

## **1. CONSEQUENCE: A Unified Model of Cognitive Control and Sequential Episodic Memory**

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Episodic memory research has given rise to the development of novel behavioral control algorithms, most of them involving the storage of static items, leaving aside the importance of temporal order. Other contextual information like goals and task states and their influence on episodic memory operations are most often overlooked too. In order to overcome these limits, a new model is proposed for the storage and recall of sequential episodic memories and their interaction with cognitive control. The model is designed in alignment with key properties of the anatomy, representations and dynamics of the prefrontal cortex and the medial temporal lobe. The prefrontal cortex module interacts with the hippocampus in a bidirectional manner, accounting for both top-down control over memory and episodic control. A neural network implementation of the model is used to assess the biological and behavioral validity of the model in a set of exemplar tasks. Overall, the model is capable of one-shot learning of sequences, modulating the retrieval of these sequences contextually, taking memory retrieval into account for simple decision-making and accounting for various phenomena commonly associated with the target brain regions. This paves the way for new developments that integrate both model-based and episodic control for making reinforcement learning algorithms more flexible and robust. The model also provides a better view of how memory and executive functions might interact in the brain.

## **2. Cognitive effects of oral chronic administration of tramadol in Sprague-Dawley rats**

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The elderly is particularly vulnerable to falls. A number of risk factors have been identified, including chronic use of medications which can lead to adverse effects, particularly cognitive ones. Confusional syndrome is common in older people (Siddiqi et al., 2006) and is defined by a sudden deterioration in vigilance or attention, but can also affect all cognitive functions (memory, spatiotemporal orientation, etc.). Tramadol, listed in many medical guidelines for pain management (Subedi et al., 2019), carries a risk of confusion (Haute Autorité de Santé, 2009) or cognitive disorders after chronic administration. According to the ANSM (Agence Nationale de Sécurité du Médicament et des produits de santé), it was the most widely used opioid analgesic in France in 2017, and its use is increasing (+68% between 2006 and 2017). In order to study the effects of chronic consumption of tramadol on cognition, a study was conducted in 24 male Sprague Dawley rats (6 weeks-old) over a 6-week administration period. To be as respectful as possible of animal welfare and closer to clinical reality, tramadol was dissolved in 3/10ths diluted sweetened condensed milk and administered orally by micropipette. 3 groups were set up for the study: a control group (sweetened condensed milk only) and two groups receiving tramadol at 25mg/kg/d and 50mg/kg/d. Tramadol was administered in the evening in order to observe the residual effects of chronic administration during behavioral tests which took place in the morning. After the first tramadol acute administration, rats were placed in actimeters in order to observe their behavior for 24 hours after tramadol administration as a model of confusion-like behavior evaluation. To assess spatial recognition memory, executive functions, episodic memory and balance, we performed the Morris Water Maze tests without and then with reversal, object recognition and the grid walking test, respectively.

### **3. Odometer process in the medial entorhinal cortex.**

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Path integration is a navigation strategy that requires the animal to integrate the distance and orientation of the movement relative to a starting location. The medial entorhinal cortex (MEC) has been suggested to play a key role in path integration. The inactivation of the MEC or perturbation of its neural oscillations impair self-motion distance computation. Moreover, the MEC contains the grid cells whose the regular hexagonal pattern of firing fields is sustained by self-motion information and integrates the travelled distance. However, it is not known how the MEC network supports distance computation and whether it is also involved in integrating learned distance information.

In this study, we recorded MEC neuronal and LFP activity in rats performing a task in which they learned to travel specific distances in a linear track using self-motion information (outbound path) and to turn and go back to the starting point to get a reward (inbound path). We demonstrated that MEC neurons (including grid cells and non-grid cells) fire at movement onset and at learned distances exclusively during the outbound paths while neuronal activity was generally lower during the inbound paths. Conversely we observed that during the inbound paths the LFP theta-gamma coupling was stronger. Moreover during both outbound and inbound paths a transient increase of beta-band power in the LFP preceded the arrival at aimed distance or reward.

Our results demonstrate that the MEC neurons signal learned distances when they are relevant for navigation and that the MEC network is able to shift to a different state possibly corresponding to other cognitive processes (offline information maintenance or reward expectation) when distance estimation is not relevant. This confirms and expands previous evidence about a role of MEC during self-motion based navigation and supports the hypothesis of a polyvalent and flexible role of the MEC in cognitive processes including spatial navigation and memory.

### **4. Retrosplenial cortex activity represents both local and global space**

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Every day, we navigate between connected rooms to reach goals. This requires a mental map of the environment based on two reference frames: one for each room (local reference frame) and one including spatial relationships between all connected rooms (global reference frame). Recent studies in rodents suggest that the retrosplenial cortex (RSC) may simultaneously code for both reference frames. Indeed, single unit recording in rats exploring two symmetrical connected rooms show that RSC contains two distinct functional cell populations: head direction cells (HDC) firing when the animal faces a particular direction regardless the number of rooms thus providing a global directional signal; and bi-directional cells (BDC) displaying distinct directions each specific for one room, suggesting that their activity is anchored to a local space. Here we tested whether these two populations of cells still provide global and local directional signals in environments with two or four visually different connected rooms. We found that HDC firing direction is maintained regardless of the number of rooms. Furthermore, BDC fire in two directions when rodents navigate between two different connected rooms and tend to fire in four directions in four connected rooms. We also observed that non-directional RSC cells show identical spatial activity but reversed between connected rooms, similarly to BDC. This indicates that coding of local and global spaces is not limited to HDC and BDC. Altogether, these results confirm that RSC may form global and local reference frames necessary for the construction of a cognitive map which allows navigation in complex environments.

## **5. Les erreurs de mémoire sémantiques et phonologiques en tâche de mémoire de travail au cours du développement**

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Les faux souvenirs désignent le fait de se souvenir d'événements qui n'ont pas été vécus mais qui présentent des caractéristiques sémantiques ou de surface (par exemple, phonologiques) similaires à des expériences réelles. Des recherches récentes ont montré que les faux souvenirs sémantiques peuvent survenir dans des tâches de mémoire de travail qui nécessitent de retenir peu d'éléments pendant quelques secondes. Ces erreurs sémantiques apparaissent dès l'âge de 4 ans et augmentent jusqu'à l'âge adulte. Cependant, les résultats des études qui portent sur le développement des erreurs phonologiques restent contradictoires. L'objectif de cette étude est double : comparer les changements développementaux des erreurs sémantiques et phonologiques de l'enfance à l'âge adulte et examiner le rôle des mécanismes de maintien de la mémoire de travail sur leur apparition. Dans un paradigme d'empan complexe, des enfants de 8 ans et de jeunes adultes mémorisent de courtes listes de mots sémantiquement ou phonologiquement reliés - en vue d'un rappel ultérieur - tout en effectuant une tâche concurrente qui empêche ou non la rétention des mots en mémoire de travail. La collecte de données est en cours. Nous pensons que le fait d'empêcher le maintien en mémoire de travail augmentera les erreurs sémantiques chez les adultes plus que chez les enfants et inversement, diminuera les erreurs phonologiques chez les adultes plus que chez les enfants. Cette étude permettra de mieux comprendre le rôle de la mémoire de travail dans l'émergence de faux souvenirs de différentes natures.

## **6. Local expansion of the grid cell map during a goal directed navigation task.**

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The aim of this project is to characterize how grid cells code spatial information during goal-directed navigation. Previous studies on the effect of goal on grid cells activity merged goal location with reward, making difficult to conclude about the nature of the information (i.e. location or reward) integrated by the grid cells network. We used a continuous-goal directed navigation task which allows separating spatial goal from the reward. We found a local distortion of the grid map around the goal that only emerges when a halt inside the goal zone is required to obtain the reward. This indicates that the grid map distortion does not simply reflect a goal coding but also integrates temporal constraints of the task. This parallels previous results demonstrating that in the same task the hippocampal place cells code for goal location through a local out-of-field activity.

We are thus performing concurrent recordings of hippocampal and entorhinal neurons to test the hypothesis that modifications of the grid and the place maps emerge in parallel. Our results strengthen the view that neuronal activity on the entorhinal-hippocampal network does not simply map the environment in a pure spatial representation but instead provides a complex representation of external events within their spatio-temporal context.

## **7. Dynamic of prefrontal cortex and dorsolateral striatum in the automation of working memory**

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Memory is a function that allows any organism to learn, consolidate and retrieve information processed by neural networks in our brain. In the brain, the hippocampus is the main structure for memory, it integrates spatial information while participating in the formation of memories. Working memory is the temporary representation of information that has just been experienced or retrieved from long-term memory. It is subject to various operations that make the information useful for goal-oriented behavior. Studies on this memory have identified the prefrontal cortex as a key structure for this memory. Indeed, inhibition (Bauer et al, 1976) and recording (Miller et al, 1996) experiments have shown that this structure is fundamental for spatial working memory and that in association with the hippocampus it participates in the encoding of information in this memory (Spellman et al, 2015). Our study focuses on the evolution of the encoding of learned information within the medio prefrontal cortex during a spatial working memory task. To do so, we inhibited the prefrontal cortex using an inducible inhibition technique (DREADD). By measuring the performance of this memory on a specific task, our results suggest that the prefrontal cortex plays a crucial role in the initial learning of the task but is not required anymore when the task is overtrained and becomes more automatic. Then, we tested the possibility of a relay from the dorsal striatum in this automation through the inhibition of the striatum (DREADD) when the animals are overtrained. Our study has shown that the striatum is involved in maintaining the rule memory in working memory once the behavior has become habitual. We were also able to observe that a disturbance of the striatum during this phase induces a new adaptation of the learning strategy towards goal-directed behavior. Our study seeks to explain the unexpected evolution of learning strategies through the analysis of specific neuronal dynamics.

## **8. Rhythmic sensory stimulation to restore brain dynamics and boost memory in early Alzheimer's disease**

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Alzheimer's disease (AD) is a neurodegenerative pathology characterized by a progressive and irreversible deterioration of cognitive functions, especially memory. A critical challenge in current research on AD is to find a reliable and early marker of the disease. Recently, our team showed that the new humanized *App<sup>NL-F</sup>xMAPT* double knock-in (dKI) mouse model could generate key information on the initial disease's stage. To better characterize network alteration in the early stage of the disease, we performed long-term high-density EEG recording starting at 2-month of age in dKI and control littermate mice undergoing behavioral testing. Using EEG microstates dynamic analyses, our preliminary results show a decrease in microstates transition together with a reduced microstates sequences complexity starting at 4-months in dKI mice. Strikingly, these microstates dynamic alterations were concomitant with the emergence of the first recognition deficits in an object-place association task. This prompts us to test the effect of a non-invasive visual stimulation on EEG microstates dynamic as recent studies have shown that 40 Hz gamma entrainment via visual stimulation protocol (vGENUS) reduce AD pathology (both at the behavioral and histopathological levels). We showed that vGENUS treatment effectively rescued memory deficits in the object-place association task as well as EEG microstates dynamic and complexity in dKI mice. Our results therefore provide new insight into

early network dynamic alterations and beneficial effect of a non-invasive gamma visual stimulation in AD.

## **9. La face cachée des normes psycholinguistiques : le *midscale disagreement problem* et ses implications**

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Les dernières années ont été marquées par une prolifération des travaux sur le rôle des informations sensori-motrices dans le traitement des mots, ainsi que des normes psycholinguistiques visant à en saisir les différentes dimensions (e.g. concrétude, forces d'action et de perception, manipulabilité). Celles-ci sont cruciales pour la sélection des stimuli expérimentaux, permettant notamment le contrôle des effets susceptibles d'influencer les résultats et ainsi d'assurer la validité des études. Leur disponibilité croissante, ainsi que celle des méga-études, permet par ailleurs de réaliser des analyses sur des centaines – voire des milliers – de mots afin d'étudier les processus sous-jacents leur reconnaissance et leur traitement. Cependant, et malgré leur importance, la validité méthodologique des normes n'a été que très peu étudiée. Les normes sont typiquement obtenues en moyennant les réponses à une échelle de Likert de plusieurs participants pour un item donné. Cette moyenne est alors interprétée comme représentant la position de l'item sur le continuum de la variable d'intérêt. Or, plusieurs patterns de réponses peuvent aboutir à une moyenne vers le milieu de l'échelle, sans pour autant refléter un consensus entre les participants (le *midscale disagreement problem*). À travers des données de Body-Object Interaction recueillies par notre équipe, nous mettons en évidence que le score moyen de la plupart des items se trouvant vers le milieu de l'échelle reflète en réalité un désaccord entre les participants et non leur position réelle sur le continuum. Nous présentons notamment trois conséquences majeures qui découlent de ce problème et explorons l'impact qu'elles ont sur la fiabilité des études qui utilisent des normes. Nous proposons finalement quelques recommandations de bonnes pratiques à adopter pour leur usage.

## **10. Evaluation of the involvement of the nociceptin system in acute stress and aversivememory in a mouse model of fear conditioning.**

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Stress has deleterious effects on memory processes, and can lead to symptoms of anxiety or depression. The mechanisms underlying these effects are not yet fully understood.

It has been shown that chronic or traumatic stress can lead to the dysregulation of an opioid-related neuropeptidergic system, composed of the Nociceptin/OrphaninFQ (N/OFQ) peptide and its G protein-coupled receptor called NOP (Gavioli et al, *Peptides*, 2021). Notably, curative administration of NOP receptor antagonists can reverse anxiety and hyperalgesia symptoms in a rat model of post-traumatic stress disorder (Zhang et al, *British Journal of Pharmacology*, 2015). More interestingly, we recently showed that acute blockade of the nociceptin system prevented the negative consequences of aversive stress in mice (D'Oliveira da Silva et al, *Neuropharmacology*, 2022). We can therefore propose that early administration of NOP antagonists has the capacity to modulate acute stress reactivity and related plasticity.

Here, we tested this hypothesis in an auditory fear conditioning model. The effect of blocking the nociceptin system on fear memory establishment and extinction was studied using a specific NOP

antagonist. At the same time, neuronal activity within neural circuits involved in fear conditioning was studied. Cellular analyses included global brain mapping of the cFos marker and identification of activity correlations between brain regions involved in fear and anxiety. We observed that blocking NOP receptors at the time of fear conditioning increased neuronal activity in a restricted set of region and notably in the central amygdala.

Characterization of the neuronal regions and networks activated during stress, and their modulation by the nociceptin system, will further our understanding of this system and its therapeutic potential.

*D'Oliveira da Silva, F., et al., The NOP antagonist BTRX-246040 increases stress resilience in mice without affecting adult neurogenesis in the hippocampus. Neuropharmacology, 2022. 212: p. 109077.*

*Gavioli, E.C., et al., Nociceptin/orphanin FQ receptor system blockade as an innovative strategy for increasing resilience to stress. Peptides, 2021. 141: p. 170548.*

*Zhang, Y., C.D. Simpson-Durand, and K.M. Standifer, Nociceptin/orphanin FQ peptide receptor antagonist JTC-801 reverses pain and anxiety symptoms in a rat model of post-traumatic stress disorder. Br J Pharmacol, 2015. 172(2): p. 571-82.*

## **11. Strategies and Cognitive Aging: The Role of Emotions.**

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Introduction

Numerous studies have shown that memory performance depends on several factors, such as encoding strategies and emotion, and that these factors interact with age. It is well established that memory performance declines with age (Rhodes et al., 2019). However, this decline is modulated by emotions. In fact, older adults remember positive stimuli better than negative stimuli, a result known as the positivity effect (Mather & Carstensen, 2005). In general, it was shown that emotions can modulate encoding, consolidation, and retrieval in memory (Crowley et al., 2019) and this is whether the stimulus is emotional or presented in an emotional context (Kensinger & Schacter, 2008). However, to our knowledge, no studies have examined yet whether emotions modulate the selection and execution of memory strategies in young and older adults. Thus, the current study examines the influence of emotions on episodic memory through the variations in the choice of strategy that older adults make.

We predict that memory will be significantly enhanced in the positive relative to the negative and neutral encoding contexts. We also expect that emotional context should influence strategy choice used during encoding.

### **Methods**

37 participants ( $M=69.053$ ,  $SD=5.141$ ) studied 3 blocks of 16 concrete words on a computer. Each block contained 16 neutral words superimposed on neutral, negative, and positive images selected from the International Affective Picture System (IAPS; Bradley & Lang, 2017) according to their valence and arousal. After a 4-second presentation of each word, participants had to specify which one of two encoding strategies (repetition or mental imagery) they had used by clicking on the mouse. Free word recall was tested immediately after each block.

### **Results**

There was no significant effect of emotion ( $F(2,70)=1.351$ ,  $p=0.266$ ,  $\eta^2p=0.037$ ) and strategy choice ( $F(1,35)=2.069$ ,  $p=0.159$ ,  $\eta^2p=0.056$ ) on memory performance, nor an interaction between these two variables ( $F(2,70)=0.350$ ,  $p=0.706$ ,  $\eta^2p=0.010$ ).

There was no effect of emotion on strategy choice ( $F(1,392,50.097)=0.433$ ,  $p=0.579$ ,  $\eta^2p=0.012$ ). Hence, there was in general a significant preference among older adults to choose repetition ( $M=28.081$ ,  $SD=15.653$ ) as compared to mental imagery ( $M=16.297$ ,  $SD=14.039$ ).

Interestingly, we found a significant difference in the efficiency of the chosen strategy during encoding ( $F(1,11)=5.248$ ,  $p=0.043$ ,  $\eta^2p=0.323$ ) with mental imagery ( $M=52.947$ ,  $SD=22.595$ ) being more efficient for recall than repetition ( $M=40.044$ ,  $SD=16.218$ ). However, no main effect of emotion on strategy

efficiency ( $F(2,22)=0.217$ ,  $p=0.806$ ,  $\eta^2p=0.019$ ) and no interaction effect were found ( $F(2,22)=0.932$ ,  $p=0.409$ ,  $\eta^2p=0.078$ ).

### Discussion

Contrary to our prediction, positive context did not enhance memory performance relative to negative and neutral context. In addition, negative context did not influence memory. Participants chose repetition more frequently than mental imagery. However, when they chose the mental imagery strategy, item memorization became more efficient. Our data suggests that memory performance is not influenced by emotional context (Moore et al. 2021) nor by the choice of strategy. But the memory performance becomes better with more elaborate strategy, i.e. mental imagery.

*Crowley R, Bendor D., Javadi, AH. (2019) A review of neurobiological factors underlying the selective enhancement of memory at encoding, consolidation, and retrieval. Prog Neurobiol. doi: 10.1016/j.pneurobio.2019.04.004.*

*Kensinger, E. A., & Schacter, D. L. (2008) Memory and emotion. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), Handbook of emotions (pp. 601–617). The Guilford Press.*

*Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005) International Affective Picture System (IAPS) [Database record]. APA PsycTests. <https://psycnet.apa.org/doi/10.1037/t66667-000>.*

*Mather, M, Carstensen LL. (2005) Aging and motivated cognition: the positivity effect in attention and memory. Trends Cogn Sci. doi: 10.1016/j.tics.2005.08.005.*

*Melody M. Moore, Emily J. Urban-Wojcik & Elizabeth A. Martin (2021) Emotional context effects on memory accuracy for neutral information, Cognition and Emotion, 35:4, 774-789, DOI: 10.1080/02699931.2021.1874880*

*Rhodes, S., Greene, N. R. & Naveh-Benjamin. (2019) M. Age-related differences in recall and recognition: a meta-analysis. Psychon. Bull. Rev. 26, 1529–1547. doi: 10.3758/s13423-019-01649-y.*

## **12. Mémoire autobiographique et continuité du Self au cours du vieillissement**

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Au cours du vieillissement, l'apparition progressive de troubles cognitifs peut engendrer des difficultés importantes de mémoire impactant la qualité de vie et l'autonomie des personnes âgées. Particulièrement, des difficultés de mémoire autobiographique ont souvent été rapportées et pourraient être liées à des troubles de l'identité et des troubles du comportement qui auraient des répercussions importantes sur la dynamique des interactions familiales et sociales. En effet, la diminution du Self, ensemble des représentations et connaissances liées à soi, peut être expliquée par l'affaiblissement de la mémoire autobiographique (El Haj et al., 2019).

Bien que les liens entre la mémoire autobiographique et le Self soulèvent un grand intérêt, les connaissances sur la nature de ces liens restent encore incomplètes. L'objectif de notre travail est d'atténuer l'affaiblissement de la mémoire autobiographique pour étudier les conséquences sur la continuité du Self. Pour cela, nous allons entraîner des participants âgés de 65 à 95 ans à la récupération des détails mnésiques en utilisant l'Induction de Spécificité Épisodique (Purkart et al., 2019). Cette méthode permettrait d'induire une augmentation de la production de détails de nature épisodique lors de la description d'un événement autobiographique. Ainsi, nous supposons que l'amélioration de la qualité de remémoration des souvenirs autobiographiques aurait un impact positif sur la construction et le maintien du Self des participants.

A ce jour, l'inclusion des participants est encore en cours, ne nous permettant pas de présenter les résultats obtenus qui seront bien analysés et présentés pour le GDR début octobre.

Ce projet nous permettrait de mieux comprendre les liens entre la mémoire autobiographique et le Self lors du vieillissement. Par la suite, l'inclusion des personnes âgées ayant des troubles cognitifs est envisagée afin d'apprendre davantage sur l'évolution du Self au cours des maladies neurodégénératives.

*El Haj, M., Boudoukha, A., Antoine, P., Moustafa, A. A., Gallouj, K., & Allain, P. (2019). Memories Supporting Myself:*

*Autobiographical Memory Supports Self-Continuity in Alzheimer's Disease. Journal of Alzheimer's Disease, 70(4), 1217-1224. <https://doi.org/10.3233/JAD-190440>.*

*Purkart, R., T. Vallet, G. & Versace, R. (2019). Améliorer la remémoration d'évènements autobiographiques et l'imagination d'évènements futurs grâce à l'induction de spécificité épisodique : adaptation et validation en Français. L'Année Psychologique, 119(1), 25-53. <https://doi.org/10.3917/anpsy1.191.0025>*

### **13. Neural correlates of attentional refreshing**

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There are several maintenance mechanisms for verbal information in Working Memory (WM). Verbal rehearsal, which refers to the articulatory repetition of information, is one of the most commonly used mechanisms. However, when verbal rehearsal is interrupted by a concurrent task involving articulation, the information is lost. This raises the question of which other maintenance mechanism may be used to retrieve verbal information when verbal rehearsal is not possible. One of the proposed mechanisms to account for the maintenance of verbal information is attentional refreshing, a mechanism that consists on the reactivation of memoranda in WM by bringing it to the focus of attention. Recent work suggests that attentional refreshing involves the use of mental imagery as a strategy since it has been observed a parietal-occipital alpha desynchronization during an attentional refreshing task, which in turn implies the involvement of visual areas. However, the link between mental imagery and attentional refreshing has not been directly studied yet. The present EEG project investigates this link directly. Participants (n=30) were requested to maintain concrete words either by using mental imagery or by using semantic linking strategies. Preliminary results showed that performance was higher in the condition using mental imagery, and that the mental imagery condition, but not the semantic linking condition, involved occipital alpha desynchronization. Moreover, and in line with previous studies, there was frontal theta activation during word maintenance (regardless of the strategy used). Theoretical implications of our results will be discussed further.

### **14. Clinical efficiency and pleasantness of EMDR and MOSAIC therapy for PTSD**

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Bilateral alternating stimulation (BAS) as used in EMDR therapy for PTSD allows desensitization of emotions associated with the traumatic memory without the use of medication. In order to understand the mechanism of action of these BAS, a model of PTSD, that of fear conditioning/extinction was used in mice (Wurtz et al., 2016) and humans. The presentation aims at explaining how these BAS modifies the brain and what are the implications of this understanding.

The addition of BAS during fear extinction allowed for the facilitation of fear extinction learning through the activation of a brain network involved in memory processing, emotions, perceptions, sensations, and self-perception (Rousseau et al., 2020). Based on these fMRI findings, the neural model of stochastic synchronization was constructed to explain the action of BAS in EMDR (Khalifa, 2019; Khalifa, 2021). This model has made it possible to propose another way of using BAS in PTSD, and thus



to build a new therapy for PTSD that avoids confrontation and exposure to the traumatic memory, the MOSAIC therapy (alternating eye movements and stimulation for brain integration) (Khalifa & Poupard, 2021). This therapy appears to be much more pleasant for PTSD patients and just as effective as EMDR therapy (Flatot-Blin et al., submitted). MOSAIC therapy thus avoids the risks of abreaction and dissociation for patients, and the risks of vicarious trauma for psychotherapists.

1. Khalifa S, Poupard G. MOSAIC: A New Pain-Free Psychotherapy for Psychological Trauma. *Am J Psychother.* 2021 Mar 1;74(1):40-43.
2. Rousseau PF, Boukezzi S, Garcia R, Chaminade T, Khalifa S. Cracking the EMDR code: Recruitment of sensory, memory and emotional networks during bilateral alternating auditory stimulation. *Aust N Z J Psychiatry.* 2020 Apr 9:4867420913623.
3. Wurtz H, El-Khoury-Malhame M, Wilhelm F, Michael T, Beetz EM, Roques J, Reynaud E, Courtin J, Khalifa S, Herry C. Preventing long-lasting fear recovery using bilateral alternating sensory stimulation: a translational study. *Neuroscience* 2016; 321: 222-235.

## **15. CHARACTERIZATION OF A RAT MODEL OF COGNITIVE RESILIENCE IN THE FIELD OF ALZHEIMER'S DISEASE**

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Alzheimer's disease (AD) is the most common cause of dementia related to aging. This neurodegenerative disorder is characterized by early episodic and spatial memory decline induced by progressive cerebral accumulation of amyloid peptide, hyperphosphorylated Tau and neuroinflammation. Intriguingly, some elderly appears to be less cognitively impaired than others, despite a same level of brain alteration. To explain such absence of correlation between the degree of brain lesions and the severity of cognitive symptoms, the concept of cognitive resilience (CR) has emerged. However, the brain mechanisms supporting CR still remain misunderstood mainly because their study requires the use of invasive approaches. We propose here to investigate such mechanisms in a preclinical model of CR based on the combination of a model of successful aging (LOU/c/jall rats) with a sporadic form model of AD. Adult male Wistar and Lou/c/Jall rats were bilaterally injected with a solution of streptozotocin in cerebral ventricles (3 mg/kg ; 5  $\mu$ L per ventricle). One month post-injection, cognitive performances were evaluated using a battery of behavioral tests and neurological hallmarks of the AD were investigated. STZ-treated groups did not affect locomotor activity or anxiety-like behavior, whatever the strain considered. However, STZ induced both spatial working memory and recognition memory deficits in Wistar rats but not in LOU/c/Jall ones. Finally, spatial long-term memory was similarly impaired by STZ in both strains. Already described as a model of successful aging, LOU/c/jall rats showed here preserved memory performances in a STZ model of AD. To confirm the supposed higher level of CR in LOU/c/jall rats, we then aim to demonstrate a similar level of neuropathology in both strains. A better understanding of the neurobiological mechanisms behind such CR may offer new insights in the research for new therapeutic targets for AD.

## **16. Intégration sensorielle et performances mnésiques au cours du vieillissement**

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L'émergence du concept de cognition incarnée et des modèles à traces multiples suggèrent l'existence d'une mémoire unifiée, multimodale et associative. Les traces mnésiques seraient formées de multiples composantes sensori-motrices extraites des expériences vécues, le codage neuronal étant largement distribué sur l'ensemble du cortex et en dynamique constante (Nadel et al., 2012 ; Versace et al., 2014).

Nos travaux ont pour objectif de développer un nouvel outil permettant d'étudier la genèse des connaissances en mémoire, en mesurant l'évolution des interactions entre les modalités perceptives sur les performances de rappel. Pour cela, nous avons adapté le test de mémoire SEMantique et Épisodique (SEMEP) de Valet et al. (2017), en y intégrant des items de différentes natures sensorielles. Notre échantillon se composait de 2 groupes de participants âgés de 18-28 ans et 40-55 ans. Notre protocole utilisait 33 planches de 3 items présentés sous forme d'images, de mots ou de sons, que les participants devaient associer catégoriquement par paires et apprendre. Les performances mnésiques ont été évaluées par une épreuve de reconnaissance et par des épreuves de rappel libre (immédiat puis différé).

Les résultats ont montré un effet de la forme de présentation des items sur les performances obtenues aux épreuves de mémoire. En effet, les mots étaient moins bien mémorisés et reconnus comparativement aux images et aux sons, quelles que soient les épreuves utilisées et le groupe d'âge des participants. De plus, un effet de l'âge a été mis en évidence entre les deux groupes, mais aucune interaction n'a été retrouvée.

Ces résultats sont expliqués par la nature perceptive plus prégnante des images et des sons alors que les items présentés sous forme de mots seraient de nature plus symbolique. Cette étude souligne l'intérêt d'utiliser des items de différentes natures dans l'évaluation mnésique et interroge le recours majoritaire aux tests verbaux en pratique clinique.

## **17. Hyperactivité & Altération de la mémoire de travail spatiale dans un modèle murin 3-hit de schizophrénie**

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Les déficits cognitifs et les symptômes négatifs associés à la schizophrénie sont encore mal pris en charge par les antipsychotiques actuels. La mise au point d'approches thérapeutiques innovantes est donc un enjeu majeur de santé publique. Afin de tester ces nouvelles approches, il est également essentiel de raffiner la validité des modèles animaux de cette pathologie.

Ainsi, afin de prendre en compte l'étiologie multifactorielle de la schizophrénie et l'hypothèse d'un déficit glutamatergique, nous avons mis au point un nouveau modèle murin associant trois facteurs: une susceptibilité génétique liée à fragilité de la synapse glutamatergique (absence de sérine racémase, l'enzyme de conversion de la L-sérine en D-sérine, co-agoniste obligatoire des récepteurs NMDA du glutamate) ; un stress précoce (séparation maternelle de 24h à l'âge de 9 jours) ; un traitement pharmacologique à la phencyclidine, antagoniste des récepteurs NMDA (PCP, 14 jours, 1mg/kg/jour ; s.c.).

L'objectif principal de cette étude était d'examiner, chez la souris femelle C57BL/6, d'une part, la validité de ce modèle d'un point de vue comportemental (caractérisation de déficits dans des tests modélisant les différents symptômes de la pathologie) et d'autre part, de mesurer la persistance de ces déficits.

Globalement, nos résultats démontrent que nos souris 3-hit présentent des symptômes de type positif (hyperlocomotion en open-field), des déficits de mémoire de travail spatiale (diminution du pourcentage d'alternance en labyrinthe en Y). Nous n'avons, par ailleurs, pas observé de déficit de sociabilité dans nos conditions. Concernant la persistance de ces altérations comportementales, seule l'hyperlocomotion est conservée au long cours.

Nos travaux ont permis de confirmer la validité du modèle utilisant le traitement à la PCP reproduisant certains symptômes cognitifs et de type positif.

## **18. Context Effect in Multi-Attribute Choice**

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Many daily decisions involve comparing options with multiple attributes (Tversky, 1972). Normative theories propose that an option's value should be independent of the choice set (Allingham, 2002). However, empirical studies have demonstrated that valuations can depend on other options within a choice set (Tsetsos, 2012). In this study, we investigate the impact of context effects on multi-attribute choice using a novel paradigm. Participants were asked to compare two sequences of numerical values and select the one with the higher or lower average. This paradigm allows for the study of imprecision and bias in integration and comparison without the need to infer preferences. To explore the influence of simultaneously displayed values, we manipulated how the numerical values were paired within each frame. Three conditions were examined: Condition 0, Condition 1, and Condition 2, representing pairings of close, mid-close, and distant numbers, respectively. Despite the identical displayed numbers in all three conditions, we observed significantly higher accuracy in Condition 0 compared to Conditions 1 and

2. This finding rejects models that solely rely on the set of numbers in each sequence, highlighting the importance of attribute-wise comparisons in the decision-making process. We evaluated various computational models incorporating attribute-wise comparisons using cross-validation. Our findings suggest that this phenomenon can be explained by a power function or by a model where the encoding noise depends on the distance between simultaneously presented values.

## **19. The effect of age-based stereotype threat on attentional resources in working memory.**

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Numerous studies have demonstrated that negative age-based stereotypes impair cognitive performance in older adults, an effect called age-based stereotype threat (ABST). In young adults, stereotype threat consumes working memory (WM) resources, which consequently impairs cognitive performance. Most recently, mechanisms underlying ABST have been investigated, but findings are mixed regarding the role of WM. Some studies have shown that the ABST effect reduces attentional resources, measured via a typical working memory (WM) task, the complex span task (CS), but other studies failed to replicate this effect. In these studies, the ABST effect was only examined on the memory component of CS tasks. However, these tasks are dual and also have a processing component that requires attention to perform correctly. The present study aimed to re-examine the role of WM in ABST by assessing its effect on both components of a CS task. Young (18-30) and older (60-77) adults performed a CS task designed to either elicit or reduce ABST. The attentional demand of the CS task was tailored to each individual's abilities and varied so that 1/3 of the trials were low-, 1/3 medium- and 1/3 high-attentional demanding. Older adults' concurrent task performance was significantly reduced by stereotype threat in the high demanding condition only. These findings suggest that ABST draw on attentional resources, because it impairs performance when the task requires a large amount of attentional resources.

## **20. A ROLE FOR THE CLAUSTRUM IN SLEEP-DEPENDENT MEMORY CONSOLIDATION**

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For memories to last, they should be transformed from an initially labile state to a more permanent one. This memory “stabilization”, also called memory consolidation, involves a dialog, mainly during sleep, between the hippocampus, where traces are initially formed, and the neocortex, where they are stored for long-term retention. Sleep is not a unitary process, and two sleep states, characterized by clear differences in electroencephalographic recordings, have been identified: rapid eye movement (REM) sleep (or paradoxical sleep) is characterized by strong theta (6-10 Hz) oscillations whereas non-REM sleep (or Slow-wave sleep, SWS) is characterized by the presence of cortical slow waves (1-4Hz), spindles (10-20Hz) and hippocampal sharp-waves ripples (150-200 Hz). The slow waves arising during SWS have received particularly prominent attention as they have been shown to synchronize cortical neural firing during sleep with hippocampal sharp wave ripples. It would be this synchronization that would regulate the hippocampal-cortical dialogue required for memory consolidation. However, the neural circuits that facilitate, or support, sleep-dependent hippocampal-cortical synchronization are not completely known. Recently, it was shown that neurons in the claustrum, a small subcortical region with extensive connections with the cortex, increased their activity during SWS. Further, we have recently shown that a subpopulation of claustrum neurons (CLASUB cells) sends excitatory outputs that co-innervate several parts of the cortical – hippocampal mantle, including the subiculum (the output of the hippocampal formation), the retrosplenial cortex (RSC) and the prefrontal cortex (PFC), and thus could be involved in large-scale hippocampal-cortical synchronization. However, a role for the claustrum in sleep-dependent memory consolidation has not been tested. To manipulate CLASUB cell activity, we used a double viral approach allowing the expression of the excitatory opsin ChETA specifically in these neurons. In addition, we performed simultaneous local field potentials (LFPs) recordings in the mPFC, the RSC and the dorsal subiculum. We showed that CLASUB cells stimulation with a 2Hz (5ms) pulse train of light during the 1st hour of SWS following learning was sufficient to increase memory consolidation. We are currently investigating the effect of such stimulation on the occurrence of hippocampal-cortical synchronized states.

## **21. Rôle des mécanismes de maintien en mémoire de travail dans la modulation de l'effet de fréquence.**

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La relation entre mémoire de travail (MdT) et mémoire à long-terme (MLT) fait l'objet d'un long débat. Une série d'expériences a examiné le rôle de deux mécanismes de maintien, la répétition articulatoire et le rafraîchissement attentionnel, dans la rétention des mots plus ou moins facilement récupérables en MLT, i.e., des mots fréquents et rares, respectivement. Les participants devaient maintenir des mots fréquents et rares tout en réalisant une tâche concurrente dans laquelle ils jugeaient la parité de chiffres. La demande attentionnelle de cette tâche variait afin de manipuler les opportunités de rafraîchissement. Orthogonalement, la répétition était soit encouragée par des instructions de répétition à haute voix ou bloquée via l'introduction d'une articulation concurrente. La disponibilité du rafraîchissement n'a pas modéré l'effet de fréquence. Cependant, l'utilisation de la répétition

articulatoire a réduit cet effet lorsque trois items étaient à maintenir. Cet effet s'inversait lorsque le nombre d'items excédait la capacité de maintien via la répétition articulatoire. Ces résultats suggèrent que l'impact de la MLT sur la MdT dépend de la disponibilité de la répétition.

## **22. Beneficial effects of 5-HT<sub>4</sub>Rs activation in mice: a transversal approach, from memory to its hippocampal correlates**

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Type 4 serotonin receptors (5-HT<sub>4</sub>Rs) have earned a place in the sun as a promising therapeutic target for the treatment of memory disorders. Indeed, both pro-mnesiant and anti-amnesiant effects of 5-HT<sub>4</sub>Rs activation have been repeatedly described in rodents and more recently pro-cognitive effects were identified in healthy volunteers. Despite some hypotheses have been raised, mechanisms at works still remain to be elucidated. A better understanding of the underpinning mechanisms would help to extend the beneficial effects of pharmacological 5-HT<sub>4</sub>Rs stimulation - *so far limited to the fields of Alzheimer's and Major depressive disorders as central nervous system diseases* – to additional brain pathologies such as Parkinson's and Schizophrenia. These disorders are characterized by early decline in episodic memory that are associated with alterations of hippocampal functioning. Hence, we herein addressed such mechanistic issue through a transversal approach. We investigated the effects of systemic administration of the 5-HT<sub>4</sub>Rs agonist RS67333 on different functions of hippocampal-dependent episodic-like memory and its neurobiological correlates such as hippocampal synaptic plasticity as well as plasticity-related brain oscillations and neurotransmitters. We identified location and novelty discrimination as two domains of episodic memory that could benefit from 5-HT<sub>4</sub>Rs activation. Besides, while hippocampal theta power was increased, the magnitude of long-term potentiation was reduced in a frequency-dependent manner. These changes were accompanied by reduced levels of excitatory neurotransmitter glutamate in the hippocampus. Overall, our results support that the beneficial effects of 5-HT<sub>4</sub>Rs activation on memory are intimately linked to changes in hippocampal synaptic plasticity. The latter are likely due to the observed variations in neurotransmitter levels and dependent oscillatory rhythms that are relevant for plasticity processes.

## **23. Effet des interactions avec la nature sur les apprentissages dans le milieu scolaire**

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Alors que les effets néfastes de la vie urbaine, sur la santé physique et psychologique, ont été observés, il semble pertinent de se questionner sur les effets bénéfiques au niveau cognitif du contact avec la nature afin de soutenir les projets de végétalisation en ville et d'éducation à l'écologie. De plus en plus de travaux vont dans le sens d'une cognition dite incarnée car ancrée dans le corps et émergeant de ses interactions avec le monde extérieur. Dans ce cadre, le sens du monde se construirait via nos interactions corporelles avec l'environnement, et l'efficacité de la mémoire et des apprentissages reposerait sur la richesse de nos expériences sensorimotrices.

L'objectif de notre étude est donc de démontrer les effets bénéfiques sur les apprentissages scolaires d'un contact régulier avec la nature, en favorisant les interactions sensorimotrices. Pour cela, nous avons mis en place un programme de sorties dans la nature ainsi qu'un programme d'entraînement quotidien à la simulation sensorimotrice auprès de 125 élèves de CE1. Quatre groupes expérimentaux ont été placés dans quatre conditions, alternant des phases de sorties hebdomadaires dans un parc à proximité des écoles et d'exercices de simulation sensorimotrice en classe. Les élèves ont été évalués

entre chaque changement expérimentaux. Un groupe contrôle (28 élèves) a été évalué aux mêmes moments. L'étude a pris fin au mois de juin et les résultats sont en cours d'analyse. Nous analyserons la différence de progression des élèves en fonction de la condition dans laquelle ils étaient avant l'évaluation.

#### **24. Hippocampal functional adaptation to hypergravity exposure: new insights for cognitive alterations in astronauts**

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One of the challenges for space exploration is the establishment of manned missions to Mars. These missions are the most difficult to date, mainly because of prolonged exposure to radiations and confinement, but also to repetitive gravitational intensity variations. Such variations could affect sensory systems and cognitive capacities altering crew performances. So far, the underlying cerebral mechanisms are poorly understood.

This study aimed to investigate the effects of a 24h, 48h or 15 days exposure to 2G hypergravity (HG) on C57BL/6J male mice hippocampus. Synaptic transmission and functional plasticity were investigated using electrophysiological extracellular recordings of CA1 region in *ex vivo* hippocampal slice preparations.

Basal synaptic transmission was unaffected by HG exposure. However, Long-term potentiation (LTP), induced by high-frequency stimulation (HFS, 1x100Hz, 1s), was impaired in 24h-exposed mice. LTP was not affected by 48h or 15 days exposure. NMDA receptor activation (required for LTP), was also impaired after 24h of HG, but this was compensated by delivering the NMDA co-agonist D-serine (100µM) to slices. This result suggests that the impaired NMDAR activation and consequently the LTP deficit could rely on a weaker synaptic availability of endogenous D-serine.

This electrophysiological study shows transient changes in functional plasticity in CA1 hippocampal networks of mice exposed to HG. These changes thus represent one of synaptic mechanisms possibly driving cognitive alterations (at least short term) in astronauts, notably during and/or shortly after manoeuvres in which gravity increases such as launching and landing.

#### **25. ODE À LA MÉMOIRE : L'IMPORTANCE DES SOUVENIRS DANS LA (RE)CONSTRUCTION DE L'IDENTITÉ**

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De la pensée cartésienne jusqu'aujourd'hui en passant par la théorie de Locke, la mémoire est considérée comme un élément fondamental dans la construction identitaire car elle permet d'intégrer les différents aspects de notre vie et personnalité et de regrouper les éléments du passé et du présent (Fuchs ; Scott 34). En revanche, la perte de mémoire est donc susceptible de menacer l'identité de l'individu, le problème qui est soulevé de manière riche et complexe par les auteures britanniques contemporaines, notamment Jackie Kay et Wendy Mitchell.

## **26. Intégration multisensorielle en mémoire chez les enfants avec un TSA**

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Les enfants avec un Trouble du Spectre Autistique (TSA) présentent fréquemment des particularités au niveau du traitement des informations sensorielles. Pourtant, peu d'études portent sur les répercussions de ce traitement sensoriel atypique sur leurs apprentissages, et notamment leurs capacités mnésiques. L'objectif de cette étude était d'évaluer les performances d'intégration multisensorielle en mémoire d'enfants avec TSA avec (TSA-di) ou sans déficience intellectuelle (TSA-hf high functioning), à partir de trois modalités sensorielles différentes. Pour cela, 10 enfants avec un TSA et 20 enfants neurotypiques ont participé à une tâche composée de différentes phases : familiarisation avec le matériel, apprentissage associatif, intégration à court-terme et à long-terme. Leurs performances d'intégration en mémoire, notamment à long-terme, ont été comparées avec celles d'enfants neurotypiques appariés en âge développemental. Les résultats ont montré que, si la phase de familiarisation a été réussie par tous les enfants, les performances d'intégration multisensorielle à court-terme étaient significativement inférieures chez les enfants avec TSA-di à celles des enfants neurotypiques. Les différences de performances entre les enfants avec TSA-hf et neurotypiques ont été observées sur la tâche d'intégration après un délai seulement. Les résultats sont discutés en termes de répercussions des particularités sensorielles sur les capacités d'intégration en mémoire.

## **27. Sensory modality and emotion of the retrieval cue interact in evoking episodic memory in humans**

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This study explores the combined effects of sensory modality and emotion of the retrieval cues on episodic memory retrieval.

A non-immersive virtual reality device was used to present a three-room house, allowing participants to freely explore three distinct episodes over three consecutive days. These episodes were constructed based on the three dimensions characterizing episodic memory: What (odor, music, face), Where (the rooms: bedroom, living room, office), and in Which context (the periods of the day: daytime, nighttime, twilight). On the fourth day, during the retrieval phase, participants were asked whether they recognized the encoded odors, music or faces among distractors, and to select both the room and the period in which they encountered the stimulus at encoding. Participants then rated each cue in terms of pleasantness, emotional intensity and motivation (i.e., to perceive the stimulus again).

The results demonstrated that episodic memory retrieval was influenced by both the sensory modality and the emotion of the memory cues, with these two dimensions interacting with each other. In a modality-unspecific manner, recognition and episodic memory were improved for the most pleasant and unpleasant cues. Moreover, odors were shown to be the most powerful memory cues compared to music and faces, and episodic memory performance was improved when odors were rated as more motivational. Musical excerpts specifically led to high levels of recognition memory, which was favored by the emotional intensity and motivation associated with the music, but failed to evoke episodic retrieval. Similarly, faces were not effective in triggering episodic memory retrieval.

These findings highlight the role of both emotion of the cue and sensory modality of the cue on

episodic memory performance. In particular, they highlight the ability of odors to evoke complex associative memories, such as episodic memory, potentially through their connection to motivational processes.

## **28. Can dopamine regulate exploration in a model of the rhesus monkey basal ganglia?**

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Beyond its role in reinforcement learning, the possible implication of dopamine in the regulation of the exploration/exploitation tradeoff has been addressed by a number of experimental studies (Frank et al., 2009; Costa et al., 2014; Cinotti et al., 2019). In 2012, with a relatively abstract model of the basal ganglia in rats, Humphries, Khamassi and Gurney showed that, indeed, modifying the tonic level of striatal dopamine could in principle control this tradeoff. This neural population-level model was characterized by strictly segregated direct and indirect pathways, which were differentially modulated by dopamine. Its parameterization, especially of its connection weights, was set so as to perform efficient selection between competing channels, rather than derived from an experimental estimation of these weights. In non-human primates, it has been shown that the direct and indirect pathways of the basal ganglia strongly overlap (Parent et al., 1995; Lévesque & Parent, 2005). We study here whether the phenomenon described by Humphries et al. (2012) still holds with a model of the rhesus monkey basal ganglia, which has strongly overlapping pathways, and which is parameterized in a function-agnostic manner (Liénard & Girard, 2014). We build a reduced version of this model, so as to operate at the same level of modeling as Humphries et al. (2012). We first show that, despite the pathway overlap, modulating the striatal dopamine of this model does control exploration through the tuning of the entropy of the output probability distribution, as in the original study. However, we show that the extra-striatal dopaminergic modulation results in the opposing effect. Consequently, the model predicts that dopamine can control the exploration/exploitation tradeoff in rhesus monkeys if the relative weights of striatal and extra-striatal dopaminergic modulations are within a restricted set of values.

*Cinotti, F., Fresno, V., Aklil, N., Coutureau, E., Girard, B., Marchand, A. R., & Khamassi, M. (2019). Dopamine blockade impairs the exploration-exploitation trade-off in rats. Scientific reports, 9(1), 6770.*

*Costa, V. D., Tran, V. L., Turchi, J. & Averbeck, B. B. (2014). Dopamine modulates novelty seeking behavior during decision making. Behav Neurosci 128(5), 556–566.*

*Frank, M. J., Doll, B. B., Oas-Terpstra, J. & Moreno, F. (2009). The neurogenetics of exploration and exploitation: Prefrontal and striatal dopaminergic components. Nature Neuroscience 12(8), 1062–1068.*

*Humphries, M. D., Khamassi, M., & Gurney, K. (2012). Dopaminergic control of the exploration-exploitation trade-off via the basal ganglia. Frontiers in neuroscience, 9.*

*Lévesque, M., & Parent, A. (2005). The striatofugal fiber system in primates: A reevaluation of its organization based on single-axon tracing studies. Proceedings of the National Academy of Sciences, 102(33), 11888–11893.*

*Liénard, J., & Girard, B. (2014). A biologically constrained model of the whole basal ganglia addressing the paradoxes of connections and selection. Journal of computational neuroscience, 36(3), 445-468.*

*Parent, A., Charara, A., & Pinault, D. (1995). Single striatofugal axons arborizing in both pallidal segments and in the substantia nigra in primates. Brain Research, 698(1), 280–284*



## **29. Neural bases of childhood olfactory autobiographical memory**

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Marcel Proust, in his book *Swann's Way* (1919), describes the smell of a madeleine dipped in linden tea as triggering an immense joy, bringing him back to the time of afternoons spent with his grandmother. This autobiographical memory is associated with various sensory information, notably olfactory cues. Autobiographical memory evoked by odors is often described as having very specific characteristics that differentiate it from other sensory memories. It is indeed often reported as being older and associated with greater emotions, especially positive ones. However, the neural bases of this olfactory memory formed in childhood are still poorly understood. In this context, the current objective is to model a positive olfactory episodic memory in infant mice, to study its neural signature in adulthood. Thus, mice were exposed during infancy, from postnatal day P23 to P33, to an odorant in a context of positive environment consisting of increased space, plays and social interactions with access to appetizing food. Using behavioral testings, we found that this experimental set-up allowed the odorant to be remembered in adulthood, with a positive emotional valence.

The first central structure that processes olfactory information is the olfactory bulb. There, granule interneurons, that are mainly formed postnatally and throughout life with a peak of intense proliferation between P1 and P7, shape the olfactory message. Granule cells are involved in different olfactory learnings and memory and those born during the immediate post-natal period are long-lasting, in contrast to most of those formed later in life, suggesting that they can support early-formed and long term memory. In this context, we are studying the implication of granule cells born at P1 and P7 in supporting the juvenile olfactory memory using respectively CldU and IdU, markers of cell division. In addition, we will assess the specific functional recruitment of these neurons using cFos expressions. Together these data will allow a better understanding of the neural basis of the Proust Effect.

## **30. Do the predictive processes of your brain affect your working memory?**

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The interaction between statistical learning (SL) and working memory (WM) has been examined by studying the effect of WM in SL. Nonetheless, the inverse relation (i.e. the effect of SL in WM) remains unaddressed in the literature. The present study aimed to explore the potential influence of implicit statistical learning on the maintenance of information in working memory. To investigate this relationship, we employed a modified version of the Brown-Peterson paradigm, wherein participants were required to memorize visuospatial information while simultaneously engaging in a statistical learning task based on non-adjacent sequential visuospatial regularities: the alternating serial reaction time task (ASRT). By comparing the performance of participants who completed the ASRT task to those who engaged in a control task devoid of predictive regularities, we sought to evaluate the impact of statistical learning on working memory. The results of our study revealed no significant differences in performance between the two groups in the visuospatial memory task. These findings suggest that implicit statistical learning does not interact with information actively maintained in working memory.

A possible explanation for this outcome could be that implicit predictive processes require little to no allocation of attentional resources. Further research is warranted to explore the underlying mechanisms and potential boundary conditions that govern the interaction between implicit statistical learning and working memory.

### **31. Corrélats EEG du traitement concurrent pendant le maintien en mémoire de travail visuo-spatiale**

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Ces dernières années, le rôle de l'attention dans le maintien en mémoire de travail a suscité un intérêt croissant. Des études antérieures ont examiné la façon dont le maintien en mémoire de travail modulait le traitement attentionnel concurrent au niveau comportemental. La présente étude visait à examiner cette question à l'aide de mesures EEG. Nous avons manipulé la charge mnésique dans une tâche de mémoire de travail demandant aux participants de maintenir des emplacements spatiaux, tout en effectuant une tâche de parité qui pouvait être effectuée au rythme de l'ordinateur, au rythme de l'individu, ou sans traitement simultané. Les résultats préliminaires indiquent que nous avons reproduit l'augmentation de la puissance oscillatoire avec une charge mnésique plus élevée dans les bandes thêta frontale-médiane et alpha occipito-pariétale. En outre, les potentiels liés à l'événement de la tâche de traitement au rythme de l'ordinateur ont révélé trois ERPs fronto-centraux en réponse aux chiffres à traiter (N180, P270, N370) dont l'amplitude était modulée par la charge mnésique. Les analyses en cours visent à vérifier si ces ERPs diffèrent entre le traitement au rythme de l'ordinateur et le traitement au rythme de l'individu en termes de localisation, de synchronisation ou d'interaction avec la charge mnésique.

### **32. Learning and exploiting a navigation model and a social interaction model in a complex reinforcement learning task**

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In reinforcement learning, robots learn to adapt their behavior based on their past experiences. To study how robots could learn to combine navigation and social interaction, we propose a new non-trivial task in which a robot guides a human through a visit of the laboratory. To succeed, the robot needs to understand the effects of its actions both in terms of navigation (moving from one room to another) and in terms of social interaction (attracting and keeping the human's attention). We propose to study this task in simulations and on a real robot with model-based reinforcement learning agents. These deliberative agents learn the structure of the task and can motivate their knowledge acquisition towards the reduction of this structure's uncertainty.

The agents build two separate models to account for the orthogonal, yet interacting, navigational and social dimensions. We also explore the idea of creating a humangeneral model, as many humans would react in the same way to the same action, and human-specific models when the robot faces individuals with unpredictable behaviors. We implement several simulations in a tabular environment with simulated humans. In this environment, the robot has access to navigation actions and social actions, such as hello, come and pointing in a direction. To add behavioral variability, humans are simulated

with different movement speeds and have different reactions to the robot actions. In addition to obtaining an accurate model of the environment, the robot needs to navigate into the human's visual field and learn to use the repertoire of actions to attract the human's attention. Then, the robot must adapt its locomotion parameters so that the human stays attentive and follows the intended trajectory. Our agents generally learn to bring the human to several different rooms in a row. We are currently working on a real robot with a simulated human, which is the second step before full human-robot interaction.

### **33. Neurophysiological Markers Of Musical And Verbal Short-term Memory: A Functional Near-infrared Spectroscopy (fnirs) Study**

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Auditory short-term memory (STM) is a key process in auditory cognition, with evidence for partly distinct networks subtending musical and verbal STM. Memory load manipulation, a useful method for studying STM, has been explored in neuroimaging studies using verbal n-back tasks, which predominantly investigate working memory processes. In contrast, the delayed matching-to-sample task (DMST) paradigm has been found suitable for comparing musical and verbal STM and manipulating memory load. In this study, functional near-infrared spectroscopy (fNIRS) was used in two experiments using the DMST paradigm: the first compared musical and verbal STM with a low-level perception task to identify frontal regions involved in memory processes, while the second manipulated memory load for both materials to determine frontal brain regions showing parametric changes in activity and their potential differences for musical and verbal materials. A FIR model was used to deconvolute fNIRS signals across successive trials without making any assumptions with respect to the shape of the hemodynamic response in a DMST. Results revealed the involvement of the dorso-lateral prefrontal cortex (dlPFC) and inferior frontal gyri (IFG) but not the superior frontal gyri (SFG) in memory tasks compared to perception tasks. The second experiment showed a parametric variation of activity with memory load in IFGs during the maintenance period, with opposite directions for musical and verbal materials. Activity in the IFGs increased with memory load for verbal sound sequences, in keeping with previous results with n-back tasks. The decreased activity with memory load observed with musical sequences is discussed in relation to existing literature on auditory STM rehearsal strategies. This study highlights the potential of fNIRS as a valuable tool for investigating musical and verbal STM including in populations with developmental language disorders associated with functional alterations in auditory STM.

### **34. Caractérisation comportementale et approche neurophysiologique de l'oubli accéléré dans l'épilepsie focale pharmaco-résistante**

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L'épilepsie focale est la plus fréquente des formes d'épilepsie de l'adulte. Malgré les traitements antiépileptiques disponibles, les crises persistent chez 33% des patients, définissant l'épilepsie focale pharmaco-résistante (EFPR). Au-delà des crises, ces patients rencontrent des complications de sévérité variable altérant leur qualité de vie, parmi lesquelles les difficultés de mémoire épisodique sont au premier plan. Conceptualisée comme une fonction hautement dynamique permettant de reconstruire mentalement un souvenir grâce à des mécanismes d'association entre l'expérience vécue et son contexte de survenue, la mémoire épisodique sollicite un réseau cérébral largement distribué, impliquant majoritairement le lobe temporal et particulièrement l'hippocampe. L'impact de l'épilepsie sur ce réseau pourrait spécifiquement perturber ces mécanismes complexes d'association indispensables à une mémoire efficiente.

En dépit d'une plainte subjective, environ 20% des patients ne présentent pas de déficit mnésique objectif lors du bilan neuropsychologique standard évaluant la mémoire à des délais d'environ 30 minutes. On suspecte alors un phénomène d'oubli accéléré à long-terme (ALF), difficile à mesurer en routine clinique du fait de l'absence de test adapté. Dans ce contexte, notre travail vise à élaborer un nouvel outil d'évaluation spécifique de l'ALF afin de mieux caractériser ce phénomène et d'améliorer sa prise en charge. Nous avons créé une tâche comportementale originale utilisant un matériel associatif, impliquant des rappels à 30 minutes et 3 jours, et mettant en jeu la recollection et la reconnaissance. Dans le cadre d'un PHRC-IR, nous proposons cette tâche à (i) un groupe de patients présentant une EFPR et (ii) un groupe de sujets contrôles sains. Par ailleurs, la constitution d'un 3ème groupe de patients implantés au moyen d'électrodes intracérébrales dans le cadre de leur parcours de soin nous permet d'étudier les signatures électrophysiologiques de l'ALF.

### **35. The effect of epistemic rewards on hippocampal replay in spatial navigation via reinforcement learning**

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Hippocampal replay is a well-studied phenomenon: it has been observed that during spatial navigation, place cells of the CA1 and the CA3 subfields of the hippocampus are tuned to physical location in their firing patterns [1], and these populations show ordered reactivation of sequences [2] contributing to efficient learning [3-4].

Reinforcement learning (RL) [5] has been proposed to be a reasonable proxy of food reward- motivated spatial navigation [6-8], allowing for a mathematical description of the underlying processes. However, where the most popular RL algorithms fall short in replicating real animal behavior is their rather slow learning curve due to the need of systematically updating their entire state space irrespective of the relevance of the updated states.

Cazé et al. [6] proposed a method to increase the efficiency of these agents using an artificial equivalent of hippocampal replay. According to their findings, targeted replay and one-step update of the most surprising states the agent has encountered results in more efficient and faster learning; while the content of such replay will highly resemble that of animal data.

However, while this model can adequately describe simple exploration and learning, it fails in more complex scenarios where animal behavior is driven not only by the expectation of food rewards, but also by curiosity. Here we propose a mechanistic account of the latter process by extending the RL model of Massi et al. [8] via the inclusion of epistemic rewards defined as the Shannon entropy of expected rewards in each state. We show that with the inclusion of this measure of uncertainty we do not significantly alter the asymptotic reward rates and the content of replay in case of simple navigation tasks; however, in the case of more complex mazes the exploration efficiency and the

reward rate is increased significantly, while the content of replay is shifted towards representing decision points instead of rewards and adjacent states.

[1] O'KEEFE, J.; DOSTROVSKY, J. *The hippocampus as a spatial map. preliminary evidence from unit activity in the freely-moving rat.* *Brain Research*, v. 34, n. 1, p. 171–175, 1971. DOI: 10.1016/0006-8993(71)90358-1.

[2] WILSON, Matthew A.; MCNAUGHTON, Bruce L. *Reactivation of hippocampal ensemble memories during sleep.* *Science*, v. 265, n. 5172, p. 676–679, 1994. DOI: 10.1126/science.8036517.

[3] GIRARDEAU, Gabrielle et al. *Selective suppression of hippocampal ripples impairs spatial memory.* *Nature Neuroscience*, v. 12, n. 10, p. 1222–1223, 2009. DOI: 10.1038/nn.2384.

[4] JADHAV, Shantanu P. et al. *Awake hippocampal sharp-wave ripples support spatial memory.* *Science*, v. 336, n. 6087, p. 1454–1458, 2012. DOI: 10.1126/science.1217230.

[5] SUTTON, Richard S.; BARTO, Andrew. *Reinforcement learning: An introduction.* [S.l.]: The MIT Press, 2020.

[6] CAZÉ, Romain et al. *Hippocampal replays under the scrutiny of Reinforcement Learning Models.* *Journal of Neurophysiology*, v. 120, n. 6, p. 2877–2896, 2018. DOI: 10.1152/jn.00145.2018.

[7] KHAMASSI, Mehdi; GIRARD, Benoît. *Modeling awake hippocampal reactivations with model-based bidirectional search.* *Biological Cybernetics*, v. 114, n. 2, p. 231–248, 2020. DOI: 10.1007/s00422-020-00817-x.

[8] MASSI, Elisa et al. *Model-based and model-free replay mechanisms for reinforcement learning in neurorobotics.* *Frontiers in Neurobotics*, v. 16, 2022. DOI: 10.3389/fnbot.2022.864380.

### **36. In the research of the Proust phenomenon. Study of odor-evoked memories.**

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Multiple studies show odor-evoked autobiographical memories to be rarely thought of, old (concerning above all the events that happened in childhood), particularly vivid and emotional.

Recent research, however, provides some contradictory results regarding the emotional dimension of odor-evoked memories and questions their established character. As a reaction to this controversy, we decided to study the emotionality of odor-evoked memories in a more exhaustive manner. 30 participants of age ranging from 60 to 80 years old were asked to recall events from their past in response to presented odors and photographs. In order to assure for the completeness of used measures, phenomenological (subjective experience questionnaire), physiological (heart rate, respiration, skin galvanic response) and speech data was collected. We made a hypothesis of a higher emotional response in the phenomenology of memory retrieval, in the physiological responses, and in the memories' speech for odor-evoked memories, in comparison to photo-evoked memories.

The analyses of phenomenological questionnaires and partial analysis of speech data did not confirm the preliminary hypothesis, as odor-induced memories were associated with lower emotional intensity felt at retrieval of the memory. The results of our research suggest that odors were less efficient than photos in memory evoking, that the participants needed more time to retrieve an odor-induced memory and that the produced discourse was slower for odor- than for photo-evoked memories. No differences in vividness or the feeling of being brought back in time were found. Finally, both odor- and photo- evoked memories showed similar age distributions. The obtained results sow doubt on the odor-evoked memories' characteristics established in current research, but further analyses must be performed to better understand the collected data.

*Keywords: odor-evoked memories, autobiographical memory, emotion*

### **37. How to explain the learning of a task by individuals using ML algorithms?**

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Imagine that you observe a rat in a maze, learning progressively to find food. How would you guess the learning process it actually uses? This question is of paramount importance in cognitive science where the problem is not to find the fastest or best learning algorithm to learn a specific task but to discover the most realistic learning model [1].

The empirical methodology for fitting any kind of learning algorithm to real learning data has been well established and emphasized [2]. The first step is performing MLE (Maximum Likelihood Estimation) on the data for parameters estimation of a model. We are observing an individual learning a task : the training data strongly depend on each other, and they are also non stationary. Extensive simulations are required : for some sets of parameters, the estimator behaves poorly. Unfortunately, there is no theoretical guarantees on whether it is possible to estimate the parameters of these models consistently. Our goal is to prove rigorously what can be said about the properties of the MLE when fitting a learning algorithm to real data.

Instead of studying a particular model and in order to work within an established theoretical framework, we focus on the adversarial multi armed bandit problem. The algorithm we specifically study (Exp3 : Exponential weights for Exploration and Exploitation) is probably the simplest algorithm for adversarial bandits [3]. Even though it is not used in the cognition literature, it shares many features with famous cognitive algorithms [4] and has given rise to many variants.

In the presentation, we will show in a particular case that trying to estimate constant learning rates leads to poor estimation whatever the estimation procedure : the estimation error decreases more slowly than logarithmically with the number of observations. In the setting where the learning rate decreases polynomially with the number of observations, we show a polynomial decrease of the prediction error of a truncated MLE.

[1] Botvinick (2008). *Hierarchical models of behavior and prefrontal function.*

[2] Wilson and Collins (2019). *Ten simple rules for the computational modeling of behavioral data.*

[3] Lattimore and Szepesvári (2020). *Bandit Algorithms.*

[4] Gluck and Bower (1988). *From conditioning to category learning : An adaptive network model.*

### **38. Évaluation de la mémorisation en situation muséale**

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La plupart des paradigmes expérimentaux utilisés en sciences de la mémoire se sont concentrés sur des tâches simples avec des stimuli peu contextualisés (Sonkusare et al., 2019). Si ces tâches ont permis d'acquérir de nombreuses connaissances fondamentales, leur validité écologique a souvent été discutée (Schmuckler, 2001). Dans une perspective naturaliste, les laboratoires lyonnais CRNL et ELICO ont mené une étude dans le but d'explorer la mémorisation dans des conditions plus naturelles : une visite de musée. En collaboration avec LUGDUNUM – Musée et théâtres romains, plusieurs expériences ont été réalisées afin de répondre à trois objectifs : (1) l'évaluation de la mémoire de visite au travers d'un questionnaire sur deux dimensions de la mémoire (épisode/sémantique), dispensé après la visite, (2) la caractérisation de la mémoire de la visite et de la réactivation mnésique relativement au profil des visiteurs (âge, habitudes muséales, connaissances préalables et motivation),

et (3) la comparaison des effets de deux types d'engagement (passif/actif) lors d'une période de réactivation de la mémoire de la visite. Les résultats montrent des liens de corrélation entre des facteurs préalables (fréquence de visite de musées, connaissances préalables et motivation) et les performances mnésiques, ainsi qu'un effet de l'âge. Ils suggèrent qu'une importante pratique de visite régulière et des connaissances plus approfondies ont un impact bénéfique sur la mémorisation, et soulignent l'intérêt de prêter attention à ces différents facteurs dans la conception de nouvelles expositions, afin d'optimiser son exploration et sa mémorisation. En complément de la recherche non-naturaliste, nous proposons que l'approche situationniste, par l'investissement du modèle muséal, peut ouvrir de nouvelles voies à l'étude de la mémoire, et favoriser l'engagement des disciplines concernées dans le sociétal.

*Avec la participation d'Armande Cernuschi et Laure de Chavanac (LUGDUNUM – Musée et Théâtres romains)*

### **39. L'effet de la valence morale : biais cognitif ou jugement moral ?**

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Cette étude s'intéresse à l'effet de la valence morale sur le jugement causal. L'effet en question se manifeste lorsqu'un agent possédant une valence morale négative (e.g., mauvaises motivations) est plus fréquemment désigné comme la cause d'un événement négatif, comparativement à un agent doté d'une valence morale positive. Deux explications concurrentes de cet effet sont examinées dans cette recherche.

D'une part, le Modèle du Contrôle Coupable soutient que le jugement causal est intrinsèquement biaisé par les réactions évaluatives des observateurs sociaux envers l'agent ayant une valence morale négative. D'autre part, l'approche pragmatique du jugement causal avance que l'origine de cet effet réside dans l'ambiguïté des questions posées. Spécifiquement, lors d'une tâche de jugement causal, deux types de représentations peuvent être impliqués : celles strictement liées à la causalité au sens strict et celles liées au jugement moral. Selon cette approche, la valence morale de l'agent n'a d'effet que lorsque la tâche est associée au jugement moral.

Pour tester ces hypothèses, les participants ont été invités à lire un scénario dans lequel un agent, dont la valence morale était manipulée (positive vs. négative), provoquait un dommage (i.e., une avalanche). Les participants devaient ensuite désigner la cause de l'avalanche. Dans une condition, la question était présentée comme posée par un juge (profession associée au jugement moral), et dans l'autre condition, elle était présentée comme posée par un journaliste (profession davantage associée aux explications d'événements, et de facto à la causalité au sens strict).

### **40. LONG-TERM IMPACT OF A SEMI-NATURALISTIC LIVING ENVIRONMENT ON RODENT ANXIETY AND COGNITIVE ABILITIES**

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The physical and social environment has been known for a long time to influence brain function. Yet, preclinical neuroscience studies are almost exclusively done in rodents raised in standard laboratory conditions with impoverished environment, limited social interactions, unlimited food access, and reduced living space. Recently, the need for a more naturalistic approach has emerged in the field of

cognitive neuroscience. Rather than trying to reduce inter-individual variability it appears essential to identify and understand its source and how it relates to experimental outcomes. This requires a housing environment that allows animals to express most of their behavioral repertoire.

As a first step toward this goal, we developed a new complex living environment composed of many interconnected modules in 3 dimensions. This first study compares a group of rats raised two by two in standard cages to a group of 10 rats housed together in this new semi naturalistic environment. A set of physiological (food intake, stress) and behavioral (social interactions and hierarchy) markers was monitored over several months. In parallel, cognitive abilities have been assessed using a variety of novel object recognition paradigms (objects, odors, in place or in context). Spatial memory performances were also evaluated using the Morris water maze test. The study was first performed on a group of males and then replicated on females. The first group data show that animals raised in the semi-natural environment show a lower level of anxiety and better cognitive performances, especially in spatial memory tests. They also exhibit more efficient exploration strategies in novel object recognition. Individual analyses are still in progress. Our goal is to characterize individual traits based on physiological and behavioral longitudinal measurements and to study the extent to which they are predictive of individual cognitive strategies and capacities.

#### **41. L'errance mentale et l'apprentissage des étudiants**

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L'errance mentale se définit comme étant le déplacement de notre attention depuis des tâches en cours, vers des pensées internes (Smallwood & Schooler, 2006). Elle occupe jusqu'à la moitié de nos pensées éveillées (Killingsworth & Gilbert 2010). C'est un état qui entraîne une baisse de la performance dans des tâches en cours (Mooneyham & Schooler, 2013) et qui semble notamment avoir un impact sur la mémoire (Smallwood, Baracaia, Lowe & Obonsawin, 2003). La mémoire est définie comme une activité biologique et psychique qui permet de retenir les expériences vécues. Elle joue un rôle fondamental dans l'adaptation d'un individu dans son environnement en permettant de structurer le présent et de se préparer à l'avenir.

L'objectif de cette étude est d'étudier les effets de l'errance mentale sur les capacités d'apprentissage auprès d'étudiants durant un enseignement académique. Le second objectif est d'étudier les liens entre la quantité d'errance mentale et certains facteurs individuels comme la dépression, l'anxiété et la motivation. Les étudiants ont répondu 4 fois à des sondes d'errance mentale durant un enseignement. La mémoire a été évaluée à travers un questionnaire de rappel du contenu de l'enseignement complété à la fin.

Notre étude a mis en évidence un impact négatif de l'errance mentale sur les capacités d'apprentissage. De plus, nous avons montré que plus la motivation d'un étudiant était élevée, moins il présentait d'épisodes d'errance mentale. Nous avons également observé que plus un individu possédait d'éléments dépressifs ou anxieux, plus la quantité d'errance mentale était élevée.

Les résultats obtenus soulignent l'importance de prendre en considération l'errance mentale des étudiants dans les environnements académiques, afin de mieux appréhender son impact sur la mémorisation et l'apprentissage des étudiants.

*Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. Science, 330(6006), 932–932.*

*Mooneyham, B. W., & Schooler, J. W. (2013). The costs and benefits of mind-wandering: A review. Canadian Journal of Experimental Psychology. <https://doi.org/10.1037/a0031569>*

*Smallwood, J. M., Baracaia, S. F., Lowe, M., & Obonsawin, M. (2003). Task unrelated thought whilst encoding information. Consciousness and cognition, 12(3), 452-484.*

*Smallwood, J., & Schooler, J. W. (2006). The restless mind. Psychological bulletin, 132(6), 946.*



## **42. Le fonctionnement de la mémoire de travail auditivo-verbale dans le syndrome de Williams: une méta-analyse.**

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La mémoire de travail auditivo-verbale (MDTAV) est une fonction cognitive essentielle pour le développement cognitif, en particulier concernant divers aspects du langage (Attout et al., 2020; Gathercole et al., 1999). Cette méta-analyse examine le fonctionnement de la MDTAV dans un syndrome neurodéveloppemental rare, le syndrome de Williams (SW), causé par une microdélétion au niveau du chromosome 7. Ce syndrome a été considéré comme une évidence génétique en faveur de la modularité du système cognitif, avec un langage oral et une MDTAV particulièrement développés en comparaison aux capacités visuo-spatiales (Grant et al., 1997). Cette préservation sélective a cependant été mise en question par la suite (Thomas & Karmiloff-Smith, 2003). Afin d'examiner le statut de la MDTAV dans le SW, une méta-analyse a été réalisée sur la base de 44 articles correspondant à nos critères d'inclusion. Une analyse multi-niveau à effets aléatoires a indiqué que, malgré une grande hétérogénéité des résultats ( $I^2 = 90.02\%$ ), l'identification d'un déficit en MDTAV auprès de personnes porteuses du SW ne dépend pas du type de tâche ( $F(5, 71) = 0.7441, p = 0.593$ ), mais bien du groupe contrôle ( $F(3, 73) = 21.1092, p < .001$ ) ainsi que du type d'appariement ( $F(6, 64) = 5.105, p < 0.001$ ) utilisés. Les personnes avec SW ont de moins bonnes performances aux tâches de MDTAV que les enfants neurotypiques appariés au niveau de l'efficacité verbale ( $g = -0.70, 95\% \text{ IC } [-1.06; -0.35], p < .001$ ), mais obtiennent de meilleurs résultats que les enfants porteurs d'un autre syndrome génétique associé à un trouble du développement intellectuel ( $g = 1.12, 95\% \text{ IC } [0.84, 1.39], p < .001$ ). Ces résultats indiquent que les capacités de MDTAV dans le SW sont en adéquation avec leur efficacité intellectuelle globale, mais restent une force comparée à d'autres syndromes génétiques tel que le syndrome de Down.

Attout, L., Grégoire, C., & Majerus, S. (2020). How robust is the link between working memory for serial order and lexical skills in children? *Cognitive Development*, 53(March 2019), 100854. <https://doi.org/10.1016/j.cogdev.2020.100854>

Gathercole, S. E., Service, E., Hitch, G. J., Adams, A.-M., & Martin, A. J. (1999). Phonological short-term memory and vocabulary development : Further evidence on the nature of the relationship. *Applied Cognitive Psychology*, 13(1), 65-77. [https://doi.org/10.1002/\(SICI\)1099-0720\(199902\)13:1<65::AID-ACP548>3.0.CO;2-O](https://doi.org/10.1002/(SICI)1099-0720(199902)13:1<65::AID-ACP548>3.0.CO;2-O)

Grant, J., Karmiloff-Smith, A., Gathercole, S. A., Paterson, S., Howlin, P., Davies, M., & Udwin, O. (1997). Phonological Short-term Memory and its Relationship to Language in Williams Syndrome. *Cognitive Neuropsychiatry*, 2(2), 81-99. <https://doi.org/10.1080/135468097396342>

Thomas, M. S. C., & Karmiloff-Smith, A. (2003). Modeling language acquisition in atypical phenotypes. *Psychological Review*, 110(4), 647-682. <https://doi.org/10.1037/0033-295X.110.4.647>

## **43. Coding dynamics of the striatal networks during learning**

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The rat dorsomedial (DMS) and dorsolateral striatum (DLS), equivalent to caudate nucleus and putamen in primates, are generally required for goal-directed and habit behaviour, respectively. This functional dichotomy is well established in instrumental conditioning, but it is less clear whether it also exists in non-instrumental learning. In this study we investigated this issue by recording DMS and DLS

single neuron activity in rats performing a continuous alternation task in which no cue instruction is provided. We first applied a classical analytical approach to identify task-related activity based on the modifications of single neuron firing rate in relation to specific task events or maze trajectories. We then used an innovant approach based on Hawkes process to reconstruct a directed connectivity graph of neurons simultaneously recorded in each learning session, that was used to decode animal behavior. This approach enabled us to better unravel the role of DMS and DLS neural networks across learning stages, from the acquisition to the optimization of the behavioral strategy. We showed that DMS and DLS display different task-related activity throughout learning stages, and the proportion of coding neurons over time decreases in the DMS and increases in the DLS. Despite these major differences, the decoding power of both networks increases during learning. These results suggest that both DMS and DLS are engaged during all learning stages, but the two neural networks gradually reorganize in different ways, in contrast with the common assumption of a gradual shift from DMS to DLS activity across learning stages.

#### **44. COMMENT SE DEVELOPPENT LES APPRENTISSAGES PROCEDURAUX CHEZ LES ENFANTS DE 6 A 10 ANS ?**

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Contexte: L'apprentissage procédural perceptivo-moteur (APPM) se réfère à l'apprentissage de séquences motrices (AS) et à l'adaptation visuomotrice (AV) (Doyon & Benali, 2005). Le développement de l'APPM fait actuellement débat opposant deux modèles théoriques : celui de l'invariance développementale et celui du modèle dynamique en « U » inversé (Zwart et al., 2019).

Approche: 192 enfants de 6 à 10 ans ont effectué deux tâches informatisées créées pour mesurer l'AS et l'AV de manière comparable. L'AS a été évalué avec une tâche de temps de réaction sériel et l'AV avec une tâche de saut de cible. Une tâche motrice de copie de texte a aussi été proposée pour évaluer le niveau moteur. La précision et la vitesse ont été mesurés pour chaque tâche.

Objectifs et hypothèses: L'objectif principal était d'évaluer l'évolution des scores d'AS/AV avec l'âge des enfants. L'objectif secondaire était de tester les corrélations entre les scores d'AS/AV et le score de copie de texte. Nous faisons l'hypothèse de dynamiques développementales différentes entre l'AS et l'AV et de corrélations avec l'âge et le niveau moteur des enfants.

Résultats: Pour l'AV, les analyses indiquent une amélioration de la vitesse et de la précision sans différence en fonction de l'âge. Pour l'AS, il existe une amélioration de la précision uniquement pour les enfants les plus âgés. De plus, certains scores d'AS sont corrélés avec l'âge et le niveau moteur.

Conclusion: Cette étude est la première à comparer les deux types d'apprentissage avec des tâches ayant des paramètres perceptifs et moteurs similaires. Les résultats indiquent une dynamique développementale différente entre l'AS et l'AV au cours de l'enfance. Bien que des analyses complémentaires soient requises, l'AV semble plus précoce que l'AS. Contrairement à l'AV, le développement de l'AS est lié à l'âge et au niveau moteur des enfants.

#### **45. A mnemonic advantage for beauty: is it self-reference or emotional processing?**

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Recent models defend a multi-process account of aesthetic judgement (AJ) integrating a subjective evaluation component based on self-referential processing. Accordingly, in a previous study, we

showed that AJ produce a mnemonic advantage comparable with self-reference (SR). Yet, it is not clear whether this phenomenon is linked to AJ *per se*, or to an underlying emotional evaluation (EE) process. In two studies, we tried to disentangle the effects of AJ and EE. In the first, we asked 45 participants to encode paintings used in our previous study in an AJ, a SR and a judgement of color condition. Retrospectively, participants had to judge their emotional reaction to each painting. In the second, we used the same procedure but replaced the SR with an EE encoding condition. If AJ relies on EE, we should find the same mnemonic advantage. We replicated a mnemonic advantage for AJ. Yet, we showed that extreme emotional ratings of paintings better predicted recognition performances in the AJ than SR condition (Study 1), and that paintings encoded in the EE condition were as well recognized as those in the AJ condition (Study 2). This suggests that AJ might involve both self-referential and emotional components.

#### **46. Topologie hippocampique des réminiscences induites par le stimulation électrique intracrânien.**

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Des phénomènes expérientiels à type de déjà-vu ou de réminiscences sont parfois rapportés par les patients épileptiques lors de stimulations électriques intracrânielles (SEIC), en particulier lors de SEIC du lobe temporal interne. Ces phénomènes sont rares (Curot et al, 2017), ce qui indique qu'on comprend mal les facteurs impliqués dans leur survenue. Dans cette étude, nous testons l'hypothèse que le site de stimulation à l'intérieur de l'hippocampe peut avoir un effet sur l'induction de PEM vs l'hypothèse contraire qu'il n'y a pas d'effet du site de stimulation.

Nous avons recueilli les réminiscences et les déjà-vus induits par des stimulations de l'hippocampe dans les bases de données de 3 centres d'épilepsie (Toulouse, Marseille, Nancy). Nous avons pu colliger les données de 9 patients correspondant à 18 PEM. Ces résultats ont été comparés à des stimulations négatives, chez les mêmes patients mais aussi à celles d'un groupe de 31 autres patients. La localisation des stimulations dans l'hippocampe a été effectuée par une analyse visuelle dans l'espace natif de l'IRM des patients.

La majorité des stimulations induisant ces phénomènes sont localisées au niveau de la région transitionnelle CA1-prosubiculum ou CA3- fimbria. Aucune, ou peut-être une, n'implique le subiculum en dehors du prosubiculum malgré de nombreuses SEIC dans cette région. Les déjà-vus sont majoritairement localisés au niveau de CA1-prosubiculum et les réminiscences au niveau de CA3-fimbria. Les stimulations induisant ces phénomènes expérientiels sont majoritairement de faible intensité (<1,5 mA) et de haute fréquence (50Hz).

Cette étude montre que le site des SEIC intra-hippocampique a un effet sur la probabilité d'induire un phénomène expérientiel mnésique. Ce résultat suggère en outre que les stimulations ont un effet focal et non pas global sur l'hippocampe, un paramètre intéressant à prendre en compte pour les perspectives thérapeutiques de la SEIC.