eXperience PROJECT

Newsletter

July 2024 Issue n°5

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eXperience

Dear Colleagues,

Welcome to the 5th issue of the eXperience Newsletter!

France entered an unusual summer pace, celebrating the Olympic Games 2024. eXperience and its WP2 too are running at full steam!

We submitted our work combining EEG, cognitive modeling and brain decoding that enabled dissociating sensory and clocking processes in the human brain. We completed the collect of two EEG experiments using a virtual environment. The first one extends prior findings on retrospective timing to explore whether the size of the environment may affect recollected time. The second experiment asks whether the size of a virtual environment alters how we produce a certain amount of time. A third behavioral experiment in a virtual environment is being written up, confirming that memory recollection depends on boundaries crossed in a virtual environment. This experiment is now being conducted with EEG to find the neural operations subtending these effects.

Very recently, Nicola and Gaetano called for a short fMRI study in the context of a WP4 x WP2 collaboration. We proposed to extend an experimental design that directly tackles psychological spaces related to duration perception and inter-individual variability. This project named the Geometry of Time is being ran behaviorally, in EEG and in fMRI. We are quite excited about this and you can read some context information about it in the Research Topics and Ideas section of the Newsletter!

We have also actively contributed to a possible final scenario that we will discuss in September with all of you.

Last, we just received the prototype from CSEM and are looking forward to exploring new research venues with the mobile device.

I hope you will enjoy this issue of the eXperience Newsletter. Wishing you a wonderful summer!

Virginie van Wassenhove, WP2 leader

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Name: Virginie
Surname: van Wassenhove
Title: Research Director
Affiliation: CEA, INSERM, University of Paris-Saclay

1. Favorite areas of interest and research

Human mind/brain, temporal cognition, multisensory perception, neural oscillations

2. What is the most promising research direction in cognitive neuroscience?

Mutiple-scales neural coding schemes and theory

3. Which innovation influenced mostly the scienfic world in the last 10-20 years?

Artificial Intelligence has been growing, providing efficient classification techniques. Yet, we only scratched the surface: information resides in brain activity to classify images or even speech but can we exploit this even more? Optogenetics provide incredible causal insights in neural circuits.... Organoïds hold new promises to provide full control over cortical development. Consortia of researchers with the same willingness to understand the fundamental principles of brain functions are building new large-scale collaborative venues. We enter an incredibly exciting era for cognitive neuroscience research! Of course, technological and methodological advances are essential and fast developing but let's not forget that we are still in dire need of theories that can explain the mysteries of consciousness and subjective experience...!

4. What was your motivation to become a researcher?

Exploring the unknowns, reaching a deeper understanding of life's intricacies.

5. eXperience is....

A multidisciplinary group of researchers dreaming of making you feel and experience what we experience.

1. My favorite books, music, movies...

Non-fictions: *«The organization of learning» by R. Gallistel; «Consciousness explained» by D. Dennett; «Biology of consciousness» by G.M.Edelman; «Eloge de la fuite» by H. Laborit; Hofstadter, Chomsky ...*

Fictions: *«La belle du seigneur» by A. Cohen; «Blindness» J. Saramago; «Equus» by Peter Schaffer; Austen, Ishiguro, Coetzee, Ernaux, Kundera, ...*

Music: *F. Schubert, D. Scarlatti, J.S. Bach, Coltrane, Radiohead, ...*

Movies: *Solaris, A single man, Ma loute, Mon oncle d'Amérique, The handmaid's tale, Inception, Eternal sunshine of a spotless mind...*

2.I like to spend my free-time....

Mind-wandering, emitting sounds on a piano, poetry, classical concerts, operas, museums, nature,...

3. The personality trait I really like....

When one's word is fully consistent with one's action.

4. My best verse...

The Brain - is wider than the Sky -
For - put them side by side -
The one the other will contain
With ease - and you – beside –
[…]

Emily Dickinson (1862)

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Camille Grasso, Ph.D., is a postdoctoral researcher involved in the EXPERIENCE Project. She is a qualified neuropsychologist and a cognitive scientist trying to understand how humans make sense of time. During her PhD, she worked on the representation and processing of abstract temporal concepts such as past and future. Currently, she is heading towards using a combination of methods (e.g., EEG, machine learning, optimal transport) to investigate how humans understand, feel, and estimate time. Specifically, she investigates the influence of spatial constraints on duration estimates and the inter-individual differences of durations representations and tries to align these representations between individuals in a purely unsupervised manner. She is a passionate researcher, who loves talking about science and who is always in quest of learning and understanding new things! Participation in eXperience: WP2.

Christina Yi Jin, Ph.D., was a postdoctoral researcher involved in the EXPERIENCE Project. She is a cognitive neuroscientist with expertise in mind-wandering and computational neuroscience. Christina contributed to setting up the VR equipment at Neurospin. She conducted an EEG study testing the different components of the internal clock through cognitive modeling (Adaptive-Thought-of-Control (ACT-R)) combined with neural decoding techniques. Timing performance was found to be influenced by both timing and non-timing factors, and the internal clock to reflect the amount of sensory processing. Christina is now a researcher at the Research Center for Augmented Intelligence in Zhejiang Lab, Hangzhou, China. Participation in eXperience Wps: WP2.

Matthew Logie, Ph.D., is a postdoctoral researcher working on the EXPERIENCE Project. He is a cognitive neuroscientist conceptually leaping towards memorable moments of change. He is primarily interested in developing theoretical accounts of cognition and develops virtual reality software to conduct both behavioural and neuroimaging experiments. The results of the experiments answer questions about how and why the segmentation of contextual drift influences both memory for details and subjective temporal experience. Participation in eXperience: WP2.

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Aligning experiential qualia

No object or situation is experienced twice in exactly the same way. Therefore, it is reasonable to expect a large degree of intra- and inter-individual variability in human subjective experiences. One of the major challenges of cognitive sciences is to find laws and regularities that can be generalised from situations to situations or from individuals to individuals.

Shepard (1980) proposed that such laws should be formulated within the appropriate - abstract - psychological space. Precisely, Shepard argued that whereas there is no necessary equivalence between a representation and its corresponding external object, there should exist a second-order structural resemblance (or "isomorphism") between relations among internal representations and relations among the external objects these representations refer to. For instance, whereas there is no necessary resemblance between my internal representation of red and the physical colour red, the relation between my red and my blue should be similar to the relation between blue and red. Importantly, as your "red" may not exactly correspond to my "red", modern supervised methods (e.g., representational similarity analysis) that assume a strict a priori correspondence between points across domains may fail to find or appropriately quantify correspondences.

Considering instead the similarities in similarity structures across individuals, a recent paper from Kawakita et al. (2023) showed that it is possible to align the subjective experience of colours across individuals in an unsupervised manner. In a first step, they collected behavioural similarity judgments about randomly presented pairs of colours, and summarised those in dissimilarity matrices. Then, they used multidimensional scaling to project these data into a lower-dimensional conceptual space that preserve the relative distances among colour pairs, resulting in "colour embeddings". In a second step, they used an unsupervised learning algorithm to align embeddings from different individuals based on Gromov-Wasserstein optimal transport. This algorithm tries to find the best alignment between two domains (here, colour embeddings) by considering exclusively the distances between points within each domain. Importantly, the distances (or correspondences) between points "across" different domains are not given. Said differently, the method does not assume a priori that this point in domain X (e.g., my "red") will correspond to this other point in domain Y (e.g., your "red"). Moreover, although the method successfully aligns the colour embeddings between individuals with typical vision, it does not work when trying to align embeddings between colour-typical and colour-atypical participants.

This paper supports Shepard's early proposition: invariances across situations, individuals, and/or species require the appropriate psychological space (here, the conceptual space defined by similarity structures). I anticipate that this method, based on a simple but powerful idea (and which can be applied to any sort of input behavioural or neural data), will have a great impact on many fields interested in the structure of representations and their alignment (e.g., cognitive sciences, neuroscience, machine learning), by providing new ways to understand human cognition and inter-individual differences.

By **Camille Grasso**

- Kawakita, G., Zeleznikow-Johnston, A., Tsuchiya, N., & Oizumi, M. (2024). *Scientific Reports*, *14*(1), 15917.
- Shepard, R. N. (1980). *Science*, *210*(4468), 390-398.

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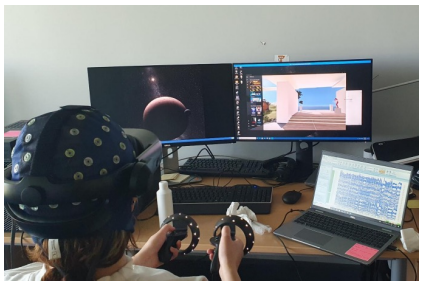
New Results: Separating sensory from timing processes: a cognitive encoding and neural decoding approach

The internal clock is a psychological model for timing behavior. According to information theory, psychological time might be a manifestation of information flow during sensory processing. Herein, we tested three hypotheses: (1) whether sensory adaptation reduces (or novelty increases) the rate of the internal clock (2) whether the speed of the clock reflects the amount of cortical sensory processing? (3) whether motion tunes clock speed. The current study used an oddball paradigm in which participants detected duration changes while being recorded with electroencephalography (EEG). For data analysis, we combined cognitive modeling with neural decoding techniques. Specifically, we designed Adaptive-Thought-of-Control (ACT-R) models to explain human data and linked them to the sensory EEG features discovered through machine learning. Our results indicate that timing performance is influenced by both timing and non-timing factors. The internal clock may reflect the amount of sensory processing, thereby clarifying a long-standing sensory timing mystery.

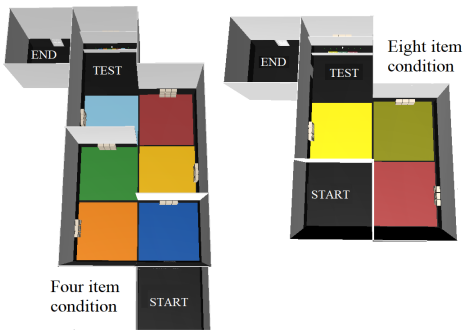
Jin, C. Y., Razafindrahaba, A., Bordas, R., & van Wassenhove, V. (2024). Separating sensory from timing processes: a cognitive encoding and neural decoding approach. bioRxiv, 2024-06.

Ongoing Studies

Passage of time and time perception in virtual reality (VR): The feeling that time passes is a core component of consciousness and episodic memory. EEG data are being collected while participants are seated in a VR environment of different sizes. Spectral dynamic analyses and time-resolved multivariate decoding techniques are being implemented to separate the distinct effects of time, VR size and their interactions.



https://youtu.be/xPUBO6zcJCM



Interplay between the fidelity of memory and experience of time in VR: The encoding of episodic memories depends upon segmenting the continuous flow of information encountered throughout life. The fidelity of memory may depend upon whether information presented within boundaries fits within working memory capacity. We created a novel virtual environment and seek to improve the accuracy (what) and fidelity (when, where) of episodic memory by limiting the quantity of information between context-shifts. Across multiple measures, including recognition, when and where judgements and response times, and EEG we show that context shifts drive the experience of time and the fidelity of memory by acting as triggers for the compression and encoding of sequences at multiple timescales.

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Last&Next Events

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15-19 July 2024 | Orlando FL, USA

46th Annual International Conference of the IEEE Engineering in Medicine and Biology Society

As social determinants of health take on an ever-important role, the conference theme, "Technology and its promise for equity and access for well-health," addresses the great potential impacts that engineers can provide to the whole of society. At this world's largest international biomedical engineering conference, a broad array of scientific tracks will cover diverse topics of cutting-edge research and innovation in biomedical engineering, healthcare technology, in particular for women and children's well-health, translational clinical research, technology transfer and entrepreneurship, and biomedical engineering education. In addition to the high-profile keynotes, the conference program will feature mini symposia, workshops, special sessions, oral and poster sessions, sessions for students and young professionals, sessions for clinicians and entrepreneurs, and exhibits from vendors and universities.

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Consortium Meeting

19-20 September 2024 | Rome (Italy)

Executive Board and General Assembly meeting @ UNITOV, Rome

The next Executive Board & General Assembly Meeting (EB-GA) will be held in person at the University of Tor Vergata on 19-20 September 2024, to get an overview of the ongoing and future research activities and of the overall management of the project.

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Latest publications

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JOURNALs

Ferrante M., Boccato T., Passamonti L., Toschi N.;"Retrieving and reconstructing conceptually similar images from fMRI with latent diffusion models and a neuro-inspired brain decoding model" in Journal of Neural Engineering, 2024 vol. 21 n. 4.

Catrambone V., Candia-Rivera D., Valenza G.; "Intracortical brain-heart interplay: An EEG model source study of sympathovagal changes" in HUMAN BRAIN MAPPING, 2024, vol 45 issue 6.

Valenza G., Di Ciò F., Toschi N., Barbieri R.; "Sympathetic and parasympathetic central autonomic networks. Imaging Neuroscience" 2024; vol. 2 1–17.

Frassineti L., Catrambone V., Lanatà A., Valenza G.; "Impaired brain-heart axis in focal epilepsy: Alterations in information flow and implications for seizure dynamics". Network Neuroscience 2024; vol. 8 issue 2: 541–556.

Ghouse A., Pfurtscheller G., Schwarz G. and Valenza G., "Uncovering Hemispheric Asymmetry and Directed Oscillatory Brain-Heart Interplay in Anxiety Processing: An fMRI Study," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 32, pp. 1984-1993, 2024.

Scarciglia A., Catrambone V., Bianco M., Bonanno C., Toschi N., Valenza G.;"Stochastic brain dynamics exhibits differential regional distribution and maturation-related changes". NeuroImage, vol. 290, 2024.

Ferrante M., Boccato T., Ozcelik F., VanRullen R., Toschi N.; "Through their eyes: Multi-subject brain decoding with simple alignment techniques". Imaging Neuroscience 2024; vol. 2 1–21.

Mora, P.; Garcia, C.; Ivorra, E.; Ortega, M.; Alcañiz, M.L. Virtual Experience Toolkit: An End-to-End Automated 3D Scene Virtualization Framework Implementing Computer Vision Techniques. Sensors 2024, 24, 3837.

Valenza G., Alcañiz Raya M. L., Carli V., Dudnik G., Gentili C., Guixeres J., Rossi S., Toschi N., van Wassenhove V. "The EXPERIENCE project: automatic virtualization of "extended personal reality" through biomedical signal processing and explainable artificial intelligence" in IEEE Signal Processing Magazine vol. 41 issue 1, 2024.

Boccato T., Ferrante M., Duggento A., Toschi N. "4Ward: a Relayering Strategy for Efficient Training of Arbitrarily Complex Directed Acyclic Graphs" in Neurocomputing vol. 568, 2024.

Scarciglia A., Catrambone V., Bonanno C., Valenza G., "Physiological Noise: Definition, Estimation, and Characterization in Complex Biomedical Signals" in IEEE Transactions on Biomedical Engineering, vol. 71, issue 1, pp. 45-55, 2024

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