i>	80
<i>Poster 24: Visual acuity thresholds for human face identity recognition, Nathan Hupin [et al.] . . . . .</i>	81
<i>Poster 25: Orientation Tuning for Faces Reflects Sensitivity to Natural Face Statistics Across the Ventral Visual Cortex, Mrittika Dey [et al.] . . . . .</i>	83
<i>Poster 26: Temporal dynamics of face perception, Dina Dagher [et al.] . . . . .</i>	85

*Poster 27: Ocular exploration of social scenes in ADHD children, Claire Wardak [et al.] . . . . . 87*

# Oral Session 1



## Vision in Real-World and Ecological Conditions

# Do lighting conditions impact mental workload while driving?

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The conditions of visual perception have an impact on driving. This research explores the hypothesis that, beyond purely visual effects (visibility, salience, etc.), the impact of lighting conditions could be mediated by mental workload.

To this end, a within-subjects driving simulator study was conducted with three experimental conditions simulating daytime, and nighttime with and without glare. The two nighttime conditions were visually simulated, but the trials were conducted during the day, allowing control over chronobiological aspects and ensuring that the measured effects were indeed linked to the visual environment.

Twenty-two participants drove on a road comprising different sections that varied in driving complexity and speed limit. Driving performance was measured via speed whereas mental workload was evaluated via several complementary measures: (1) subjective indicators, using the NASA-TLX questionnaire to evaluate task demands and perceived effort, (2) performance to a secondary task (Detection-Response Task, DRT) to measure cognitive load, (3) physiological indicators, including blink rate and cardiac activity measurements to assess general arousal.

Analyses were conducted with lighting conditions and road section as fixed effects, and participants as random effects (repeated measures). Mental workload was estimated using the 6 dimensions of the NASA-TLX questionnaire, secondary task response time (DRT), blink rate and heart period.

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Different effects of lighting conditions were found:

- No effect on speed, but an interaction between road section and lighting conditions, with post-hoc analyses showing effects on two particular sections (arrival at a roundabout and rural section with bends).
- An effect on one of the six dimensions of the NASA-TLX questionnaire - mental demand - with higher mental demand in glare conditions compared to daytime driving.
- A complex effect of lighting conditions on the secondary task response time; the main result is a higher response time in the glare condition compared to the night condition.
- An effect on the blink rate (higher during the day), but this variable is debatable here as a measure of mental workload since lighting conditions can have a direct effect on blinking.
- A complex effect of lighting conditions on heart period; the main result is a lower heart period, and so a higher heart rate in the glare condition compared to daytime driving.

In conclusion, lighting conditions do seem to have an impact on mental workload in driving, but not in all situations (particularly regarding the complexity of driving) and not in the same way depending on the different measures of mental workload.

**Keywords:** charge mentale, éclairage, éblouissement, conduite automobile

# Applying Principles of Sensorimotor Learning to Robot Assisted Surgery

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During robot-assisted minimally invasive surgery (RAMIS), surgeons remotely control robotic arms, which are equipped with surgical instruments and an endoscopic camera. Surgeons are seated at a master console from where they use so-called master manipulators to teleoperate the robotic arms and attached surgical instruments. Thus, RAMIS requires surgeons to learn and execute complex and challenging sensorimotor behaviors and involves a number of unique sensorimotor challenges. However, understanding of surgeons' sensorimotor behavior during RAMIS remains incomplete. In this work, we focused specifically on sensorimotor learning, aiming to gain a better understanding of the visuo-motor mechanisms at play during learning in RAMIS contexts. We designed and piloted a tool-to-target reaching task, presented on-screen in a virtual 3-dimensional environment. During the task, participants controlled an on-screen tool via a physical stylus-like tool. Thus, the task was designed to minimally simulate a RAMIS-like setting. We measured participants' performance, hand-motion based behavior, and their gaze behavior via eye-tracking, as they completed the task. Results showed that participants' performance improved with practice in the task. This was indexed by decreased reaction and trial completion times, as well as a decreased tool path length over the course of the task, and increased tool velocity. Furthermore, analysis of participants' gaze behaviors suggested that increasing familiarity with the task, and the associated performance gains, were accompanied by a shift in participants' gaze strategy over the course of the task. Specifically, in early trials participants seemed to follow the tool with their gaze via smooth pursuits to a greater extent. As participants progressed through the task, they made fewer smooth pursuits and

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instead seemed to shift their gaze between the tool and target, increasingly fixating on the target. Finally, in later trials, participants seemed to shift their gaze directly to the target at the start of the trial, without tracking the tool, thus making fewer longer fixations in late trials. In support of this, the results showed that the total duration of smooth pursuits decreased over the course of the task (mean smooth pursuit duration (seconds) in the first 10 trials =  $1.21 \pm 2.90$ , mean smooth pursuit duration in the middle 10 trials =  $0.80 \pm 1.35$ , mean smooth pursuit duration in the last 10 trials =  $0.74 \pm 1.37$ ). Concurrently, fixation duration (seconds) decreased initially, before increasing slightly (mean fixation duration in first 10 trials =  $1.77 \pm 0.93$ , mean fixation duration middle 10 trials =  $1.29 \pm 0.63$ , mean fixation duration in the last 10 trials =  $1.36 \pm 0.90$ ). Overall, this work provides preliminary insights into the visuo-motor processes that support learning, as well as indications of potential gaze-based metrics that could be used to assess skill learning, in RAMIS contexts and possibly beyond.

**Keywords:** Hand, eye coordination, Sensorimotor learning, Robot Assisted Surgery

# Central visual information improves peripheral scene visibility

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Past behavioural studies showed that information from an object in a scene could affect the subjective appearance of its scene-context. In these studies, blurred scene-contexts that contained a meaningful intact object were subjectively perceived as sharper than an objectively identical scene-context containing meaningless information (Carrez-Corral et al., 2025). These findings suggest that information from an object can enhance the subjective perception of scene context, especially when the visual signal is noisy. Given that scene context is usually perceived in the peripheral visual field while objects are processed in central vision, this raises the question of whether information from central vision can enhance perception in the periphery. However, these studies used small images of scenes as stimuli and did not control for the central vs. peripheral presentation of objects and scene contexts. The present study aimed to address this question. Participants ( $n = 29$ ) were presented with stimuli composed of a peripheral ring revealing a scene embedded in 1/f noise at various scene-to-noise ratios and a central disk containing either an intact congruent scene, an incongruent scene or a phase-scrambled scene. Each participant performed two sessions. In the DetectScene session, they were instructed to maintain fixation at the center but attend to the peripheral ring and they had to report whether they perceived a scene

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\*Speaker

within noise in the peripheral ring. In the DetectNoise session, they had to report whether they perceived the presence of noise within the scene in the peripheral ring. In both sessions, the scene-to-noise ratio was adapted trial-by-trial using a staircase procedure (starting with 100% noise in the DetectScene session and 0% noise in the DetectNoise session). These two sessions respectively allowed us to obtain scene and noise detection thresholds, providing complementary measures of scene visibility. Results showed that meaningful central visual information (i.e., congruent or incongruent) facilitates peripheral scene detection in noise and also helps to better resist to noise in scene, relative to meaningless information (i.e., phase-scrambled). We also observed that congruent central information further improves scene visibility in peripheral vision relative to incongruent information. We interpret these findings in the context of predictive processing theories whereby predictions based on information extracted from central vision enhance perception of degraded congruent information in peripheral vision.

**Keywords:** Scene perception, Central vision, Peripheral vision, Psychophysics

# Oral Session 2



# Oculomotor Behaviour

# Motion Direction Representations in Fixational Eye Movements

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Eye movements occur even during fixation. Tremors, drifts, and microsaccades less than a visual degree of angle occur while participants look at a stable visual stimulus and are referred to as fixational eye movements. Recent findings show that these movements are shifted towards stimulus orientation, suggesting that fixational eye movements may reflect stimulus processing. In the current study, we replicated these findings with motion direction. We presented participants with a random dot kinematogram for 500 ms, and they waited 2000 ms before matching the remembered motion direction on a continuous scale. The stimulus could move in 16 equally spaced directions. We measured eye movements throughout the entire trial and analyzed their representational geometry. The results showed distinct fixational eye movement patterns for each stimulus direction, which started with stimulus onset and were maintained throughout response delay, suggesting the maintenance of stimulus information in working memory. Fixational eye movements were again distinctly directed just before the response, showing the reactivation of stimulus information in preparation for the response. These results provide an exciting opportunity to measure mental representations at high temporal resolutions and at a low cost. We are further investigating if and how stimulus representations across trials interact and lead to attractive and repulsive history effects in eye movements and perception.

**Keywords:** fixational eye movements, mental representations, microsaccades, visual working memory, history effects

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\*Speaker

# Hierarchical Classification of Eye Movements using Ensemble and Deep Learning with Multi-Label Vergence Detection

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Accurate eye movement classification is essential for understanding gaze control and its relationships with visual and cognitive processes. However, existing approaches present critical limitations: threshold-based algorithms require manual parameter tuning, deep learning models struggle with small imbalanced datasets, and ensemble classifiers produce physiologically implausible temporal sequences. The challenge is particularly acute when introducing microsaccade detection, which constitute only 1 to 2% of fixation samples, and vergence movements that co-occur with conjugate movements, necessitating multi-label classification.

We propose a hierarchical two-stage architecture that addresses these limitations. The first stage performs multi-label classification of primary eye movements (fixations, saccades, smooth pursuits, blinks, vergence) by combining an ensemble classifier (EMCCF) with Hidden Markov Models to enforce physiologically plausible sequences. To enable vergence detection, we extended EMCCF to multi-label predictions, enriching standard input features (gaze position, velocity, direction) with binocular vergence descriptors including vergence angle and temporal velocity. The second stage focuses on microsaccade detection within fixations identified by the first stage, employing hard negative mining to handle class imbalance. Classification is performed using Residual Networks optimized for time series data. We validated our framework on surgical eye tracking data obtained on a da Vinci XI surgical robot during training tasks. Leave-one-subject-out cross-validation ensured robust generalization to unseen participants.

By successfully detecting both vergence and microsaccades alongside primary conjugate movements, our framework represents a significant step toward a generalized classification model capable of identifying most eye

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\*Speaker

movement types present across diverse research contexts. Experimental results demonstrate substantial improvements over state-of-the-art methods, establishing practical feasibility for different research fields including cognitive load and fatigue assessment, 3D display research, and surgical robotics where depth perception and binocular coordination appear critical for surgical performance.

# Oral Session 3



## Quantity & Numerosity

# Perception of quantity is modulated by segmentation for line stimuli

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The question addressed at the foundation of the field of psychophysics was to determine the difference in magnitude of a test stimulus and that of a reference, needed for them to be reliably differentiated. Classical studies also demonstrated that the same physical attributes could lead to different perception of magnitude depending on the context. That is, perception of size as a psychological process is susceptible to modulation by configural factors as demonstrated by Müller-Lyer, Ebbinghaus and Ponzo illusions, where two physically identical stimuli may be perceived different in size. Here we provide psychophysical evidence across multiple experiments, for a reduction in perceived size, when comparing the size of an intact line with the combined size of multiple line segments. Larger number of fragments leads to larger reduction in perceived size such that a line object fragmented to 10 pieces is perceived to be less than half of the size of the intact line. The findings persist, irrespective of stimulus duration, and are not as a result of a stimulus bias. We have also shown that the findings from computer based studies extend to real objects. The implications of this perceptual underestimation will be discussed in relations to activities of daily life.

**Keywords:** size perception, magnitude estimation, length perception

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\*Speaker

# Redundancy masking underlies underestimation and the radial-tangential anisotropy in numerosity perception

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People can estimate the number of items in a scene without counting, a capacity known as numerosity perception. A central debate in this field centers on whether the visual system can directly extract numerosity from the visual input, i.e., whether a "number sense" exists. This debate is informed by several consistent characteristics of numerosity perception. One characteristic is a general tendency toward underestimation, with observers typically reporting fewer items than are presented. Another characteristic is its radial-tangential anisotropy: items predominantly arranged radially are perceived as less numerous compared to items predominantly arranged tangentially. Redundancy masking (RM) is the reduction of the number of reported items in repeating patterns, and has been proposed as a mechanism underlying both underestimation and anisotropy. However, a direct link between RM and numerosity perception in the typical estimation range has not been established.

We generated radial and tangential arrangements by placing discs within an angular region extending from fixation, with the opening angle determining numerosity. Five reference numerosities (9, 13, 18, 24, 30) with probes at  $\pm 1-4$  were tested. Discs formed local triplets arranged radially or tangentially, with slightly larger spacing to the remaining discs. Each local triplet reproduced a classical RM stimulus, and larger numerosities were constructed from multiple triplets. A small-numerosity range condition (3, 4, 5) with  $\pm 1$  probes was also tested, using perfectly radially and tangentially arranged triplets, identical to classical RM stimuli. On each trial, a radial and a tangential arrangement were presented to the

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left and right of fixation, with one serving as the reference and the other as the probe. Participants judged which side was more numerous. For the small-numerosity range (typical RM range), radial arrangements were perceived as less numerous than tangential arrangements. The same pattern was observed for large numerosities: psychometric functions were consistently shifted toward underestimation for radial arrangements. These results suggest that the radial-tangential anisotropy generalizes from small to larger numerosities. The systematic anisotropy (relative underestimation in radial arrangements) with as few as three items suggests that fundamental constraints in spatial vision can shape perceived numerosity. While a dedicated number-sense mechanism may contribute, RM is likely the dominant process underlying both underestimation and radial-tangential anisotropy in numerosity perception.

**Keywords:** numerosity

# Feature enhancement in peripheral vision explained by redundancy masking, density perception and the compression of visual space

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In redundancy masking (RM), the number of items in repeating patterns is systematically underreported. For example, three identical peripheral items are often perceived as two. RM is linked to radial spatial compression, in which the perceived radial extent of stimuli is reduced, and to increased item-to-item spacing, where the perceived distance between items is increased. Here, we hypothesized that RM enhances feature discrimination of the items that are perceived when RM occurs. Across two experiments, we presented arrays of 3–5 identical bars arranged radially with uniform spacing, randomly to the left or right of fixation. Observers reported the number of bars they perceived. In Experiment 1, a foveal probe containing the reported number of bars was presented, and observers adjusted both bar width and spacing to match their perception of the array. In Experiment 2, a single-bar probe was presented, and observers adjusted its perceived width. Participants consistently reported fewer items than were presented, demonstrating robust RM in both experiments. In Experiment 1, when the number of bars was underreported (RM trials), observers reported wider, and more accurate, bar widths, along with larger, but less accurate, spacing than in No-RM trials (correct number reports). In these RM trials, the reported horizontal extent of the arrays was reduced, indicating radial compression of visual space. Notably, perceived density was similar across RM

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and No-RM trials and closely matched the actual stimulus density. In Experiment 2, the difference in reported bar width between RM and No-RM trials was smaller than in Experiment 1, but width estimates in RM trials remained closer to the veridical value. Taken together, our findings suggest that RM can enhance feature perception, likely linked to the combined effects of spatial compression and accurate density perception. These results indicate that RM preserves global density perception by simultaneously compressing space and reducing the perceived number of items. We propose that RM reflects a mechanism through which the visual system efficiently compresses information while retaining critical stimulus features.

**Keywords:** spatial vision, peripheral vision, masking, crowding, density, information compression

# Oral Session 4



## Multimodal Approaches for Exploring Vision

# Testing the quantum nature of color perception through hue cancelation experiments

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A novel paradigm for understanding color perception, grounded in quantum information theory, has been recently proposed by M. Berthier, E. Provenzi and their collaborators. Departing from classical CIE colorimetry models, the quantum model focuses on the intrinsic mathematical properties of color sensations, revealing an inherently hyperbolic chromatic space which aligns with experimental observations over the past century. By interpreting this hyperbolic space as the state space of a quantum system, the model uses the rigorous framework of quantum information theory to explain established phenomena like chromatic opponency and predict new properties useful in image processing.

Perceptual colors are treated as quantum observables, with their states represented by density matrices. This approach draws a direct connection to Hering's chromatic opponency theory, where color perception is modeled as superpositions of incompatible chromatic states (red-green, yellow-blue).

Quantum measurements in this framework are inherently probabilistic, with perceived colors constrained within a finite convex subset known as the color solid, reflecting the real limits of human color perception. The model introduces novel mathematical tools to describe state transformations induced by perceptual measurements, linking them to well-established theories in physics.

Furthermore, the quantum model rigorously defines chromatic attributes such as hue and saturation. This precise mathematical formulation eliminates the circularity often found in traditional color theory definitions and offers a coherent framework for understanding complex color phenomena.

Applications of this model extend to practical domains such as white balance correction in imaging, where it outperforms classical methods in

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\*Speaker

reducing color casts. These promising results highlight the potential of the quantum approach in technological applications.

However, to fully validate and refine this innovative model, comprehensive visual experiments are essential. The theory predicts new perceptual phenomena and offers fresh interpretations of known effects, but empirical verification is crucial. We call upon the scientific community to engage in collaborative efforts to design and execute experiments that can rigorously build the chromatic state space of the quantum model by means of the well-known hue cancelation techniques.

**Keywords:** Color perception, Quantum information, Chromatic opposition, Visual experiments.

# Cortical Traveling Waves in Visual Search: a TMS-EEG study

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The right frontal eye field (rFEF) plays a critical role in the covert allocation of endogenous (voluntary) attention (Thompson et al, 2005). Neurostimulation studies using transcranial magnetic stimulation (TMS) have demonstrated that transient pulses delivered to rFEF not only disrupt behavioral performance in visual attention task, but also significantly alter the evoked responses in the visual cortex (Fernandez et al., 2023; Taylor et al., 2007). These findings raise the question of which neural processes support inter-area communication from rFEF to early visual areas during endogenous attention.

Difficult visual search is a classic paradigm for studying exploratory endogenous attention. Prior work has shown that probing rFEF or primary visual cortex (V1) at various latencies rhythmically modulates search performance in the theta frequency band (4-7 Hz; Dugué et al., 2019; Fiebelkorn et al., 2019), consistent with the observation of theta oscillations in these regions (Dugué et al., 2015; Fiebelkorn et al., 2019).

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Recent research recognizes that brain signals can be non-stationary. Specifically, traveling waves, smooth phase shift over cortical space (Dugué and Chavane, 2025), were linked to attentional allocation (Fakche and Dugué, 2024; Alamia et al., 2023), and proposed to explain more variance in data than stationary signals (Fakche and Dugué, 2024; Grabot et al., 2025). In the context of our study, we hypothesize that rFEF interacts with early visual cortex during difficult visual search via functionally relevant traveling waves at theta frequencies.

We tested whether theta traveling waves propagate from rFEF to early visual areas (directionality) during visual search and whether these waves can predict search performance (behavioral relevance). Healthy human participants (N=16) performed a difficult visual search task, identifying the presence or absence of a target letter "T" among distractor "L"s (in left visual field), while their brain activity was recorded with EEG. At various delays following stimulus onset, a double-pulse TMS (25 ms interval) was applied to the rFEF or to the vertex (control site). Using a singular value decomposition (SVD)-based analysis (Alexander et al., 2013; Alexander and Dugué, 2026), we characterized single-trial traveling waves properties, including their strength and direction.

We first established the relevance of examining traveling waves in TMS-EEG by showing that global traveling waves dominate EEG dynamics and that TMS robustly disrupts overall wave activity. We further observed that theta-band traveling waves propagate predominantly from rFEF to occipital visual areas following TMS onset. The next step will be to correlate their magnitude with visual search performance. Together, these results contribute empirical evidence clarifying the causal role of traveling waves in inter-area neural communication during endogenous visual attention.

**Keywords:** Traveling Waves, TMS, EEG, visual search

# Oral Session 5



# Perception of Faces

# Preserved Human Face Categorization in Temporal Lobe Epilepsy revealed by periodic visual stimulation and electroencephalography

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**Rationale:** Cognitive impairments are commonly observed in neuropsychological tests performed in patients with drug-resistant Temporal Lobe Epilepsy (TLE). However, isolating and quantifying these impairments is challenging with explicit neuropsychological tests due to difficulties in task understanding, decision making as well as stress, motivation and fatigue in TLE patients.

**Methods:** Here we use a robust, implicit electroencephalographic (EEG) approach, fast periodic visual stimulation (FPVS), to evaluate the integrity of human face categorization in 34 TLE patients and 34 matched healthy adults. Both groups were presented with natural human face images embedded periodically (1/5) in a rapid stream of non-face images (animals, plants, built objects, houses, etc.) with a frequency of 6 images per second (6 Hz). This well-validated paradigm was administered in only 2 minutes.

**Results:** A robust and objective neural face categorization response (at 1.2 Hz and harmonics) was found over the typical regions of the occipito-

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temporal cortex for both TLE patients and healthy controls (as in previous studies in neurotypical individuals). The amplitude was numerically larger in the right hemisphere, compare to the left hemisphere, in both groups (+7.8% for controls and +10.6% for patients), but without significant hemispheric effect. While the response was slightly decreased in TLE, in both hemispheres (right: 11%, left: 14%), these was no significant effect of group, nor any interaction.

Significance: These results show that rapid human face categorization, a key brain function supported by Ventral Occipito-Temporal Cortex regions in humans, is preserved in TLE.

**Keywords:** Temporal Lobe epilepsy, human face recognition, EEG, FPVS

# Human face categorization is radially-biased: Fast periodic visual stimulation evidence

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At the fovea, face identity recognition preferentially relies on horizontally-oriented face information. Since radially oriented input is privileged in the periphery, along the horizontal meridian (HM) the engagement of face-selective mechanisms is enhanced and subject-level radial bias predicts the speed of saccadic eye movements toward faces. Here, we investigated whether basic-level face categorization is similarly tuned to horizontal information and shaped by the radial bias.

Thirty-two participants were tested using Fast Periodic Visual Stimulation (FPVS) combined with EEG. Face images were periodically embedded at 1.2 Hz within rapid streams of non-face objects presented at 6 Hz. This frequency-tagging approach allows face categorization responses to be objectively isolated at predefined frequencies with high signal-to-noise ratio and critically enable dissociation between high-level categorization responses (1.2 Hz, i.e. face oddball frequency) and general visual responses (6 Hz, i.e. base frequency). Stimuli were presented at four peripheral locations (left, right, up, down), while participants performed an orthogonal task to ensure vigilance.

Neural response to face oddball frequency were localized on occipitotemporal electrodes with a significant right lateralization. This neural marker of face categorization was strongest along the horizontal meridian. It was also stronger in the upper than in the lower visual field in line with past evidence. In contrast, the general visual response at 6 Hz was maximal along the vertical meridian and in the lower visual field, consistent with known low-level visual anisotropies.

Together, these results indicate a clear distinction in visual field anisotropy

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\*Speaker

between high-level face categorization responses, selectively enhanced along the horizontal meridian and in the upper visual field, and low-level visual responses, which preferentially reflect vertical-meridian and lower-field biases. In conclusion, basic-level face categorization is most robust along the horizontal meridian, likely reflecting enhanced access to diagnostic horizontal information. These findings indicate that radial bias selectively modulates horizontal-vertical meridian anisotropies at high-level, category-selective stages of visual processing, following a pattern that is qualitatively distinct from low-level visual responses.

**Keywords:** Radial bias, face perception, peripheral vision

# Horizontal image compression significantly impairs human face identity recognition

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Face identity recognition (FIR) is a key aspect of human social interactions, supported by specialized neural mechanisms. Previous studies have reported strikingly surprising resilience of FIR to horizontal compression of images, generally taken as evidence that spatial (configural) cues may play a limited role in this function. However, resistance of FIR to geometric distortion rests on limited evidence, i.e., behavioral accuracy rates obtained with iconic familiar face images presented for extended response windows. Here we objectively quantify the impact of horizontal compression on validated implicit neural markers of FIR. Twenty-one participants viewed the same unfamiliar face presented 6 times by second at one of five compression levels (0%, 22%, 45%, 67%, 90%), with various identity changes occurring periodically every five faces. Robust electroencephalographic (EEG) FIR responses observed over the occipito-temporal cortex at 1.2 Hz and harmonics at low compression levels (0–22%) progressively declined with increasing distortion, showing near-complete suppression at 90%. These observations demonstrate that unlike artificial intelligence networks that can efficiently adapt to linear image transformations, horizontal image compression significantly impairs human FIR.

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# Is the Other-”Race” Effect Really About ”race”? Evidence Supporting a Familiarity- and Cognitive Capacities-Based Account

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In social cognition, the other-”race” effect (ORE) refers to both a reduced ability to individuate outgroup faces compared to ingroup faces,

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\*Speaker

and faster race categorization of outgroup faces. Multiple studies seem to converge on the idea that "race" categorization is a less resource-intensive task than individuation, and thus may require less representational resources. We investigate whether the ORE may result from the interaction between familiarity (exposure) and cognitive capacity (representational resources).

To this aim, we train a shared-backbone convolutional-neural network (CNN) with dual task ("race" categorization vs. identification). This network structure aims to incorporate a common stem to reflect the basics of the functional organization observed in neuropsychology models of face perception. We manipulate outgroup exposure and the dimensionality of the face space (neurons to encode the network activity at the penultimate layer). We evaluate performance, face space representational geometry, and image-space saliency, and develop an evidence-accumulation model of the ORE operating on the face spaces.

As expected, increasing outgroup exposure improves outgroup identification but also sharpens psychological "race" separability. However, our analyses reveal a clear dissociation: reducing the dimensionality of the face space disproportionately disrupts identification, whereas categorization remains relatively unaffected. The evidence accumulation process recover an outgroup RT advantage in categorization together with an ingroup RT advantage in identification that are modulated by the psychological similarity-matching process. Particularly, indicating that modest similarity-matching during retrievals facilitates access to "race" diagnostic evidence, whereas strict similarity-matching slows individuation.

On the contrary, our image-space analyses do not show any ingroup vs. outgroup differences in task-related saliency while controlling for the early perceptual encoding stage. These results unify perceptual- (face space) and socio-cognitive accounts of the ORE, showing that exposure-driven tuning of the visual system's interaction with finite neuronal capacities suffices to produce the bias and its decision-level asymmetries.

**Keywords:** Other, Race Effect, Racial Bias, Convolutional Neural Networks, Evidence Accumulation, Saliency Faces, Perception

# Pupil responses in rest and reactivity paradigms

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Pupil diameter is shaped by central arousal mechanisms, autonomic drive and the biomechanical constraints of the iris. Although tonic pupil size is often treated as an index of baseline arousal, pupillary dynamics reflect partially dissociable physiological axes. We aimed to characterise this multi-system organisation in a cohort of young adults and to test whether pupillary profiles can be identified within the population.

Sixty-six healthy adults (18-31 years; 35 females) completed three pupil-lometric blocks under controlled ambient illumination using a Tobii Pro Fusion eye-tracker (250 Hz): fixation (2-3 min) to quantify spontaneous oscillations (hippus), a pupillary light reflex (PLR) block to characterise pupil integrity and kinematics, and dynamic emotional face videos to elicit socio-affective dilation. We extracted hippus indices (baseline, frequency, amplitude), PLR metrics (baseline, amplitude, latency, constriction velocity, recovery), and face-evoked dilation measures (baseline, amplitude, latency). Cross-parameter associations were tested using Spearman's rank correlations with correction for multiple comparisons. Robustly normalised features were then clustered using k-means, and cluster separability was assessed with one-versus-rest ROC analyses.

Tonic measures were strongly coupled across paradigms, with hippus baseline correlating with baseline during face videos. Baseline pupil diameter was also associated with reflex amplitudes, consistent with a peripheral contribution. Clustering revealed three distinct profiles with good discrimination ( $AUC > 0.80$ ): a high-tonus/fast profile (short PLR latency, high constriction velocity), a hypo-reactive profile (low

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\*Speaker

tonic level with attenuated PLR and face responses), and a slow/hyper-dilated profile (delayed PLR kinematics with large face-evoked dilation). Cluster membership differed by sex.

Overall, pupil dynamics grouped into three profiles, consistent with an interplay between the tonic central state, autonomic kinematics and iris-related mechanical constraints. This classification cautions against single-mechanism interpretations of pupillary measures, supports individual stratification, and motivates multimodal studies to disentangle central arousal from peripheral gain.

**Keywords:** Pupillometry, PLR, Hippus, Arousal, Face videos



# Posters

# An Active Inference Modelling of Visual Exploration and Decision Making in a Football Task

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Performing sequences of actions in dynamic environments often requires optimizing gaze shifts toward task-relevant sources of information. We studied this issue using a football-based decision-making task in which participants had to receive a ball from a first teammate and pass it to a second teammate moving behind them. Successful performance required managing two sources of visual information that could not be accessed simultaneously: information about ball reception (e.g., is the ball coming to the left or right foot?) and information about the teammate’s running direction (e.g., is she running to the left, or right?). Participants therefore had to actively select when and where to sample visual information in order to guide action.

We adapted a partially observable Markov decision process (POMDP) model within an active inference framework to simulate this task and to reproduce the sequences of actions observed in an experiment comparing two groups of participants: experts and novices. The model was designed to allow the agent to gather informative cues before committing to an action. We manipulated three candidate factors that could explain the observed group differences in policy selection: (i) the reward structure associated with action outcomes, reflecting prior preferences over these outcomes (i.e., how much the agent values being in a particular state at a given time); (ii) the precision of the agents’ beliefs about action consequences; and (iii) the reliability of sensory information.

Our results indicate that the reward structure of the task influenced pol-

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icy selection, suggesting that expert agents place greater value on rapid task resolution than novices. This reward structure is likely learned through practice and shaped by specific performance constraints. Increasing noise in the agents' beliefs altered policy selection and could lead to the adoption of novice-like strategies under high uncertainty. Similarly, degrading sensory signals induced a transition from expert to novice strategies, but only when the reward associated with rapid task resolution was sufficiently low high. In this latter case, agents selected a policy that involved gathering information related to the ball location and, then passing the ball without acquiring cues about the teammate's movement. This strategy resulted in a substantial drop in decision accuracy. Overall, these findings suggest that expert decision-making relies on more precise generative models and on different intentions than those of novices, which influenced when and where visual information is acquired.

**Keywords:** Predictive coding, Visuomotor, Affordance, Gaze

# Crossing a moving gap: how the visual dynamic of the gap affects pedestrian approach speed?

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From survival task such as pursuing prey to recreational activities like rugby, intercepting or avoiding an obstacle moving parallel to the ground plane is a ubiquitous challenge in human and animal locomotion. Numerous studies have aimed to identify the visual information humans rely on to control their displacement in this kind of situation. For instance, in the context of road traffic, researchers have shown that when crossing between two cars at an intersection, drivers and cyclists tend to be attracted toward the centre of the gap formed by the vehicles (Chihak et al., 2010; Louveton et al., 2012). In the present study we aimed to investigate for the first time whether pedestrians exhibit similar behaviours.

To focus on identifying the optical variables involved in locomotor control, we design a virtual scene in which all urban semantic cues were removed. The task was therefore simplified: participants were immersed in a minimalist virtual environment and were instructed to walk toward

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a target located 15-m ahead while two moving obstacles, separated by a gap, were about to cross their path. The two obstacles consisted of two spheres positioned at eye-height, between which participants were instructed to pass. Spatiotemporal task constraints were manipulated by varying the initial conditions (offsets) with respect to the time of arrival of the gap centre. The dynamics of the gap – in terms of gap centre velocity and gap size – was also manipulated according to 4 conditions: (i) control condition: constant velocity with constant gap size; (ii) constant velocity with expanding size; (iii) accelerated velocity with expanding size; (iv) decelerated velocity with expanding size.

The results showed that variations in initial offsets led to functional, continuous, and gradual adjustments in approach speed, which were initiated early during the approach to the intersection. Most importantly, the results show that in all gap dynamic conditions participants regulated their approach speed to cross the gap towards its centre. Moreover, compared to the control condition, although it was not necessary to modify their behaviour in the three other conditions, participants nonetheless did so. This indicates an influence of the dynamic parameters of the gap on the on-line regulation.

Chihak, B. J., Plumert, J. M., Ziemer, C. J., Babu, S., Grechkin, T., Cremer, J. F., & Kearney, J. K. (2010). Synchronizing self and object movement: how child and adult cyclists intercept moving gaps in a virtual environment. *Journal of experimental psychology: human perception and performance*, *36*(6), 1535.

Louveton, N., Montagne, G., Berthelon, C., & Bootsma, R. J. (2012). Intercepting a moving traffic gap while avoiding collision with lead and trail vehicles: Gap-related and boundary-related influences on drivers' speed regulations during approach to an intersection. *Human movement science*, *31*(6), 1500-1516.

**Keywords:** Perception, action, Locomotion, Interception, Collision avoidance

# A novel method combining motion capture, eye tracking and 3D modeling to characterize human visuospatial behavior in complex real environments.

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Understanding human visual behavior during spatial navigation in uncontrolled natural environments is an important scientific challenge, but it poses significant difficulties for the experimenter due to its complexity. Standard experimental approaches either limit these difficulties by performing simplified navigation experiments in controlled laboratory environments or by simulating realistic environments in virtual reality. Both these approaches limit ecological validity of the obtained results. In this study we propose a novel behavioral measurement system that combines the power of motion capture technology, mobile eye tracking and 3D simulation in order to accurately characterize visual and spatial behavior of human subjects. The novelty of the system compared to its predecessors consists in embedding body- and eye-tracking data into an exact 3D model of the external environment, allowing for an accurate tracking of subject position, gaze direction and fixation target coordinates while performing a spatial navigation task in a complex real environment – Paris train station. The subjects were asked to follow given trajectories in the train station (approximate length: 100m) either with predefined fixation targets or with information signs located

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\*Speaker

at different heights. To illustrate the unique properties of the system, we defined a metric called time-to-fixation which is the time between the moment the region of interest becomes theoretically visible to the subject and the time it took to fixate it for the first time.

The overall positional accuracy of the proposed measurement system was about 1m (1% of the trajectory length), and the gaze vector accuracy under 1 m for targets as far as 10 meters away. Mixed-model analyses of these errors have shown that substantial proportions of these errors (positional: 42%, fixational: 60%) were explained by the combined effect of target eccentricity, cumulative positional error caused by inertial position sensors, distance to visual target, travelled time and distance. We found that participants were significantly quicker at fixating their gaze on the sign located in the floor than on the sign located in the overhead condition.

Thus, the proposed behavioral analysis method allows the experimenter to precisely characterize visual behavior in human subjects navigating in complex environments, while ensuring both the ecological validity of the experiment and the access to detailed simulation data, such as that usually available in virtual reality setups.

**Keywords:** gaze vector, motion capture, 3D visualization, cognitive science, behavioral experiment

# Visual history shapes perceptual choice and smooth pursuit during ambiguous 3D motion

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Ambiguous visual stimuli can elicit distinct perceptual interpretations despite constant sensory input. In the case of the kinetic depth effect (KDE), a rotating sphere is perceived as rotating in one of two opposite directions, with spontaneous perceptual reversals. Here we investigate how short-term and long-term visual (non ambiguous) experience biases perceptual choice and associated smooth tracking eye movements during KDE perception. Participants viewed ambiguous and disambiguated rotating spheres under three conditions: fully ambiguous stimuli presentation, long-term visual priming (a single disambiguated rotation direction interleaved with ambiguous trials across a session), and short-term visual priming (interleaved disambiguated trials corresponding to different directions). Perceptual reports were collected via key presses, and smooth pursuit eye movements were analysed as a function of the first perceptual choice. We show robust priming effects from both prior stimulus information and prior perceptual dominance, the latter being especially evident during fully ambiguous viewing. These perceptual biases were accompanied by systematic modulations of smooth pursuit eye movements, including changes in pursuit latency and early tracking dynamics. Together, these results indicate that recent visual and perceptual history jointly shape early perceptual decisions and oculomotor behavior during bistable 3D motion perception.

**Keywords:** bistable perception, ambiguous stimuli, smooth pursuit, perceptual stability, priming effects

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# Does Working Memory Load Dictate Foraging Strategy?

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Visual foraging refers to tasks in which observers look for multiple targets among multiple distractors. Previous research revealed that participants adapt their foraging strategy to the difficulty of the task. In easy tasks, in which targets and distractors are distinguished by a single feature (e.g., yellow and blue dots among green and red dots), participants typically select the nearest available target and frequently switch between target types. However, in difficult tasks, in which targets and distractors are distinguished by a conjunction of features (e.g., green dots and red squares among green squares and red dots), participants focus on one target type at a time. However, some participants (so-called "super foragers") keep switching between conjunction target types, despite the higher cognitive load. Previous work suggests that this behaviour may be explained by higher working memory capacity, but no study has tested this hypothesis. Here, we examined whether increasing the number of target types (i.e., increasing working memory load) would favour a category-based strategy in all observers, including "super foragers". To tackle this question, participants completed two feature- and two conjunction-based exhaustive foraging tasks. They had to successfully complete 14 trials in each foraging task by selecting the 42 targets and ignoring the 42 distractors. The number of target types was manipulated. In Block 1, participants looked for two target types,

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while in Block 2 they looked for three target types (e.g., yellow, blue and pink dots among green, red and purple dots for feature foraging and e.g., green dots, red squares and yellow triangles among distractors defined by all other color–shape combinations for conjunction foraging). Eye movements were recorded during the task. Preliminary results indicate shifts in foraging strategy both between tasks and between trials of a same task, suggesting strong influence of working memory load on visual foraging. Our results highlight the need to investigate individual differences underlying this shift in foraging strategy. Moreover, ongoing analyses of eye-movement behaviour during the task aim to characterize oculomotor signatures of foraging strategy.

**Keywords:** foraging, visual search, visual attention, working memory

# Investigating the learning of statistical regularities during visual foraging

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Unlike traditional single-target visual search paradigms, foraging tasks require the detection of multiple targets among distractors within a single display. As such, they provide a valuable framework for investigating the dynamics and efficiency of attentional deployment. Previous work has demonstrated that several factors (e.g., proximity, priming) compete for determining the next target selection during visual foraging. Here, based on results from the literature on single-target visual search, we investigated whether learning of statistical regularities could influence target selection during visual foraging. We used a conjunction foraging task in which targets and distractors were defined along two dimensions (shape and color), and we contrasted two statistical regularities, namely frequency and conditional probability. Forty participants searched for targets randomly distributed within two of sixteen screen quadrants. In the Probability condition, the two target-containing quadrants had a conditional probability of 1; whenever targets appeared in quadrant A, they also appeared in quadrant B, although their overall frequency in the experiment was low. In contrast, in the Frequency condition, the two quadrants containing the targets had a conditional probability of 0.5; targets appearing in quadrant C predicted their appearance in quadrant D on only half of the trials, but their overall frequency in the experiment was high. Participants completed 200 foraging trials during a learning phase, followed by 20 switch-phase trials in which targets appeared in novel quadrant pairs. We expected reaction times-defined as the interval

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between two target selections in a trial-to decrease steadily during the learning phase and to increase during the switch phase. Although our results did not provide clear evidence of such learning, they showed that reaction times were biased by the spatial locations of targets as well as by the relative spatial relationships between the paired quadrants containing the targets. These pilot findings provide important insights for the implementation of follow-up studies.

**Keywords:** Visual attention, Foraging, Learning, Statistical regularities

# A Model of Rhythmic Visual Attention

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Rhythmic fluctuations of visual attention have been consistently observed in both behavioral performance and neural activity, suggesting that attentional selection, or the modulation of sensory information, operates through temporally structured sampling (Kienitz et al., 2022). Despite the strong empirical evidence, there remains a lack of mechanistic understanding of how attentional signals dynamically modulate sensory neural responses and their associated behavioral outcomes. Here, we propose a biophysically plausible model of rhythmic visual attention based on the ORGaNICs (Oscillatory Recurrent Gated Neural Integrator Circuits; Heeger and Mackey 2019) framework. The model combines recurrent neural dynamics with modulatory control mechanisms that selectively gate sensory input and regulate the strength of recurrent interactions. Importantly, within this framework, the canonical computation of divisive normalization emerges from the interaction between recurrent amplification and modulatory control and is not an ad hoc computation. Using populations of orientation or spatially tuned units, we show that rhythmic modulation of the ORGaNICs input gain variable produces phase-dependent changes in contrast response functions and discriminability, consistent with empirical findings on rhythmic visual attentional sampling. We further explore extensions of this framework to spatially structured neural circuits, enabling the study of attentional traveling waves across the visual cortex (Dugué and Chavane, 2025). This model serves as a general framework for testing hypotheses and

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predictions linking rhythmic attentional modulation of neural circuits to behavioral outcomes.

**Keywords:** Attention, Neural Oscillators, Recurrent Neural Networks, Traveling Waves

# Links Between Eye Movements and the Updating of Ensemble Representations

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Visual perception of our environment is an active process. It relies on visual exploration, which is characterized by an alternation between very rapid eye movements-known as saccadic eye movements-and fixations, during which the eyes remain relatively stable for a variable duration (between 100 and 500 ms). The first fixations within a visual scene allow us to rapidly process the gist, that is, the global meaning of the scene, whereas subsequent fixations enable more local and detailed processing of some individual elements.

Processing a scene globally involves automatically extracting (as early as 50 milliseconds) the spatial organization (the structure) of the constituent elements, as well as the statistical properties (numerosity, variance, density, mean) of groups of elements sharing common features (orientation, shape, color, etc.). Previous research has shown that observers can extract a fairly precise representation of the average size of a set of briefly presented disks. This form of ensemble perception does not seem to require prior processing of each individual element composing the set.

However, it has been demonstrated that the accuracy of ensemble representations improves when the ensemble is available for longer presentation durations. The mechanisms underlying this improvement remain to be identified. We hypothesized that eye movements contribute to the refinement of ensemble representations. To test this hypothesis, we examined the influence of presentation time with and without eye movements across different spatial eccentricities, an aspect that remains limited or insufficiently controlled in previous studies.

To this end, 37 participants (aged 18–35) estimated, using an adjustment task, the average size of six disks of varying dimensions across

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two blocks of 150 trials. In one block, eye movements were unrestricted, whereas in the other, participants were required to maintain fixation on a central cross. Eye movements were recorded on every trial. The presentation duration of the disks (100, 400, or 1000 ms) and their eccentricity relative to the fixation cross (30 or 150) were intermixed within each block.

Analyses revealed greater accuracy in size estimates when the disks were presented at 30 rather than 150 of eccentricity, and when participants were allowed to move their eyes freely. Interestingly, accuracy improved with longer presentation durations, but only in two conditions: when participants maintained fixation with disks at 30, or when they were free to move their eyes with disks at 150. These findings suggest that eye movements are necessary to more accurately extract global ensemble representations when the elements occupy a wide region of the visual field.

**Keywords:** Ensemble perception, Visual exploration, Time course, Eccentricity

# Dissociable Internal Models for Perceptual Decisions and Eye Movements

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Perceptual behaviour emerges from internal models that integrate sensory evidence with contextual information, such as statistical biases favouring the occurrence of certain visual events over others, or specific distributions of sensory noise. Previously, our work demonstrated that the internal representations observers rely on during decision-making can be identified through response biases. Across different visual discrimination experiments, perceptual choices were shown to depend on the selection among equally valid internal representations of context formed through unconscious interpretation of the setup. Different representations could lead to opposite behavioural choices within the same trial, contradicting customary predictions based on the standard internal model. Concurrently, our group and others have shown that anticipatory predictive eye movements are consistently aligned with the most frequently observed sensory event. However, the influence of different possible internal representations of the probabilistic context on visually-guided eye movements has been less studied.

By comparing perceptual decision biases and eye movements in a motion direction discrimination task, this study assesses whether perception and actions (both during anticipatory and visually-guided epochs) share the same internal representation or are governed by different internal models.

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Twenty observers ( $N = 20$ ) performed a two-alternative forced-choice task (2AFC) in which they reported the perceived leftward versus rightward motion direction of random-dot kinematograms (RDK), while their eye movements were recorded. The experiment began with an adaptive staircase to estimate individual direction-sensitivity thresholds, followed by a main task in which motion coherence varied randomly across trials. The prior probability of motion direction was manipulated, shifting from an unbiased distribution (50/50) during threshold estimation to a biased distribution (80/20) during the main task, thereby introducing a global directional bias across trials. Consistent with our previous findings and with a new twin-experiment conducted online with the same RDK direction discrimination task ( $N=24$ ), observers' perceptual decisions exhibited a strong bias toward the less frequent motion direction on low-coherence trials. This counterintuitive bias persisted over hundreds of trials and counters the normative expectation that observers would favour the more frequent motion direction. Unlike perceptual decisions, anticipatory eye movements exhibited a significant bias toward the more frequent motion direction, consistent with previous findings from our group. Interestingly, early visually guided smooth pursuit was influenced by recent trial history (with a positive correlation), with no significant effect of direction probability. Taken together, these findings support a partial dissociation between the internal representations governing perceptual decisions and those involved in eye-movement control.

**Keywords:** perceptual decision, making, internal models, response bias, anticipatory eye movements, smooth pursuit, probabilistic context, visual motion

# Peripheral scene context modulates the temporal dynamics of saccadic choice

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Peripheral vision plays an important role in visual recognition. Previous studies suggest that during single-eye fixation, the rapid extraction of global features in peripheral vision would allow a rudimentary representation of the scene, known as the *gist*, associated with prior knowledge about regularities in the visual environment. This knowledge would then be used to rapidly categorize the scene, but also to generate predictions about the objects it contains, thus improving their categorization in central vision. However, visual perception is a dynamic phenomenon, alternating between ocular fixations on an object and saccades toward new objects of interest in the periphery. In two experiments, participants performed a saccadic choice task in which two objects were simultaneously presented in peripheral vision, one to the left and one to the right of a fixation. On each trial, the two objects belonged to different semantic categories (animal vs. furniture). Participants were instructed to initiate a saccade toward the object belonging to a target category (animal or furniture), with each participant performing both target categories. Objects were embedded within a peripheral scene that was semantically congruent with the target category (outdoor scenes for animals, indoor scenes for furniture) or replaced by 1/f noise. The scene was presented

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either simultaneously with the objects (Experiment 1) or 150 ms before object onset (Experiment 2), in order to manipulate the temporal availability of contextual predictions. Across both experiments, similar effects were observed, with no difference between simultaneous and delayed scene presentation. The congruent context did not increase either the proportion of first saccades directed toward the target or the speed of these correct saccades, compared with a noisy context. However, a systematic effect emerged for erroneous saccades: when the first saccade was directed toward the distractor, it was slower in a congruent scene context than in a noisy context. This finding suggests that, although contextual information in peripheral vision does not prevent errors, it delays the initiation of saccades toward the distractor. Within an evidence accumulation framework, this pattern is compatible with the hypothesis that a congruent scene context slows the access of the distractor to the decision threshold. This study demonstrates that contextual information in peripheral vision, although irrelevant to the task, influences the temporal dynamics of saccadic choice.

**Keywords:** Gaze orientation, Predictive cognitive model, Saccadic choice task, Object categorization, Scene perception

# Timing pre-saccadic attention : Temporal dynamics of the Size-Eccentricity Effect's compensation

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Pre-saccadic attention is known to enhance perception at saccade targets, improving the processing of features such as orientation, contrast, and spatial resolution. In previous work, we (Laaboudi et al., 2025) demonstrated that preparing a saccade can reduce the sizeeccentricity effect (SEE), i.e., the usual underestimation of object size in peripheral vision.

Whereas other perceptual enhancements typically emerge approximately 150 ms and peak around 75 ms before saccade onset, we observed SEE compensation at an average delay of ~200 ms between object offset and saccade onset. In the present study, we investigated the temporal dynamics of this size perception enhancement. Participants completed a forced-choice task, comparing a test disk varying in size, briefly presented in the left visual field, to a foveal reference disk shown at the saccade landing position. On saccade trials, participants executed an eye movement toward the memorized location of the test disk. The

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timing of an auditory cue triggering the saccade was manipulated to sample stimulus–saccade intervals ranging from 50 to 550 ms. Psychometric function parameters were estimated separately for five temporal bins. In a separate block, fixation trials with no saccades were also included to assess peripheral size perception in the absence of saccade-related attention shifts. Contrasting responses across pre-saccadic delay intervals and fixation condition should delineate the temporal boundaries of pre-saccadic attentional modulation of size perception. Preliminary results (full data collection is ongoing) are interpreted in light of current theories of attention and action–perception interactions.

**Keywords:** Presaccadic attention, Size perception, Psychophysics

# On the missing link between perceptual decision-making and saccade initiation

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Two lines of research have investigated decision-making and saccade generation, each yielding sophisticated models. On the one hand, decision circuits operate as stochastic accumulators of evidence. On the other hand, saccade initiation is a brainstem-driven process in which omnipause neuron inhibition releases burst neuron activity. Although these accounts have been developed separately, their computational and physiological properties suggest a possible common mechanism. In the present study, we tested the hypothesis that brainstem burst neuron activity and the associated activation of the agonist extraocular muscle reflect the same evidence-accumulation signal observed in decision circuits. Participants performed a leftward/rightward random-dot motion discrimination task and communicated their choice with a saccade to one of two lateral targets. Motion coherence and target eccentricity were manipulated. We used saccadic acceleration profiles as a proxy for ocular muscle activation, given that muscle activation produces force, and following Newton’s second law of motion. Saccadic acceleration profiles were consistent with evidence accumulation, exhibiting a build-up rate that scaled with motion coherence. However, the build-up rate was further modulated by an amplitude-dependent gain, such that identi-

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cal changes in coherence produced larger kinematic differences for larger saccades. These results suggest that evidence accumulation signals are scaled by movement metrics along the final oculomotor pathway, likely to compensate for the greater biomechanical demands of larger saccades.

**Keywords:** decision, making, motor control, saccades, acceleration, evidence accumulation

# Sensory attenuation of auditory pitch: reduced perceptual sensitivity of tones triggered by keypresses, but not by ocular saccades

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Sensory attenuation refers to reduced neural and perceptual responses to self-generated tones compared to tones triggered externally. Our previous study showed that the strength of action-outcome coupling (SAOC) influences the perceptual biases for sound intensity. Indeed, we observed that the overall perceived intensity of tones triggered by keypresses (strong coupling) was attenuated, in contrast to tones triggered by ocular saccades (weak coupling).

Building on this earlier study, we investigated the influence of SAOC on perceptual attenuation for auditory pitch. Indeed, to date, no behavioral study has demonstrated any sensory attenuation effect regarding pitch perception, although it has been suggested that attenuation may manifest in this case as a change in the ability to perceive pitch differences (discrimination sensitivity).

A total of 140 participants were divided into three groups. They performed a pitch discrimination task in which test tones of varying frequency were triggered either by an ocular saccade, a keypress, or played after a cue (no action required, or "passive" group). Test tones were presented 150 ms or 1500 ms after the action (or cue).

Results revealed lower discrimination sensitivity in the keypress group compared to the passive group (Cohen's  $d = 0.66$ ). In contrast, no sig-

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nificant difference was found between the saccade and passive groups. Also, in the keypress group only, we observed a small effect of delay (Cohen's  $d = 0.14$ ), with reduced sensitivity at the shorter action-outcome interval.

This reduced perceptual sensitivity for keypress-triggered tones may reflect sensory attenuation (sounds are more difficult to differentiate), possibly due to predictive mechanisms. Importantly, the absence of a significant difference between the saccade and passive groups, together with the small size of the delay effect, suggests that this reduction in sensitivity cannot be explained by dual-task interference alone. These results align with our previous findings suggesting that a strong action-outcome coupling is necessary to observe perceptual attenuation.

**Keywords:** sensory attenuation, action, outcome coupling, auditory pitch

# Predictable Vertical Eye Movements in Binaural Monopolar Galvanic Vestibular Stimulation

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Galvanic vestibular stimulation (GVS) is widely used to probe vestibular function by artificially activating vestibular afferents, eliciting eye movements, postural adjustments, cortical activations, and self-motion perception (Marchand, Langlade, Legois et al., 2025). The most commonly employed configuration is bilateral bipolar stimulation, in which opposite polarities are applied to each vestibular organ. This configuration induces a characteristic oculomotor pattern, including ocular torsion toward the anode, skew deviation, and a small horizontal eye movement away from the cathode (Séverac Cauquil et al., 2003), accompanied by postural sway toward the anode in the frontal plane (Fitzpatrick & Day, 2004). The amplitude of these responses has been shown to increase with stimulation intensity. Another, less explored configuration is binaural monopolar GVS, where identical polarities are delivered to both vestibular organs. Previous studies have reported anteroposterior postural effects (Séverac Cauquil et al., 2000) as well as specific cortical activations (Aedo-Jury et al., 2020). However, the oculomotor consequences of this stimulation mode remain unknown, and it is unclear whether eye movement responses follow a specific directional pattern or scale with stimulation intensity.

In the present study conducted on 18 participants, GVS was delivered via electrodes placed on the mastoids and C7 using 1.8-s pulses at 0.8, 1.2, and 1.6 mA, applied in randomized order with either cathodal or anodal mastoid stimulation. Binocular eye movements were recorded at

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1000 Hz.

Repeated-measures ANOVA revealed conjugate vertical eye movements with similar responses in both eyes. A significant main effect of stimulation configuration (cathodes vs anodes) was observed, with different vertical eye movement responses depending on whether cathodal or anodal currents were applied over the mastoids ( $F(1,17) = 10.29$ ,  $p = .005$ ). At stimulation onset, the direction of the vertical eye movement depended on the stimulation configuration: cathodal stimulation over the mastoids induced upward eye movements, whereas anodal stimulation resulted in downward eye movements. In addition, stimulation intensity significantly modulated this effect, as indicated by a direction  $\times$  intensity interaction ( $F(1.88, 31.98) = 6.11$ ,  $p = .006$ ), suggesting that the magnitude of the vertical eye movement response varied as a function of current strength.

These findings show that binaural monopolar GVS elicits configuration-dependent vertical eye movements, extending previous evidence of its effects beyond posture to the oculomotor domain. By revealing systematic ocular responses in the anteroposterior plane, this study bridges the gap between well-established postural effects and previously unexplored eye movement responses, and provides new insight into the vestibular mechanisms underlying anteroposterior motion processing.

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**Keywords:** Galvanic vestibular stimulation, Eye movements, Eye tracking

Poster 15's abstract ("Central visual information improves peripheral scene visibility") can be found in **Oral Session 1**.

# Central–peripheral interactions in scene recognition across the adult lifespan

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In young adults, central vision gives access to fine visual details based on high spatial frequencies (HSF), and peripheral vision provides coarse information based on low spatial frequencies (LSF). These two sources interact during scene recognition: coarse peripheral information can guide the interpretation of central details, and central details can in turn influence how peripheral information is categorized when attention is directed outward. How such interactions evolve with age remains unclear, particularly given age-related changes in visual abilities that affect the processing of HSF based details. We adapted a central and peripheral congruency paradigm to examine scene recognition in younger and older adults. Participants categorized a briefly presented target scene (indoor

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versus outdoor) either in central vision while ignoring a peripheral scene, or in peripheral vision while ignoring a central scene. The ignored scene distractor was independently manipulated in semantic congruency (congruent versus incongruent) and spatial frequency content (LSF versus HSF) to assess how contextual signals interfere with target categorization. Data collection and analyses are ongoing. Preliminary observations reveal a congruency effect across conditions and age groups: incongruent distractors tend to impair categorization performance regardless of whether the target scene is central or peripheral. Trends suggest that incongruent LSF peripheral distractors might amplify this interference in older adults, but this tendency still needs to be confirmed. These preliminary results provide an initial indication that reduced access to central HSF based information with age may increase the relative influence of peripheral and LSF based contextual signals during rapid scene recognition.

**Keywords:** Scene recognition, Spatial frequencies, Peripheral vision, Central vision, Healthy aging

# Disentangling redundancy masking and visual resolution in foveal vision

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Redundancy masking (RM) is a phenomenon by which the visual system compresses redundant information. For example, observers often report two items when three identical items are presented in the peripheral visual field. Redundancy masking has been well-characterised for peripheral vision; however, it remains unclear whether it occurs in the fovea with its high visual acuity. Here, we tested RM in foveal vision. Stimuli consisted of three, four, or five radially arranged lines. We varied eccentricity (0.5° and 1°), directions from fixation (left, right, up, and down), and line width (0.03°, 0.04°, and 0.05°). Participants' eye movements were tracked using an eye tracker, and a stimulus was displayed only if fixation was maintained for one second. Stimuli were presented for 83.3 ms. In the number task (the main task), participants reported how many lines they perceived. After the main task, participants performed a two-line resolution task where they reported whether they perceived one or two lines. The results of the number task showed that observers often reported fewer items than were presented at both eccentricities and in all four directions. As expected, the magnitude of underreporting decreased with increasing line width. Performance in the two-line resolution task partially predicted the results in the number task: Observers with high accuracy in the two-line resolution task tended to underreport the number of items less in the number task. However, the presence of strong underreporting in the number task, even in participants with high performance in the two-line resolution task, suggests that RM may occur in the fovea when visual resolution is sufficient.

These preliminary results suggest that there may be RM in foveal vision. However, disentangling visual resolution and RM is particularly

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necessary—and challenging—in foveal vision because of the high visual resolution in the fovea. Future studies will further examine whether RM exists in the fovea and whether peripheral and foveal RM share similar characteristics.

**Keywords:** Redundancy masking, Foveal vision, Information compression

# Does flow-parsing play a role in Time-To-Contact estimation?

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Perceiving object motion during self-movement is an essential ability of humans. When an object moves within the environment during an observer’s self-motion, the resulting retinal motion reflects a combination of both scene-relative object motion and the observer’s own movement. Previous studies have reported that the visual system uses information in optic flow to subtract the retinal motion component due to self-movement to recover scene-relative object motion – a mechanism called flow parsing (Warren and Rushton, 2007). This study investigates whether such a mechanism plays a role in estimating the time remaining before an object reaches a particular location, known as Time-To-Contact estimation task (TTC; Tresilian, 1995).

Classical accounts emphasize the optical invariant *tau* as a robust source of TTC information under ideal conditions (Lee, 1976). However, recent studies show that TTC judgments are also influenced by additional motion cues, including object velocity, surface texture, and contextual motion signals (Battaglini & Ghiani, 2021). Task-irrelevant motion, in particular, has been shown to bias TTC judgments without improving temporal sensitivity, suggesting the involvement reference-frame-based mechanisms rather than optimal cue integration (Oberfeld et al., 2011).

Here we investigate the potential influence of optic flow (direction) on TTC estimation. Participants were faced with a cloud of dots displayed on a 2-D screen and were asked to complete a classic prediction-motion task of an object moving toward the centre of the screen. The design included 3 TTC (500, 800, 1000 ms) and 3 background motion conditions: static, contracting flow (congruent), and expanding flow (incongruent). Performance was assessed using signed error, intra-individual variability, and mean absolute error.

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Results revealed a systematic effect of optic flow on response bias. Static and congruent conditions were associated with conservative TTC judgments, whereas incongruent (forward) optic flow significantly reduced this bias, yielding responses closer to veridical timing and anticipatory responses for longer TTCs. In contrast, neither variability nor mean absolute error was affected by optic flow, although both increased with TTC duration.

These findings indicate that global optic flow does not enhance temporal sensitivity or overall accuracy, but instead induces a directional bias in responses. The absence of an effect of contracting flow is consistent with previous evidence showing that task-irrelevant motion biases TTC judgments primarily under incongruent conditions (Oberfeld et al., 2011; Beardsley et al., 2011). As a next step, we aim to extend this paradigm to biological motion, since point-light walkers provide structured, articulated kinematic cues that enhance motion detection and predictive processing, we hypothesize that this type of movement strengthening scene-relative object motion perception.

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**Keywords:** Optic flow : Flow parsing : Time, to, contact : Prediction, motion task : Motion perception

# Perceived time of visual events is affected by spatiotemporal grouping

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Visual objects are processed along the visual hierarchy in spatially distributed brain areas. The processing at different stages introduces delays, making it difficult to predict when a visual object is perceived (Moutoussis & Zeki, 1997, *Proc R Soc*; Nishida & Johnston, 2002, *Curr. Biol.*). When two similar visual objects appear briefly in quick succession at nearby locations, they are processed together and grouped into a strong percept of apparent motion (Wertheimer, 1912). Here we ask when these objects are perceived.

To measure the perceived timing of visual events, we used a temporal order judgement task. On each trial, a target visual event (a pair of blue Gaussian blobs), was presented on either side of the fixation point at an eccentricity of 4°. The target was either preceded or followed by a large blue ring (inner radius 9.5°, outer radius 10.5°) centered on the fixation point. Participants estimated whether the target or the circle appeared first.

To test the effects of grouping, we presented another pair of blobs as a distractor (gray), before or after the target pair (blue), at different locations on the virtual circle. In different blocks, we varied the spatial separation between the two pairs (20, 50 and 90 degrees of arc). The stimulus onset asynchrony between the target and the distractor was fixed to 120 ms. The parameters were chosen such that a strong percept of apparent motion was elicited for the small separation, whereas no reliable percept of apparent motion occurred for the large spatial

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\*Speaker

separation. Participants were asked to attend to the blue target pair and blue ring, while ignoring the gray distractor pair. Finally, a baseline condition was included, in which only the target and ring were presented.

We found a strong effect of the distractors on the perceived time of events. The perceived time of the target relative to the ring was biased by the presentation of the distractor pair. It was shifted towards the presentation time of the distractor: the target was perceived later when the distractor pair was presented after the target, and earlier when the second pair preceded it. Sensitivity of temporal order judgements was also affected, and it decreased when the target was presented before the distractor, especially for the small spatial separation between the target and the distractor (when apparent motion was strong).

In summary, the findings suggest that when visual events are grouped into a coherent percept of apparent motion, their perceived time is shifted towards the time of the group percept. These results are consistent with previous work suggesting that the perceived timing of visual events depends on concomitant processing of their spatiotemporal context.

**Keywords:** time perception, visual grouping, apparent motion

# Effect of flash presentations on brightness induction

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Brightness induction is a well-known phenomenon in which brightness of a central region depends on the brightness of the surfaces that surround it. There are two different types of brightness induction: contrast (the brightness of the central region shifts in the opposite direction from the inducing surface) and assimilation (the brightness shifts toward the inducing surface). Here, the contrast effect is obtained with a test ring positionned within a uniform background. The assimilation effect was displayed with a patterned background where the stimulus is composed of nine concentric rings and the test ring is displayed in the middle. The strength of the brightness was determined in using a matching technique. The first experiment examined the effect of exposure time at 10 and 500 msec. Results indicated that assimilation and contrast effects were found at 500 msec, but different brightness shifts were obtained at 10 msec: the simultaneous brightness contrast was enhanced and the brightness assimilation effect was reversed. The second experiment studied induction phenomena as a function of five stimulus time presentations ranged from 10 to 500 msec. In the contrast condition, results showed that the strength of the brightness steeply decayed when stimulus duration increased. In the assimilation condition, results indicated that an assimilation effect was observed for the longer stimulus presentation (> 60 msec) when the effect is reversed at brief stimulus presentation (< 30 msec). Finally, the last experiment evaluated the effect of the luminance contrast between the test ring and the contiguous surface for a long and a flash time presentation. The results were similar to those obtained previously and the strength of brightness decreased when the luminance contrast decreased. The present study suggests the existence of a fast and common processing for estimating surface appearance in brightness induction.

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**Keywords:** Brightness, Contrast, Assimilation

# Effect of orientation on accumulative size for line stimuli

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Current theories on how we estimate area of two dimensional stimuli, such as additive area heuristics, rely on cumulative estimates of lengths along multiple dimensions. However, the preliminary findings from our laboratory provide evidence for a systematic underestimation of total length for sets of segments compared to a single reference line. Any putative mechanism utilised for integration of size of multiple line segments would need to correct for this systematic underestimation. In addition, these mechanisms need to operate in an orientation invariant manner to account for real world interactions. Therefore, we aimed to examine the orientation dependency of the mechanisms estimating the cumulative size of line stimuli by altering the angular configuration of line segments with respect to that of a single reference line.

The experimental paradigm consisted of presentation of a single reference line of constant length as well as a single test line; or a set of six segments test stimulus. Five experimental conditions compared identical, mirrored, and random orientations for the test relative to the reference. Participants judged which side of the display contained the greater total length, enabling the estimation of psychometric functions and points of subjective equality (PSEs) for each condition. The results for the multi-segments conditions display remarkably similar psychometric functions, supporting the orientation invariance of accumulative size for line stimuli.

**Keywords:** Psychophysics, size perception, length perception, orientation

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\*Speaker

# A Comparative Analysis of Methods of Confidence Reporting

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Decision confidence is the subjective probability that a choice is correct (Balsdon et al., 2020, Nat Comms). To measure confidence, confidence ratings (an ordinal scale) are widely used for their simplicity, but are susceptible to response biases. An alternative is the confidence-forced-choice (CFC) paradigm, where observers compare their confidence across two consecutive decisions and select the decision they believe is more likely to be correct (Mamassian, 2020, Perception). This paradigm is bias-minimising, but may introduce additional memory demands. A direct empirical comparison of these measures has not yet been documented. Here, we conducted a pre-registered online experiment to investigate whether the type of confidence report affects measures of confidence.

Forty participants performed a visual orientation discrimination task followed by either i) a 4-point confidence rating, or ii) a CFC judgement. Each participant completed two sessions, during which they performed both confidence reporting conditions in counter-balanced block order. We used the confidence-noise confidence-boost model (Mamassian & de Gardelle, 2025, A PLoS CB) to assess the contribution of additional noise and additional information (boost) to confidence reports relative to the perceptual decision, and compute confidence efficiency as the relative sensitivity of confidence reports (to discriminate decision accuracy).

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Confidence efficiency was significantly lower for the CFC reporting condition than for confidence rating reports. This may be explained by additional information being used when providing a confidence rating, as suggested by larger values of confidence boost. Additionally, participants with a ‘biased’ use of the rating scale had lower confidence efficiency than those who used the scale uniformly. This latter result demonstrates that, despite overall higher efficiency for confidence ratings, this measure remains subject to additional unique biases. Our results indicate the existence of task-specific suboptimalities in confidence, which may be important for what inferences can be drawn from experimental data. Measurements of confidence are shaped by the method used to report confidence. These findings highlight the importance of selecting an appropriate confidence measure when designing experiments.

**Keywords:** Metacognition, Perceptual decision, making, Signal detection theory, Psychophysics

# The neural basis of the general metacognitive mechanism

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When we make a decision, we can feel more or less confident in our choice. It has been proposed that a general metacognitive mechanism serves to evaluate confidence across all forms of decision-making. Here, we aimed to provide causal evidence of this general metacognitive mechanism, and examine its neural basis. We developed a confidence adaptation technique where prolonged exposure to high (or low) confidence decisions altered how humans evaluate their confidence in a different decision-making task. We could then examine neural activity that predicts this change in confidence. We found such activity in the dorsal anterior cingulate cortex, and the insula (commonly correlated with confidence in previous studies), changed according to the alteration in confidence evaluation. The change in the insula strongly predicted the change in behaviour, suggesting this region is critically engaged in evaluating confidence.

**Keywords:** Confidence metacognition fmri adaptation

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\*Speaker

# Visual acuity thresholds for human face identity recognition

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**Purpose :** Visual function of patients is usually assessed in clinical settings with behavioral tests such as the visual acuity grid of Snellen or the visual field evaluation with standard automated perimetry. However, the sight abilities evaluated have little in common with the challenging day-to-day complex visual recognition functions. Here we use fast periodic visual stimulation (FPVS) with electroencephalography (EEG) to objectively assess the impact of visual acuity (VA) on an automatic daily visual task: facial identity recognition (FIR).

**Methods :** We tested automated discrimination of unfamiliar face identity with a well-validated FPVS-EEG paradigm in 12 normally sighted adult volunteers with a 68-electrode EEG system. Visual acuity was artificially decreased using a blur technique to obtain a linear scale of LogMar VA from 1,3 to 0.

**Results :** At the group level, a right occipito-temporal FIR emerges already at a monocular VA threshold of 1,0 LogMar ( $z$ -score= 2,7259,  $p$ =.0032), with half of the sample showing a significant response. Neural amplitude reaches saturation at 0,7 LogMar ( $z$ -score= 7,798;  $p \approx 0$ ). Influence of monocular VA on FIR response can be separated in two trends: A first increase in neural response from 1,3 LogMar to 0,7 LogMar and a second flat trend from 0,7 LogMar to 0 LogMar.

**Conclusions :** FIR in normally sighted participants is extremely well

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preserved at low VA, with a threshold around 1,0 LogMar of monocular VA.

# Orientation Tuning for Faces Reflects Sensitivity to Natural Face Statistics Across the Ventral Visual Cortex

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Human observers identify upright faces best based on horizontal cues. The high-level, face-selective, fusiform face area (FFA) also shows stronger responses to horizontally-oriented information in upright faces. Orientation is typically regarded as a low-level image feature, processed in early visual areas like the primary visual cortex (V1). Orientation tuning in high-level visual areas may reflect sensitivity to low-level features that carry the natural statistics of the face stimulus. How these natural statistics in the orientation domain are represented and shared between early and category-selective areas remains unclear.

To examine how orientation tuning for faces varies across the ventral stream, we scanned 19 participants with 3T fMRI viewing upright, inverted, and scrambled faces filtered into orientation bands from 0° to 180°. Inversion and scrambling disrupt natural face statistics and face-selective responses, without altering orientation content.

Univariate responses in V1 showed horizontal suppression for both upright and inverted faces. Scrambled images showed no tuning and differed from faces only at horizontal orientations. In higher-level visual areas like the lateral occipital complex (LOC), occipital face area (OFA), and FFA, upright faces elicited stronger responses than inverted faces, specifically in the horizontal range, suggesting horizontal information selectively engages specialized processing for upright, but not inverted faces, in these regions.

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Voxel activation patterns in V1 were more stable for faces than scrambled images in the horizontal range, despite univariate suppression, consistent with sharpened representations. Multivoxel pattern analysis in higher-level areas revealed better decoding for upright than inverted faces, particularly at cardinal orientations. Additionally, activation patterns for horizontally-filtered faces in these regions generalized best to upright full-spectrum faces.

Our findings indicate that upright face processing in high-level areas is tuned to low-level features that preserve diagnostic information about the face category, with horizontal orientations providing privileged access to natural face statistics across the ventral visual cortex.

**Keywords:** natural statistics, low, level vision, orientation tuning, face perception, face representations, ventral visual cortex

# Temporal dynamics of face perception

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Two modes of visual exploration are traditionally distinguished based on oculomotor signatures: first, an ambient mode (brief fixations, large amplitude saccades), followed by a focal mode (long fixations, small amplitude saccades). We test the hypothesis that these exploration modes reflect distinct perceptual processes: ambient mode would promote the rapid extraction of low-spatial-frequency information (tied to the overall meaning or schematic representation of a scene), while the focal mode would promote high-frequency information (details).

In this study, we examined the perceptual consequences of these modes by combining perceptual and eye-tracking measures in healthy participants. On each trial, 12 place-holders were presented on the screen, containing pink noise or a face with varying identity and emotion. The stimuli were created by morphing images of the same face showing two different emotions to obtain intermediate faces. We manipulated the number of faces (4, 8, or 12) and their presentation duration (500, 1500, or 3500 ms). At the end of each trial, participants performed a forced-choice task, presented in separate blocks (order counterbalanced between participants): (i) estimation of the average emotion of the faces or (ii) recognition of an individual item.

We predict better estimation of the average emotion at short durations, as these are associated with ambient processing, and improved estimation in identity recognition as the duration increases, consistent with later focal processing. Joint analysis of performance and oculomotor parameters (fixation duration, saccade amplitude) will enable us to link,

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\*Speaker

over time, the transition from ambient to focal to a change in encoded information content. This approach aims to clarify the temporal dynamics by which visual exploration constrains access to global versus detailed information in a scene.

# Ocular exploration of social scenes in ADHD children

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Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by inattention and/or hyperactivity-impulsivity symptoms. ADHD affects individuals in all aspects of their everyday life, with troubles in concentration, organization and motor restlessness for example. These troubles in attentional and inhibition processing can translate on oculomotor functions, with difficulties in holding fixation and suppressing unwanted saccades. While these oculomotor differences between ADHD and neurotypical (NT) individuals have been well documented, it is less clear how they can affect spontaneous ocular exploration of visual scenes. Ocular exploration reflects both attentional saliency (bottom-up and top-down) and oculomotor programming, and in turn affects globally visual perception. In this study, we investigated how ADHD and NT children spontaneously explored social scenes. Based on the literature, we hypothesized ADHD children would explore visual scenes with more saccades and shorter fixations than NT children.

44 NT (m=9 years, 23 girls) and 33 ADHD (m=9.9 years, 7 girls) 6-12 years-old children were recruited in Tours Hospital. ADHD diagnosis

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followed DSM-5 or CIM-10/11 criteria and was assessed by trained clinicians. Additionally, parents filled out the SNAP-IV questionnaire to quantify inattention and hyperactivity/impulsivity aspects. Scores were used to constitute four profiles: non symptomatic (NS), inattentive (IN), hyperactive/impulsive (HI), combined (C). Ocular exploration data were acquired with a Tobii Pro Fusion 250Hz eye-tracking device. Following a 5-points calibration procedure, children were recorded while spontaneously watching 2 silent videos of about 45 s displayed on a 1920x1080 px screen at around 70 cm. One video (*people scenes*) consisted of close-up clips of people being interviewed on the street. The other video (*city scenes*) consisted of street clips displaying mainly moving vehicles. For both videos, we analyzed saccades, fixations, and time spent in Areas Of Interests (AOI) defined by bottom-up saliency or top-down expectations.

Our preliminary analyses revealed no significant difference in the characteristics of saccades or fixations as a function of group (NT vs. ADHD) for both types of scenes. However, some small differences were observed between NS/IN/HI/C profiles. In particular, the C profile made more, shorter and slower saccades, as well as more fixations, when viewing the people scenes. We also observed a general effect of age, with more fixations and faster saccades for older children. Overall, our AOI analyses revealed no significantly different time spent in salient regions of the dynamic scenes.

Our preliminary findings suggest that overall, visual exploration of social scenes is not very different in ADHD compared to NT children.

**Keywords:** Attention, Saccade, Fixation, Gaze, Social, ADHD

Poster 28's abstract ("Is the Other-Race Effect Really About Race ?  
Evidence Supporting a Familiarity- and Representational  
Capacities-Based Account") can be found in **Oral Session 5**.