PARIS LODRON UNIVERSITÄT SALZBURG

CCNS Centre for Cognitive Neuroscience

Imaging the Mind Doctoral Program

FWF Österreichischer Wissenschaftsfonds

DK "Imaging the Mind" Satellite Symposium to SAMBA 2024

10th July 9:00 am – 18.35 pm (15' + 5')

HS Agnes Muthspiel / Unipark (Erzabt Klotz Straße 1, 5020 Salzburg)

Abstracts:

Mohamed AMEEN

"Do we measure oscillations when we think we are measuring oscillations?"

Brain oscillations are sought to underly various cognitive and sensory processes. However, the measurement of such activity can be conflated by many factors including signal noise and detection algorithms. In recent years, numerous studies have shown that brain signals contain non-oscillatory components that provide valuable information about brain dynamics. These components are often ignored, discarded, or incorrectly included in oscillatory estimates when measuring brain activity, raising a timely question: How can we accurately measure oscillations in electrophysiological signals? This presentation discusses the problems associated with the conventional methods of detecting and analyzing brain oscillations, investigating whether they are influenced by other variables leading to potential misinterpretations. I will also review refined approaches for defining, detecting, and analyzing oscillatory activity in the brain. As our aim has always been to understand the signals obtained from electrophysiological measurements and their correlation with cognition, redefining our approach to measuring brain oscillations should be at the forefront of cognitive neuroscience research in the coming years.

Christine BLUME

"Unlocking the Neuronal Language of Sleep: Insights from Information-Theoretic Analyses"

Introduction

During sleep, the human brain switches to a 'sentinel processing mode', allowing for continued processing of environmental stimuli. This framework has been developed through studies comparing brain responses such as event-related potentials (ERPs) in the electroencephalogram (EEG) to acoustic stimuli across sleep stages. However, ERPs preclude qualitative comparisons between vigilance stages due to differences in the underlying brain activity. Additionally, they do not represent the signal's actual information content. Here, we approached this issue by using temporal generalisation analyses (TGA) to assess (dis-)similarities in the neural code underlying processing of auditory prediction errors across vigilance stages. Further, we investigated the information content with information theoretic measures (i.e., mutual information and co-information), to quantify signal information content and identify redundant and synergistic shares in brain signals. We hypothesised a shared neural code among sleep stages, with deeper sleep being associated with decreased information content and increased signal redundancy.

Method

Following an adaptation night, twenty-nine healthy individuals aged 23.2±2.8 years (15 women) engaged in an auditory 'local-global' oddball paradigm during wakefulness and a subsequent 8-hour sleep opportunity with polysomnography. We focused on prediction errors, i.e., brain responses to a deviating fifth tone after four standard tones (0-900 ms relative to stimulus onset).

Results

During wakefulness and sleep (i.e., N1-N3, REM), deviating tones elicited larger ERPs than standard tones and amplitudes increased with sleep depth. TGA revealed that the neural patterns during wakefulness generalised to sleep only to a limited extent, while there was considerable generalisation among sleep stages. Mutual information analyses revealed that early encoding of prediction error information decreased with deeper sleep, indicating that ERP amplitudes do not reliably quantify information processing. Furthermore, co-information analyses indicated that with increasing sleep depth, the neural dynamics became increasingly redundant over time. This suggests that the brain loses its ability to process new information and instead, brain signals encode more of the same information.

Conclusion

We demonstrate that predictive coding information processing is altered dramatically when we fall asleep. Further, we show that the 'sentinel processing mode' is characterised through common neural patterns shared between vigilance stages, more redundant, and less-rich neural information in the human cortex.

Michael DOPPELMAYR, Marc VAREL & Adrian ZEITNER

"Movement prediction and inter brain synchrony in cooperative tasks"

When individuals try to communicate effectively, a shared understanding—referred to as common ground (CG) is essential. This includes a joint idea of the conversation's content and progression. This is manifested by the listener's prediction of the next words to be spoken by the speaker. Deviations from such predictions are linked to the N400 component in electroencephalograms (EEGs) (Kutas und Federmeier 2011). Notably, predictive processes are relevant not only in language but also in motion contexts (Sebanz & Knoblich 2021). Recognition of (intentional) movements activates the Mirror Neuron System (MNS) and the Action Observation Network (AON) (Basler et al. 2014). In physical activity contexts, from dance-duos to team sports, the recognition and prediction of specific motion sequences and motion intentions are crucial.

The simultaneous recording of EEG data from two or more individuals (as from a dance duo) is termed "hypersampling," and meanwhile multiple studies have demonstrated that EEG patterns among interacting individuals tend to align, creating what is known as inter-brain synchrony (IBS) (Davidesco et al. 2019, Dikker et al. 2017).

Two key research questions are under investigation in my lab, and I will present ongoing data on these two questions:

1) Do individuals in fact make specific predictions in a movement context? We conducted an EEG study presenting congruent and incongruent sequences of movements (visually on a PC). Additionally we also presented linguistically correct and incorrect words/sentences (N400 paradigm). This allows for a comparison of the effects of accurate predictions across the linguistic and the motor domain.

2) Does cooperative activity indeed lead to an increase in IBS, and is this related to the level of difficulty or the extent of necessary cooperation? Since movement-intensive cooperations like dancing or ball games are challenging to record without artifacts, we initially pursue this question with a simple PC game where the level of required interaction varies. For the first analysis, theta frequency data from frontal electrodes are examined using circular coherence and the phase-locking index.

Balser, N. (2014): Prediction of human actions: expertise and task-related effects on neural activation of the action observation network. In: Human brain mapping 35 (8)

Davidesco, I., et al. (2019): Brain-to-brain synchrony between students and teachers predicts learning outcomes.

Dikker, S. et al. (2017): Brain-to-Brain Synchrony Tracks Real-World Dynamic Group Interactions in the Classroom. In: Current Biology : CB 27 (9), S. 1375–1380. DOI:
Sebanz, N., & Knoblich, G. (2021) Progress in Joint-Action Research. Current Directions in Psychological Sci., 30(2), 138-143.

Michael HAHN

"Neural population coding efficiency in the hippocampal-neocortical memory network during human and rodent sleep"

Sleep facilitates memory consolidation and restores cognitive resources by disengaging the brain from the external world. However, the mechanisms underlying how sleep supports information processing remain largely unknown. Synaptic scaling models suggest that learning during wakefulness accumulates neural information, which is then consolidated and downregulated during sleep. From an information-theoretical perspective, the consolidation process during sleep should reduce neural pattern variability. Yet, there's a lack of in-vivo data elucidating how sleep normalizes information processing capacities. Here, I will present cross-species evidence of a tradeoff in the neural population code during sleep, with the neocortex displaying higher information coding efficiency compared to the archicortex, humans compared to rodents, and wakefulness compared to sleep. Critically, non-REM sleep specifically decreases information coding efficiency in the neocortex, likely reflecting neural pattern recapitulation. The hippocampus, however, shows a consistent but more redundant population code across sleep stages. These results support the neocortex's role in long-term memory storage. Moreover, task engagement enhances coding efficiency, while induced unconsciousness disrupts the population code. In summary, neural pattern variability is crucial for cognitive engagement and memory formation, with repetitive patterns likely aiding in the consolidation process.

Simon HANSLMAYR

"How the human hippocampus stores an index for individual memory episodes"

Episodic memory enables us to recall past memories. For example, I can vividly remember when I hiked up the Schafberg with Wolfgang last year during my summer holidays. When I mentally travel back to that time point, I can remember a number of things, e.g. the exciting conversations we had around Wolfgang's new book, the good advice he gave me regarding my own science, and how nimble and fast Wolfgang still is. The hippocampus is at the heart of this remarkable ability, but we don't know how neurons in the hippocampus code such episodic memories. Single neuron recordings in humans can uniquely inform this process, however, the results disagree on the mechanism that enables the hippocampus to bind a multitude of things into one coherent episode. At the heart of the disagreement are two competing frameworks; one framework posits that concurrent activity of concept coding neurons (CNs) provide the building blocks of memories, with each neuron representing a specific element involved in that episode. Within this framework, my memory of meeting Wolfgang last year on the Schafberg would be coded by concurrently active 'Wolfgang' and 'Schafberg' neurons[1]. An alternative framework, called the Indexing Theory[2], suggests that neurons code for the conjunction of the various elements within an episode, instead of coding for individual elements. In keeping with the above example, one assembly of neurons would code for the memory of hiking up the Schafberg with Wolfgang. This Indexing code would act as a unique time stamp for individual memories. In this talk I present recent findings from human single neuron studies where we recorded hippocampal neurons that are consistent with the latter theory, i.e. they behaved as would be expected from neurons that perform an indexing function[3]. I will then present a framework that reconciles the two competing theories and integrates them, by assuming that the two codes (one for the index, and another one for concepts) reside in different hippocampal subfields. Specifically, I assume that an index code resides in area CA3 and dentate gyrus, whereas a concept code resides in area CA1. I will present preliminary data from ultra-high resolution 7T fMRI that is in part consistent with this theory. I will end the talk by speculating how these results could be used to construct a neural prosthesis for memory to recover memories in patients that otherwise would be lost.

References

1: Quian Quiroga, 2012, *Nature Reviews Neuroscience,* https://www.nature.com/articles/nrn3251
2: Teyler & DiScenna, 1986, *Behavioral neuroscience,* https://psycnet.apa.org/record/1986-21328-001
3: Kolibius et al., 2023, *Nature Human Behaviour,* https://www.nature.com/articles/s41562-023-01706-6

Christopher HÖHN

"Shining Light on the Modulation of Brain Electrophysiology during Sleep and Wakefulness"

Recent research has highlighted the potential of non-oscillatory EEG features that may offer additional insights into our understanding of brain functioning. Furthermore, it is well-known that brain activity and circadian rhythms are also modulated by environmental stimuli, such as light exposure. In modern society, artificial short-wavelength light exposure, especially during the evening, poses a significant challenge for the synchronization of our circadian rhythms.
I will present work from the last four years, in which we conducted a comprehensive FWF-study and assessed the role of non-oscillatory EEG parameters and the effect of artificial evening light exposure on melatonin secretion, subsequent sleep and memory consolidation. We collected data from 68 male participants (33 adolescents and 35 young adults) that slept in the laboratory on three experimental nights and underwent multiple cognitive tasks as well as a 90min reading session on a smartphone or printed book on each evening.
In Publication 1, we show that the spectral slope and Lempel-Ziv complexity can differentiate between the various tasks and sleep stages. We further demonstrate that employing different frequency bands (30 – 45Hz vs. 1 – 45Hz) strongly affects these parameters. In Publications 2 – 4, we show that blue light filtering software can mitigate disruptive sleep effects, even though it does not prevent light-induced melatonin suppression. Furthermore, we demonstrate that adolescents recover more quickly from the melatonin suppression than young adults and show less sleep impairment when the smartphone is put away 50min before bedtime. Finally, sleep-dependent memory consolidation and the coupling between slow oscillations and sleep spindles are fully preserved in both age groups.
This work demonstrates that non-oscillatory EEG markers hold promise for future brain state classifications and underpins the importance of adhering to sleep and light hygiene recommendations while accounting for age-specific differences in light sensitivity.

Wolfgang KLIMESCH

"Known and unknown aspects of EEG Sync"

About 100 years of EEG research has accumulated rich knowledge about the functional meaning of brain oscillations. Nonetheless, basic aspects of the EEG are not yet understood. There is something like a miracle, if we consider two facts. First, we know that electric stimulation influences brain activity. Second electric activity, generated in the brain, sums up to yield LFP's and finally the surface EEG. Because this in turn influences brain activity, what is it that prevents an outbrake of a chaos in the brain? It is argued that mathematical laws of oscillatory sync may provide an answer for explaining this ‚feedback sync'.

Julia LECHINGER

“Effects of transcranial direct current stimulation on sleep and cognition in patients with Schizophrenia.”

In recent years various studies from different research groups indicate that slow oscillations (SO) and the associated deep sleep can be positively influenced by pulsed transcranial direct current stimulation (tDCS) in the SO frequency range. The aim of our research is to investigate potential beneficial effects of tDCS on sleep and sleep-dependent cognitive function in patients with schizophrenia.

Schizophrenia patients often suffer from cognitive deficits including reduced memory capability and impaired selective attention. Furthermore, in addition to positive symptoms during psychosis, patients also experience negative symptoms including reduced mood and less restorative sleep. Correlations between changes in sleep structure, in particular a deficit in deep sleep, and deficits in the sleep-dependent consolidation of declarative memory content have been documented several times in these patients. In healthy participants, an increase in deep sleep and an improvement in sleep-dependent memory consolidation were demonstrated after low-intensity transcranial current stimulation during nighttime sleep. The main aim was to stimulate slow oscillations which are characteristic of deep sleep and are considered essential for the consolidation of newly learned declarative memory content. A brief overview of previous results in healthy and schizophrenia patients will be presented. Overall, results are still heterogeneous and the exact (potential) mechanisms of action of SO-tDCS are not yet fully understood. Although, tDCS can be a cost-effective and non-invasive treatment option, valid protocols yielding reliable benefits seem to be difficult to establish.

Eleonora MARCANTONI

“Closed-loop MEG and multisensory theta stimulation to improve human memory”

Hippocampal theta oscillations are considered critical for binding multisensory information into episodic memories. Recent studies suggest that entraining theta oscillations through 4-Hz audio-visual Rhythmic Sensory Stimulation (RSS) can significantly enhance episodic memory performance in humans. This “one-size-fits-all” approach, however, neglects the differences in brain activity among and within individuals, which could account for the variability in the results. To address this limitation, we developed a new tool to estimate the individual hippocampal theta frequency in real-time during an associative memory task and dynamically align the stimulation parameters to it.

The key components of the pipeline involve extracting the hippocampal signals during a MEG measurement using an LCMV beamformer. Then, theta activity is separated from the broadband signal applying a Generalized Eigenvalue Decomposition (GED). Finally, the Cyclic Homogeneous Oscillation detection method (CHO) is applied to detect the presence of an oscillation and identify its centre frequency. This frequency is then used to adjust the flickering frequency of the sensory stimuli.

We validated the feasibility of this pipeline to reliably estimate the frequency on rodent LFP data, aiming to replicate the well-established correlation between running speed and hippocampal theta frequency. The results indicate that the pipeline could replicate previous findings ($R = 0.24$, $p < .001$). After that, the full pipeline, including source reconstruction, was tested offline on a MEG dataset involving 4-Hz RSS during an associative memory task. Here, our objective was to assess whether the pipeline could identify the entrainment effect induced by the stimulation, with the hypothesis that if the hippocampus is entrained during RSS, its frequency should be closer to the stimulation one. Our results indicate that hippocampal frequency was indeed significantly closer

to 4 Hz during the stimulation, compared to pre- and post-stimulus time windows (main effect of time $F_{6,120}$ =24.99, p < .001, $\eta^2 = 0.315$).
Next, we will validate the pipeline in a concurrent MEG–iEEG dataset, to compare the identified frequencies in MEG data with the ground-truth frequency in the hippocampal signal recorded through iEEG. Together, the results so far suggest that we can reliably extract and detect theta frequency from hippocampal signals in real-time. This tool can be used for closed-loop neurotechnology to interface with brain oscillations in deep structures like the hippocampus non-invasively.

Christoph NISSEN

"Sleep and psychiatry: update and new developments"

Sleep and mental health are closely interconnected. This talk explores potential neural mechanisms, including synaptic plasticity and metabolic clearance processes, and focuses on concepts for modulating sleep to enhance mental health. These concepts encompass cognitive behavioral therapy for insomnia and its adaptation for psychiatry, as well as non-invasive brain stimulation techniques such as auditory stimulation.

Charline PEYLO

"Neural oscillations on the go: A dynamic perspective on cognition and the brain"

We live in a highly dynamic world with both short-term fluctuations in the environment and long-term adaptations in our responses to such, yet most previous neuro-cognitive research has primarily focused on stationary effects in traditional staccato-like paradigms. In this talk, I will present the results of two electroencephalography (EEG) studies, in which we probed the dynamics of cognition and corresponding neural signatures using dynamic stimulus presentations and learning-dependent changes over time. Our results suggest that short-term shifts of spatio-temporal attention can be tracked by dynamic alpha power modulations and slow negative potentials and that fidelity-dependent long-term changes in memory matching might be reflected by theta-gamma phase-phase coupling and evoked gamma activity.

Elie EL RASSI:

"Beta-band frequency shifts as decision signals in prefrontal cortex"

Brain rhythms are generally thought to support brain activity by rhythmically modulating the excitability of neuronal populations. Rhythms in the 13-35 Hz frequency range, a.k.a. beta oscillations, initially assigned a sensorimotor role, are increasingly being linked with cognitive functions such as decision-making. So how do beta oscillations engage with the neuronal populations that decide? Beta dynamics are flexible and short-lived; I like to think of them as scaffolds of brain activity. Depending on needs or task demands, the appropriate scaffold can be set up. In the case of a task with two possible decision outcomes, one of two scaffolds would be needed at the moment of deciding. What does it do? We think it selectively engages the neuronal population that encodes the decision and facilitates the transfer of decision information downstream. How does it do it? By operating at a particular frequency, distinct from that of the alternative decision. Think of a radio metaphor where the frequency of the oscillation is the radio channel, and neuronal activity is the audio. In this talk I'll present evidence of these ideas from monkey LFP and single-cell recordings, as well as human EEG and MEG.

Michaela REIMANN

"Speaking Through Strands: Prenatal androgen levels from neonate hair samples predict early language development"

Pregnancy is characterized by hormonal changes that are essential for both the maintenance of pregnancy and fetal development. For sex hormones, in particular, there is first evidence suggesting that fetal testosterone levels measured from amniotic fluid predict language development. For dehydroepiandrosterone (DHEA), a precursor of testosterone, less is known about its function in early development.

The current study investigates whether prenatal testosterone and DHEA levels from neonates' hair samples, reflecting hormone levels during the second and third trimesters, can explain productive language development during the first year of life. Moreover, the study examines whether the postulated association of androgens and development is language-specific or applies to general cognitive abilities.

To this end, we assessed prenatal testosterone and DHEA levels in neonates (n = 49, 25 females) through hair samples collected 2 weeks after birth. In addition to their androgen levels (testosterone: M = 1.62 pg/mg, SD = 1.40; DHEA: M = 19.00 pg/mg, SD = 9.27), we longitudinally assessed infants' cognitive (M = 113.27, SD = 14.45) and productive language skills (M = 13.69 raw score, SD = 2.00) using the Bayley Scales of Infant and Toddler Development at 6 months of age.

Linear regression analysis revealed prenatal DHEA levels to significantly predict infants' productive language performance at 6 months (p = .01). This association does not hold for infants' general cognitive abilities (p = .26), suggesting that the predictive effect of DHEA on early development is specific to language. In contrast, fetal testosterone was unrelated to early language outcome (p = .80).

These findings show first that prenatal sex hormone levels can be captured by neonate hair samples reflecting hormonal changes during the last trimesters of pregnancy. Second, they show that prenatal hormonal levels have a unique explanatory value in early language development.

Paul SAUSENG

"One to rule them all: Oscillatory brain activity as unified control mechanism for working memory and social cognition"

The human brain's capacity for processing information is very limited. This is why it needs to carefully select which information to process or store in memory and which information to suppress. Moreover, many cognitive operations require the brain to sequentially coordinate processing steps. But how does our nervous system achieve a coordinated mind? Here, I will show that slow rhythmical brain activity might contribute to optimal timing and coordination of neural activity patterns distributed across the human neocortex. I will highlight that deployment of cognitive resources across different domains is reflected by these slow oscillatory processes, and that deviation in this mechanism could be one of the reasons for cognitive deficits in some psychiatric conditions.

Gesa SCHAADT

"How psychological wellbeing of mothers in the pre- and postnatal period relates to their children's language development"

Language development starts well before the infant is born, with foundations of language being established already during the first weeks after birth. Early disruptions in development can increase the risk for later language difficulties. As language development hinges on social interaction, with the primary caregiver's mood affecting communication with the infant, maternal mood can be considered a potential risk factor associated with early language acquisition milestones.

I will present our data on the association between the fetuses' superior temporal gyrus (STG) volume, a brain area relevant for language abilities, and their expressive vocabulary 2-3 years after birth. Further, I will demonstrate that maternal self-perceived stress during pregnancy negatively relates to fetal STG volume, as well as children's expressive vocabulary and that the effect of maternal prenatal stress on a child's expressive vocabulary is partially mediated through fetal STG volume. The STG is involved in the elicitation of the Mismatch Response (MMR), an event-related potential indicative of speech perception abilities. We therefore further investigated how maternal mood in the postnatal period moderates the longitudinal trajectory of infant speech perception. We found that more depressed maternal mood was associated with weaker longitudinal changes of infants' speech perception, as well as with lower later expressive vocabulary.

Together, these findings indicate the importance of considering the primary caregiver's mood in the pre- and postnatal period in shaping the fetal and infants' language-relevant brain development and advocates for systematic early screenings for mothers' psychological wellbeing and their support, also when considering their children's language development.

Manuel SCHABUS:

"The Virtual Sleep Lab - a novel method for accurate 4-class sleep staging using heart-rate variability from low-cost wearables"

Insomnia treatment options are currently insufficient, necessitating effective solutions. We evaluated the effects of a CBT-I-based app combining sleep training with subjective and objective sleep monitoring on sleep and subjective-objective sleep discrepancies (SOSD) in 57 volunteers (aged 20–76; 39 female) with sleep problems. Participants were randomly assigned to an experimental group (EG, n = 28) or a waitlist control group (CG, n = 29). During the 6-week app phase, the EG used the CBT-I-based program and a heart rate sensor for daily sleep monitoring and feedback, while the CG used sleep monitoring only. Sleep was measured subjectively via questionnaires (Insomnia Severity Index, ISI; Pittsburgh Sleep Quality Index, PSQI), objectively via ambulatory polysomnography (PSG), and continuously via heart-rate (HR) sensor and sleep diaries. Sleep classification was done with an affordable HR sensor and (Sleep^2) in-house algorithms, achieving high accuracy compared to gold-standard PSG. The model demonstrated high accuracy for REM (87%), deep sleep (80%), light sleep (86%), and wake (79%), maintaining accurate classification even in users on heart or psychoactive medication.

Data revealed interactions for ISI ($p = 0.003$, $\eta 2part = 0.11$) and PSQI ($p = 0.050$, $\eta 2part = 0.05$), indicating training-specific improvements in the EG but not in the CG. PSG-derived outcomes were less training-specific, though a tendential reduction in wake after sleep onset (WASO) was observed in the EG ($p = 0.061$, $d = 0.55$). Improvements in SOSD for sleep efficiency, sleep onset latency, and WASO ($p \leq 0.022$, $d \geq 0.46$) were noted in the EG, with both groups showing SOSD reduction for total sleep time. The presented sleep solution, integrated into the sleep^2 App, offers a reliable, sensor-agnostic approach to sleep classification, addressing the need for precise and accessible sleep monitoring and coaching and allows large scale sleep studies in the field.

Carlotta SCHNEIDER

“Sleep-wake perception: new insights and clinical relevance”

The primary criterion of insomnia disorder is a subjective complaint about reduced quantity or quality of sleep that is often not observed in objective sleep measurements. This discrepancy limits the understanding of the pathophysiology and new treatment developments. This study aimed to further characterize sleep-wake perception in patients with insomnia disorder and healthy controls and potential neural underpinnings.
Thirty patients with insomnia disorder (20 female, 8 male, 2 divers, 39±15 years) and 30 healthy controls (21 female, 9 male, 36±13 years) reported on their sleep-wake perception from up to 12 awakenings performed from consolidated NREM (N2/N3) sleep.
Patients reported significantly worse sleep than controls on various subjective measures, including Insomnia Severity Index (large effect size). Objective sleep parameters (baseline night) did not differ between both groups (small effect sizes). We performed a total of 500 awakenings from N2/N3 sleep (278 in controls, 222 in patients), with 147 congruent (PSG sleep/subjective sleep) versus 131 incongruent events in controls (PSG sleep/subjective wakefulness), and 97 congruent versus 125 incongruent events in patients. There was no significant difference in the percentage of wake reports between controls (47.9±32.5%) and patients (59.7±33.5%, small effect size). PSG or spectral power values did not inform about subsequent sleep-wake perception.
Our study promotes the hypothesis that the complaint of insomnia disorder does not primarily emerge from sleep loss or direct sleep-wake perception, but from “downstream” cognition and emotion (sleep-related anxiety). Our study furthermore highlights the need for novel concepts and measurements of sleep, possibly related to fluid sleep-wake regulation.

Matthias THOLEN

“Memory’s forgotten process: What happened to the man on the bus?”

Neuroscience has examined the brain processes of recognizing and identifying a known person. But the process of integrating the representation of a temporarily unrecognised person with the representation of the familiar person is not yet known (e.g., as in Mandler's butcher on the bus). This process is one of identification; the stranger (man on the bus) has to be seen as identical to the old acquaintance (butcher from the supermarket). Our fMRI experiment contrasts this case of belated recognition with immediate recognition. The results show stronger activation of left inferior parietal lobe (IPL) and the left anterior temporal lobe (ATL) for identification over pure recognition. The data are discussed under the mental files framework providing an important extension to current person recognition paradigms.