Keynotes

Jean-Luc Schwartz (GIPSA-lab, Université Grenoble Alpes)

Computational models enlightening and enlightened by neurocognitive data: the study of neurocognitive processes in speech perception

In this talk, I will try to show, from several examples taken from research on speech perception, how the computational models that we have been developing for years allow us to shed light on, and to a certain extent explain, certain neurophysiological or neuroimaging data, and even to suggest new experiments aimed at testing certain hypotheses coming from modeling; and how, in return, neurocognitive data allow to modify and improve the models under development. I will discuss these relationships between data and models around two major questions concerning, firstly, sensory-motor relationships in speech perception, and secondly, temporal processing in relation with neural synchronization phenomena.

Jessica Dubois (Inserm Unité NeuroDiderot, Université de Paris. CEA NeuroSpin, Gif-sur-Yvette)

The developing language brain network: explorations of structural-functional changes and relationships by MRI and EEG in infants

The brain shows intense development during the last weeks of pregnancy and the first months after birth, in relation to the baby's sensory perceptions, motor and cognitive acquisitions. Non invasive exploration techniques, such as magnetic resonance imaging (MRI) and electroencephalography (EEG), allow to explore these developmental processes in vivo. Different studies have shown the progressive and asynchronous maturation of brain networks related to different functional modalities. In particular, the language-related network shows an early architecture, with important asymmetries in the perisylvian cortical regions and in the white matter bundles connecting them. Moreover, important structural and functional changes observed during infancy have been related by combining MRI and EEG measurements. These studies allow a better understanding of typical infant brain development, but also of early alterations after pre- or perinatal events that can lead to various neurodevelopmental disorders.

Jérémy Danna (Laboratoire de Neurosciences Cognitives, Université Aix-Marseille)

(Re)Learning to handwrite in the digital age.

Learning to write by hand constitutes a double challenge: children have to learn both how to spell the words and how to trace the letters. The relationship between spelling and graphomotor processes has been studied mainly through the study of the effects that spelling constraints exert on handwriting movements. But to our knowledge, the combined effect of orthographic and graphomotor constraints during handwriting acquisition has not yet been investigated. From a graphomotor point of view, learning to write requires a sophisticated coordination of the muscles

and joints recruited in order to trace letters consistently as quickly as possible. The massive insertion of digital tablets in schools and homes induces a considerable change on the practice of writing. How can we take advantage of this evolution to help in learning to write or in the diagnosis and rehabilitation of handwriting difficulties? This conference will be an opportunity to discuss the importance of the motor component of handwriting and to present the work we have done on augmented reality methods to help its motor control and (re)learning.

Sophie Bouton (laboratoire Dynamique Du Langage, Université Lumière Lyon2) :

The resolution of audiovisual conflicts involves time-sensitive neural processing dynamics.

In face-to-face communication, audio-visual (AV) stimuli can be fused, combined or perceived as mismatching. While the left superior temporal sulcus (STS) is presumably the locus of AV integration, the process leading to combination is unknown. Our modelling work (Olasagasti, Bouton & Giraud, 2015) showed that combination might result from a complex dynamic originating in a failure to integrate AV inputs, followed by a reconstruction of the most plausible AV sequence. In two different behavioural tasks and one MEG experiment (Bouton, Delgado Saa, Olasagasti & Giraud, 2020), we observed that combination is more time demanding than fusion. Using time- and source-resolved human MEG analyses with linear and dynamic causal models, we show that both fusion and combination involve early detection of AV incongruence in the STS, whereas only combination is further associated with enhanced activity in regions sensitive to AV asynchrony (auditory and inferior frontal cortex). Based on neural signal decoding, we finally show that only combination can be decoded from the IFG activity and that combination is decoded later than the fusion in the STS. These results indicate that the outcome of AV speech integration primarily depends on whether the STS converges or not on an existing multimodal representation of syllables, and that combination results from subsequent temporal processing, presumably the off-line re-ordering of incongruent AV stimuli.

Xavier Alario (Laboratoire de Psychologie Cognitive, Université Aix-Marseille) :

Cortical Tracking of Keystrokes During Typing

Typing is a pervasive phenomenon, yet the underlying neural processes have hardly been studied. Deciphering the neurophysiology of typing should be informative about core cognitive processes, including those involved in language production, in interfacing action selection and execution, or in solving the problem of serial order. To investigate these issues, we developed a "research model" in which expert typists, like you and me, perform simple laboratory tasks and the electro-encephalographic activities recorded over sensorimotor areas are examined time-locked the keystrokes. A recurrent pattern is observed. It involves negative and positive activities in electrodes contra- and ipsilateral to the responding hand, similar to what is observed in simpler choice reaction time tasks. The variations of this pattern can then be used to investigate different aspects of typing. In the talk, I will summarize what we have learned from this line of research.

Sutdent/post-doc talks

Are alpha and beta oscillations spatially dissociated over the cortex in context-driven spoken-word production?

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Decreases in oscillatory alpha- and beta-band power have been consistently found in spoken-word production. We probed whether the effects in alpha and beta bands are spatially distinct with MEG data. Participants read a sentence that was either constraining or non-constraining towards the final word, which was presented as a picture to be named. The sources of alpha- and beta-band oscillations were localized based on the participants' individualized peak frequencies defined on the 1/f free power spectra computed by IRASA. Alpha- and beta-power decreases overlapped in the left posterior temporal and inferior parietal cortex. By contrast, for left frontal regions, the spatial distributions differed between alpha and beta effects. Our results suggest that for conceptual-lexical retrieval, alpha and beta oscillations do not dissociate spatially.

Supra-normal skills in processing of visuo-auditory prosodic information by cochlear-implanted deaf patients

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Our study aimed to identify how CI patients use multisensory integration between visual and auditory information to process paralinguistic prosodic information of multimodal speech and the visual strategies employed. A psychophysics assessment was developed, in which CI patients and hearing controls (NH) had to distinguish between a question and a statement.

This study confirmed that prosodic processing is multisensory but it revealed that CI patients have supra-normal multisensory integration skills when integrating visual and auditory linguistic prosodic information, and a specific adaptive strategy developed as it participates directly in speech content comprehension.

Adaptation neurale aux sons vocaux et non-vocaux dans les troubles du spectre de l'autisme : résultats préliminaires chez le sujet sain

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Les troubles du spectre de l'autisme combinent des difficultés d'interaction sociale et un besoin d'immuabilité. Les particularités de détection du changement observées dans l'autisme pourraient être associées à une habituation atypique à la régularité. Au niveau cérébral, l'adaptation neurale, c'est-à-dire la diminution de l'activité neuronale en réponse à un stimulus répété, a été étudiée principalement dans la modalité auditive en réponse à des sons purs. Qu'en est-il de l'adaptation en fonction de la nature sociale ou non des stimuli à encoder ? Pour répondre à cette question un protocole de roving a été utilisé combinant des stimuli vocaux (avec ou sans émotion) et non-vocaux. Les premiers résultats chez le sujet sain seront présentés. L'analyse des indices électrophysiologiques de l'adaptation (P1, N100, RP) montre une dynamique différente selon les stimuli : l'adaptation est présente pour les sons vocaux et non-vocaux, mais nécessite plus de répétitions pour les vocaux. L'implication des émotions dans l'adaptation, plus difficile à interpréter, sera discutée. Ce travail préliminaire chez le sujet sain sera poursuivi chez les personnes autistes.

Mémoire à court-terme musicale et verbale dans l'amusie congénitale: une étude MEG

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L'amusie congénitale est un trouble neurodéveloppemental de la perception et de la production musicale. Il a été montré que les personnes présentant une amusie congénitale ont un déficit de mémoire à court terme musicale et qu'elles présentent un fonctionnement anormal des générateurs frontaux-temporaux de la N100m pendant l'encodage de l'information musicale (Albouy et al. 2013). L'étude présentée ici a pour but de comparer le fonctionnement de ce réseau fronto-temporal entre amusiques et contrôles pendant le traitement en mémoire à court terme. Dix amusiques et dix contrôles appariés ont été recrutés et ont été enregistré en MEG pendant qu'ils passaient une tâche de mémoire à court terme auditive avec du matériel musical et verbal.

Déficit de la perception des hauteurs dans l'amusie congénitale : une étude comportementale et électrophysiologique (MEG).

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L'amusie congénitale est un trouble neurodéveloppemental caractérisé par un déficit de perception musicale, plus particulièrement du traitement des hauteurs. La hauteur est la caractéristique d'un son

qui nous permet de déterminer les intentions et émotions d'un locuteur ou d'apprécier une musique. Au niveau cérébral, des études ont mis en évidence une altération du réseau fronto-temporal dans l'amusie. Cependant, les mécanismes affectés sont toujours étudiés. Dans cette étude, nous avons caractérisé les déficits auditifs non-verbaux dans l'amusie en comparant les performances des participants amusiques et contrôles lors de tâches de perception musicale, de prosodie émotionnelle et d'analyse de scène auditive. Les réponses cérébrales ont été étudiées en utilisant une tâche de mémoire à court terme des hauteurs et un paradigme oddball passif. Nous avons observé chez les amusiques, une altération du traitement des hauteurs ainsi qu'une diminution de la N1 et de la MMN.

Acoustic & Semantic Processes during Speech Segmentation in French.

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We designed two experiments that tested the listeners' perceptual capacities during online segmentation of homophonic word boundaries while processing sentential information. In French, listeners often use variations in fine acoustic indices to detect word beginnings. We measured event-related potentials (ERPs) evoked by phonemically identical sequences, such as *l'affiche* ("the poster") and *la fiche* ("the sheet"), both [lafiʃ], which were contained in either congruent or incongruent sentences. Results showed that although listeners can detect acoustic variations in homophonic sequences, these may not be salient enough when contextual information is also present. Shifting attention from sentence meaning (Task 1) to lexical information (Task 2), enhanced the listeners' perception of fine-grained acoustic details. Thus, top-down processes are likely to modulate speech perception and segmentation.

Favoriser la synergie entre les systèmes cognitifs, une approche efficace pour l'apprentissage de la lecture?

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Afin de mieux comprendre un processus cognitif ou un apprentissage, les recherches en neurosciences cognitives se focalisent habituellement sur un système cognitive donné (visuel, auditif, moteur, cognition de haut niveau…). Cela permet de mieux comprendre l'organisation interne de divers systèmes cognitifs. En revanche, cette approche peut générer une vision biaisée de comment le cerveau fonctionne et apprend, en négligeant l'impact des autres systèmes cognitifs, car les systèmes s'inter-influencent (e.g., effet McGurk, effet Stroop). Je montrerais un exemple d'amélioration substantielle d'une difficulté visuelle avec les lettres chez les enfants au CP, en utilisant un entrainement à l'école centré sur une approche de synergie entre systèmes cognitifs. Les résultats ont montré une nette amélioration de la perception visuelle et de l'écriture des lettres. Mais le plus important c'est que les enfants ayant bien consolidé cet entrainement, 4 mois plus tard, lisaient deux fois plus vite que les enfants des groupes contrôles.

Sound likeability in ASD: interaction between social information and noise level.

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An atypical interest for musical and vocal sounds in autism could be attributable to different noise level in the sound. To investigate this hypothesis, 16 autistic adults and 16 typically developed adults rated the likeability of vocal (sung, spoken, and whispered voices) and non-vocal sounds (musical, animal and environmental sounds), with varying harmonic-to-noise ratio (HNR). A linear mixed model with subjects and sounds as random effects revealed that participants rated sounds with a high HNR as more pleasant for non-vocal sounds, while for vocal sounds spoken voices were the most pleasant. Participants with ASD rated vocal sounds as less pleasant than TD participants and vocal sounds. TD participants rated as more pleasant sounds with a high HNR relative to ASD participants. So different sensibility to sound category and noise level was observed in TD and ASD participants.

Verbal recognition memory decline associated with the progression to prodromal Alzheimer's disease in asymptomatic at-risk individuals

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In elderly individuals, subjective memory complaints (SMC) are difficult to allocate to either normal cognitive aging or preclinical Alzheimer's disease (AD). Our aim was to longitudinally assess subtle episodic memory differences occurring in individuals at-risk for AD: 1) associated with amyloid-β burden or neurodegeneration; 2)that can preclinically identify who develops AD. 264 cognitively functional individuals with SMC from the INSIGHT-preAD protocol performed a computerized adapted version of the free and cued selective reminding test [FCSRT]. Data were collected yearly and behaviour performance (accuracy and reaction time [RT]) longitudinally (5years) assessed. Using linear mixed-effect models, recognition discriminability between Old and New words did not change in the presence of amyloid-β or Neurodegeneration separately, but when together seemed to produce a deleterious effect. In non-converters to prodromal-AD, accuracy was longitudinally stable and RT improved, while in the converters, accuracy declined and RT increased. Hence, this FCSRT version is a promising preclinical diagnostic tool on detecting very subtle memory alterations.

The spatio-temporal dynamics of mental time travel to one's personal past and future as a function of temporal distance

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Mental time travel to the personal past and future share remarkable cognitive and neural characteristics. Both processes rely on the same core network that can be differently recruited depending on task

demands. However, it is still unclear how the temporal distance of the (p)re-experienced events modulates the recruitment of this network when mental time-travelling to the past and the future. The present study explored the electrophysiological correlates of remembering and imagining personal events at two temporal distances from the present moment (near and far). Within this aim we assessed event-related components associated with recollection (Late Parietal Component, 500-800ms) and post-retrieval/simulation monitoring (Late Frontal Effect, 800-1500ms) processes. Modulations of temporal distance were observed on both components, although they differed in past and future event (p)re-experiencing. Findings suggest greater recollection for near as opposed to far future, and the implementation of greater post-retrieval/simulation monitoring for near as compared with far past.

Relation between Memory/Attention and Dream Recall Frequency

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Several factors have been shown to influence dream recall frequency (DRF), such as gender, creativity, sleep stage… Working memory abilities have been suggested as well to be related to dream recall, but there is only mixed evidence in the literature. More recent findings also suggest that high dream recallers (HR) have a higher attentional sensitivity than low dream recallers (LR).

In order to assess the role of working memory abilities and attention in DRF, we used a paradigm designed to evaluate these abilities and their interaction in LR and HR, called MEMAT (MEMory and ATtention). MEG recordings were also collected during the task.

LR had higher performance than HR in this paradigm, and this difference was amplified by increasing the attentional difficulty of the task. These results and the analysis of the MEG data should improve our understanding of cognitive and neural correlates of DRF.

Open Loop and Closed Loop acoustic stimulation during sleep to investigates the neural correlates of motor memory consolidation.

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Targeted memory reactivation (TMR) during post-learning sleep is known to enhance motor memory consolidation but the underlying neurophysiological processes remain unclear. The set of studies presented here confirms the impact of auditory TMR on motor performance. At the neural level, open loop auditory TMR enhanced slow waves (SW) characteristics and modulates phase-amplitude coupling between slow (0.3-2 Hz) and sigma (12-16 Hz) oscillations. Before the negative peak of the SW, phase amplitude coupling (PAC) is higher when the sleeping brain is exposed to sounds not associated to learning. After the SW negative peak, SW-sigma PAC increased with TMR behavioral benefits. Closed loop stimulation allowing to target specific SW phases with auditory stimulation revealed that auditory cues presented at the trough of the SW is detrimental for the consolidation of the motor memory trace associated to them. Conversely,

motor memory consolidation was not impacted when the auditory cues were sent at the peak of the SW. Preliminary neurophysiological results show a phase-dependent modulation of sigma oscillation power depending on the temporal coordination with the SW negative peak. Cues sent at the trough induced higher sigma power after the SW whereas cue associated to the peak of the SW induced stronger sigma oscillations before the SW. Our research shows that slow and sigma oscillations play a crucial role in either memory reinstatement or protection against irrelevant information; two processes that critically contribute to motor memory consolidation.