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Preface

Founded in Spring 2001 by the nomination of Axel Mecklinger as a Full Professor of Psychology, the Experimental Neuropsychology Unit at the School of Psychology passed its second year of existence. The year 2002 was characterized by a continuous growth of the group's personnel and its research activities.

With the start of two projects in the DFG-Research Group "Binding: functional architecture, neuronal correlates and ontogeny" in the beginning of 2002, Daniela Czernochowski and Mikael Johansson joined the group. Thanks to the support of the Cognitive Modeling Unit, our office and lab space could be increased, and several student assistants started to work in our three DFG projects. In the SFB 378 we continued our in-house cooperation with the Cognitive Psychology Unit and the Developmental Psychology Unit. Together with the Max-Planck Institute of Cognitive Neuroscience, a project in the DFG Research Group "Working Memory" was successfully continued. It will terminate in Spring 2003.

In summer, we started two cooperative research projects with the Saarland University Hospital in Homburg/Saar. Together with colleagues from the Neuroradiology Department, a first fMRI study was conducted. The results will be presented on the Annual Meeting of the Cognitive Neuroscience Society in spring 2003. In cooperation with the Department of Neurology a clinical event-related potential (ERP) study with patients suffering from hypertension was started in the summer.

In our ERP lab, we launched a series of ERP studies. The results of which will enter various doctoral and diploma theses that will be finalized in 2003. Finally, I should mention that our efforts in building up a children ERP lab were successful. A first ERP study on memory development in school-aged children is currently ongoing.

With these cooperations and research initiatives we hope to contribute to the growth and development of the neuroscience community in Saarbrücken and Homburg/Saar.

Axel Mecklinger, January 2003

1 The Experimental Neuropsychology Unit

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(a) supported by Deutsche Forschungsgemeinschaft

(∗) left the institute during 2002

2 The Research Program

In our research program, we examine memory and learning processes and their functional representation in the human brain. Memory and learning rely upon several memory systems that have dissociable neuronal substrates. We use event-related potential (ERP) measures to elucidate the timing characteristics of these systems. In addition, we try to identify the brain regions that mediate memory and learning processes by means of functional magnetic resonance imaging (fMRI). This year, our research focused on three main topics: (1) the neuronal correlates of recognition memory and the role of emotions in the formation and retrieval of bound memory representations; (2) maintenance and control processes of working memory; and (3) binding mechanisms during learning and memory formation.

Our research on the neuronal correlates of recognition memory is guided by a neurocognitive model published by Mecklinger (2000). The extension of this model and its relation to binding processes during memory retrieval is the main focus of one current project (2.1). Another project examines the retrieval of feature conjunctions in famous and non-famous faces by means of ERP recordings (2.2). A behavioral approach was used in project 2.3 to examine the contribution of familiarity and recollection to false and veridical memories. The relationship between memory retrieval processes and cognitive control processes is examined in project 2.4 by means of ERP slow wave activity. Explicit and implicit memory processes for emotionally valenced faces are examined in projects 2.5 and 2.6. In an additional study, we examine the effects of brain maturation on recognition memory by means of ERPs recordings from children in various (school) age groups (2.7).

Working memory processes and their neuronal substrates are the main focus of two fMRI projects. In project 2.8, we investigate inhibitory control mechanisms for different working memory contents. The role of hand motor programs for visual working memory is investigated in project 2.9. An additional fMRI project examines the role of the prefrontal cortex in auditory deviance detection (2.10).

Binding mechanisms in learning and memory formation are the major focus of two other projects. Project 2.11 examines the interplay between the hippocampus and the prefrontal cortex during artificial grammar learning by means of fMRI and ERP measures. In project 2.12, it is investigated whether the hippocampus is differentially involved in context specific and decontextualized learning processes.

In two clinical projects, we use ERP recordings to elucidate functional deficits after neurological diseases. Project 2.13 tries to identify risk factors for vascular dementia by means of ERP recordings. In project 2.14 we examine the nature of language comprehension deficits after temporal lobectomy.

2.1 A late parietal negative slow wave indexes the binding of attribute conjunctions during memory retrieval

Mikael Johansson & Axel Mecklinger

The focus of the present project is to elucidate the functional significance of a late posterior negative slow wave (LPN) that has frequently been reported in event-related potential (ERP) studies of memory. A recent overview of these studies suggests that two broad classes of experimental conditions tend to elicit this component: (a) item-recognition tasks associated with enhanced action-monitoring demands arising from response conflict or uncertainty and (b) source-memory tasks that require the binding of items with contextual information specifying the study episode (e.g., color) (Johansson & Mecklinger, submitted). A combined stimulus- and response-locked analysis of data from two studies (Nessler & Mecklinger, in press; Johansson et al., 2002) mapping onto these classes allowed a temporal and functional decomposition of the LPN. While only the LPN observed in the item-recognition task could be attributed to the involvement of a posteriorly distributed response-locked error-related negativity (ERN/Ne) occurring immediately after the response, the source-memory task was associated with a stimulus-locked negative slow wave occurring prior and during response execution that was evident when data were matched for response latencies. We argue that the presence of the former reflects action monitoring due to high levels of response conflict, whereas the latter reflects retrieval processes that may act to reconstruct the prior study episode when task-relevant attribute conjunctions are not readily recovered or need continued evaluation. Currently ongoing experimental work aim at evaluating the validity of the proposed functional account.

2.2 Face recognition and its modulation by biographical context

Bertram Opitz

According to a widely held view on recognition memory, two distinct processes guide remembering of previously learned information. A central role in this view plays our ability to bind a particular item to the context in which it occurs. In case of face recognition there is a wealth of stored information about an individual. A current issue in memory research pertains to the effect of experimentally induced contextual information (e.g. biographical information) on face identification.

Participants (N=16, 8 male) were instructed to remember pictures of faces. At study, the faces were either associated with brief biographical information (name, residence, hobby) or not. Alternatively, they could belong to a famous person (actor, politician etc.). Each of these faces was presented three times during study. It was assumed that, despite the artificial nature of the circumstances, faces associated with a biography do correspond to faces of known individuals (e.g. famous persons). When these faces of known individuals were presented during recognition they should engage recollective processes, typically associated with a late parietal ERP old/new effect. Additionally, after the recognition test a paper and pencil cued recall test was administered. Upon presentation of a face, participants were asked to write down the appropriate biographical information.

The behavioral results corroborate the assumption of superior recognition memory for famous faces as compared to both groups of non-famous faces. In contrast, both groups of unknown faces exhibited increased performance from first to third presentation.

In the ERPs to the first presentation of a face, an early (200-500ms) frontally distributed old/new effect was observed for all three conditions. Additionally, famous faces only showed a late (500-800ms) parietal old/new effect (cf. Fig. 1, left panel). In the ERPs elicited by the third presentation, only the early old/new effect was observed, irrespective of the status of the depicted face (famous, with or without context).

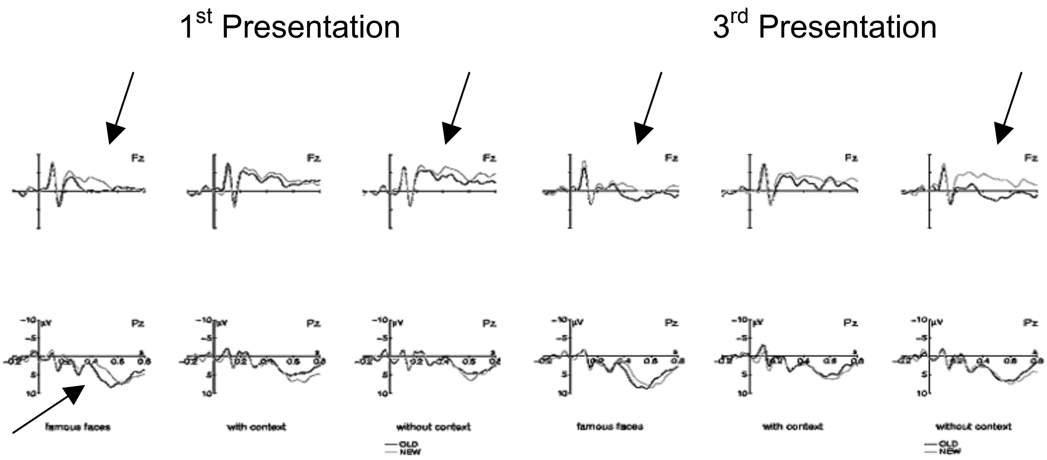

Figure 1. ERPs recorded during the test phase for famous faces, faces with and without biographical context and new faces. Recordings were plotted for selected electrode sites of the 10-20 system. First presentation (left panel) and third presentation (right panel) are shown.

These results are in agreement with previous findings, in that early and midfrontal ERP old/new effects reflect familiarity-based recognition, whereas late and parietal old/new effects indicate recollective processes. Contrary to our hypothesis, faces of known individuals (i.e. presented with brief biographical context) did not elicit a parietal old/new effect neither during first nor third presentation. Given the relatively poor recognition performance for faces presented with context, one could argue that the biographical information was not sufficiently bound to the face. This will be further elucidated by evaluating the recall of context cued by the face presentation.

2.3 Recollection is differentially involved in true and false memories: Behavioral evidence

Christoph Schwanck & Axel Mecklinger

The design of this behavioral study was derived from an ERP false memory study (Nessler et al., 2001), intended to examine the contribution of familiarity and recollection to false recognition judgments. A second question was whether familiarity and conscious recollection are mediated by qualitatively distinct brain systems. Among other findings, ERP data suggested less active recollection in false relative to true recognition.

By adding a remember/know task, our study was intended to validate these findings behaviorally. We assumed that in case of true recognition, participants would show a higher rate of remember decisions compared to know decisions, whereas a clear reversal of these parameters should be found for false recognition. In a study period, lists of semantically categorized words associated to non-presented words (LUREs) had to be learned. In the subsequent test period, old words, new words, and LUREs were presented. For each item, participants had to make an initial old/new decision that was followed by a remember/know decision for each word rated as old. We carefully instructed each subject, defining *Remembering* as conscious recollection of an item's previous occurrence and *Knowing* as a strong feeling of familiarity in the absence of conscious recollection (Tulving, 1985). Both definitions were accompanied by lucid examples from everyday life. As can be seen in Figure 1, participants' performance indeed confirmed our expectations about remember/know rates for OLD and LURE words, by this contradicting findings of Roediger and McDermott (1995) on this point. Our data suggest that participants' false judgments of LURE items are rarely based on any active recollection of a previously formed memory trace, but primarily emerge from a feeling of familiarity due to conceptual features shared by studied and LURE words.

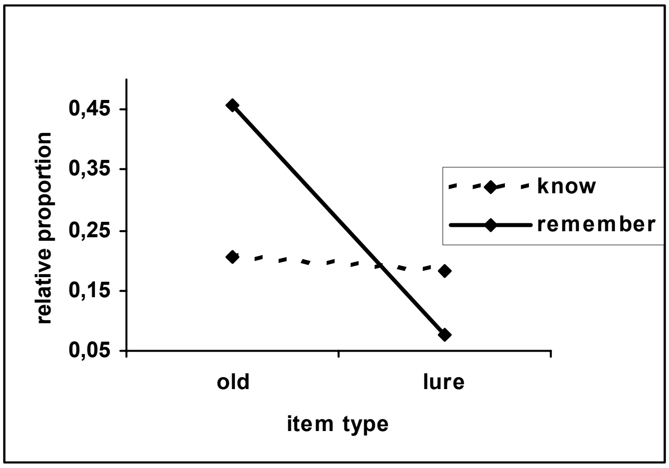

Figure 1. The figure shows the relative proportion of K- and R-responses separately for “old“ responses to old items (correct) and to LUREs (false).

2.4 Prefrontal control of episodic memory retrieval as revealed by ERP slow waves

Markus Werkle, Axel Mecklinger, Jutta Kray, Patric Meyer & Emrah Düzel

Entering and maintaining a specific cognitive mode (´retrieval mode´ Tulving, 1983) seems to be crucial for successful retrieval of episodic information from long-term memory. In addition, effective performance on episodic retrieval tasks also requires the ability to flexibly adapt to changing retrieval demands ('retrieval orientations'; Rugg & Wilding, 2000).

Even though a variety of neurocognitive studies has shown that the prefrontal cortex is critically involved in the control of memory retrieval, it remains unclear whether maintaining a specific retrieval orientation and changing flexibly between different retrieval demands are mediated by the same process or whether dissociable aspects of retrieval control are involved. Here we aimed to clarify this question by means of ERP-recordings.

In our study, 14 participants had to perform two different recognition memory tasks. One required mere old/new-decisions for words (GENERAL-task), whereas the other task required the additional retrieval of each word's study font typeface in order to make appropriate old/new judgments (SPECIFIC-task). Furthermore, we presented both recognition tasks within two sequence conditions. The participants had either to perform the same task continuously or had to switch between the two tasks after every second test word. This latter manipulation enabled us to examine the two aspects of retrieval control mentioned above: maintaining a task instruction over a complete continuous block or flexibly adapting the retrieval demands during alternating blocks.

A comparison between ERP slow waves for correct rejections within alternating blocks and those within continuous blocks ('block-effect', see Fig. 1) shows more positive-going ERP slow waves for alternating blocks over bilateral anterior-frontal recording sites, independent of task instruction. These findings suggest that there are electrophysiologically dissociable control processes for maintaining a retrieval orientation and for flexibly changing between varying retrieval demands.

FIGURE 1

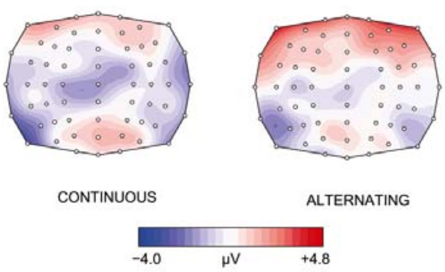

FIGURE 2

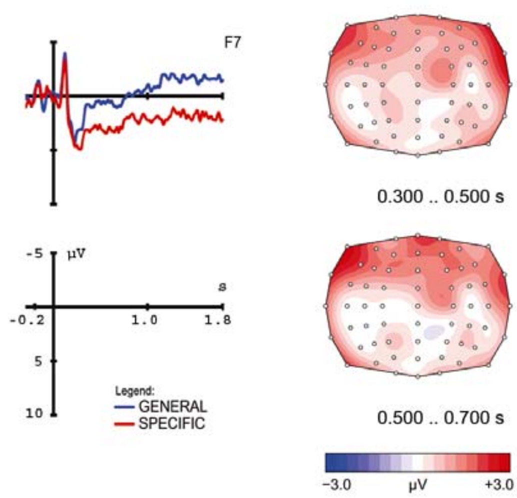

Figure 1. Topographical maps for ERPs elicited by correct rejections to new items under GENERAL-task instruction, depicted separately for continuous and alternating blocks (300 – 500 ms after stimulus onset).

Figure 2. Left panel: ERPs elicited by correct rejections to new items within continuous blocks for the F7-electrode, according to the 10-20 system. Right panel: Topographical maps for ERP difference-waves (SPECIFIC minus GENERAL) for correct rejections to new items within continuous blocks.

In addition, contrasting ERP slow waves elicited by correct rejections within continuous blocks for the two task types, revealed more positive-going ERP slow waves over fronto-lateral recording sites in the SPECIFIC-task than in the GENERAL-task. This task effect started as early as 300 ms after stimulus onset and was more pronounced over the left hemisphere (see Fig. 2). This task-difference resembles previous findings by Ranganath and Paller (1999, 2000). Consistent with these authors, we assume that this latter effect is related to the retrieval of perceptual details from the study phase.

2.5 Electrophysiological correlates of memory for emotionally valenced faces

Mikael Johansson, Anne-Cécile Treese & Axel Mecklinger

Memory for emotional events is generally enhanced as compared to neutral events. However, it remains unclear whether memory for neutral and emotional information is mediated by qualitatively distinct memory mechanisms. While previous event-related potential (ERP) memory studies have examined words with emotional valence, the present project extends this line of research by examining the ERP old/new effects associated with memory for positive, negative, and neutral faces. In a recent recognition memory study, participants encoded the emotional information incidentally by making gender judgments during the study phase and were subsequently instructed to discriminate between old and new faces. Behavioral data indicated equal discriminability for the three levels of emotion and, moreover, that participants tended to show a greater bias to respond “old” to negative than to neutral faces. Reliable old/new effects were observed for both negative and neutral faces in a 400-600 ms time window, but were characterized by different scalp distributions (see Fig. 1). Capitalizing on previously proposed ERP correlates of familiarity and recollection, the results suggest that memory for neutral faces was based on familiarity (midfrontal old/new effect), whereas memory for negative faces was based on recollection (left parietal old/new effect). Interestingly, the absence of a midfrontal effect for positive and negative faces results from the fact that new emotional faces elicited more positive ERPs relative to neutral, thus, suggesting emotion-induced processing independent of memory. In a follow-up behavioral study, the same participants were instructed to make *remember/know* judgments to each recognized face. In agreement with the ERP results, negative faces were remembered to a greater extent than neutral and positive faces. Taken together, the results support the view that negative emotional information is recollected rather than familiar. Currently ongoing research examines whether this pattern of findings is mediated by facilitated feature-binding processes during the encoding of emotionally negative events, and, moreover, attempts to elucidate the functional significance of the mid-frontal positivity elicited by emotional faces irrespective of their old-new status.

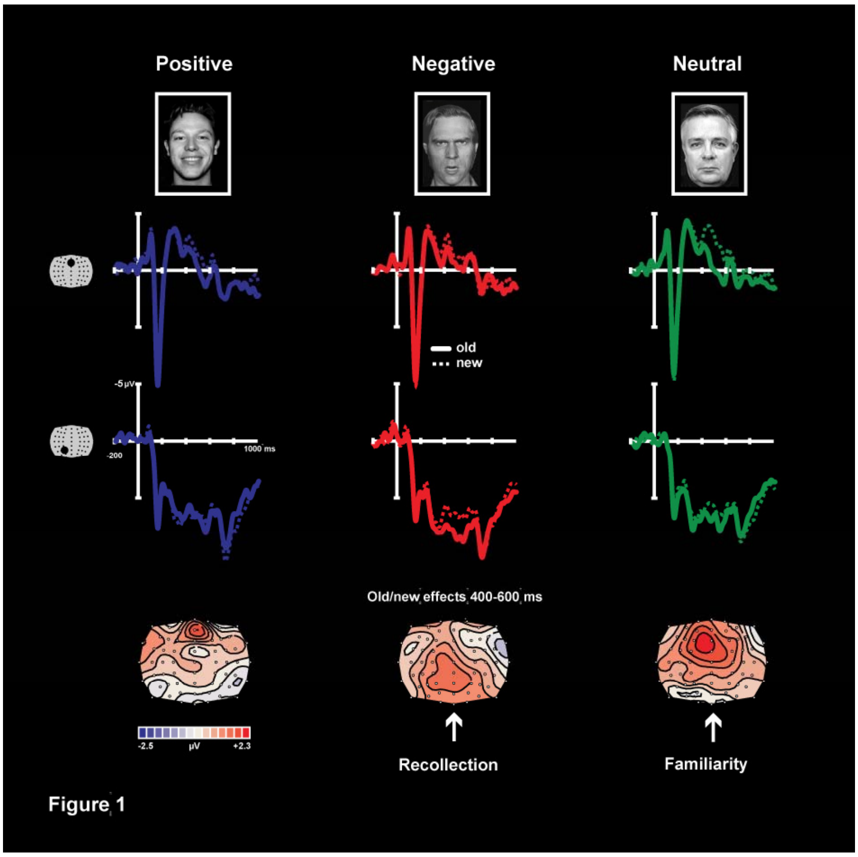

Figure 1. ERP old/new effects elicited by positive, negative and neutral faces.

2.6 Priming of emotion: An ERP study to investigate the implicit effects of emotional facial expressions

Stefanie König & Bertram Opitz

It has been demonstrated in numerous previous studies that the emotional content of study items has an impact on how they are processed, resulting in enhanced free recall and recognition performance in episodic memory tasks as compared to neutral items. However, it is still an open issue whether this superior memory for emotionally valenced items will also be evident on implicit memory tests.

In this study, event related brain potentials (ERPs) were recorded to take a closer look at implicit emotional processing. Participants (n=14, 7 females) performed a famous/non-famous decision on pairs of faces expressing different emotions (positive, neutral, negative). To control for face repetition effects, the experimental design also employed the presentation of two identical faces. ERPs to repetition of emotional valence irrespective of the expressing face were compared to face repetitions, irrespective of emotional status. ERP waveforms were more positive for the second presentation of an emotional face as compared to a neutral facial expression in an early time window (300-500 ms) at frontal sites. This effect was most pronounced when two identical faces were presented, thereby reflecting perceptual priming (see Fig. 1). Taken together, the results support the view of perceptual and emotional priming. In light of the highly similar scalp distribution, there is no conclusive evidence with respect to different brain mechanisms subserving perceptual and emotional priming.

Additional analyses revealed that faces expressing positive emotions can also prime faces with negative expressions and vice versa. This finding suggests that the processing of the emotional expression of a face can be facilitated by a preceding presentation of a face irrespective of its emotional valence. This preliminary result has, however, to be elucidated in further experiments.

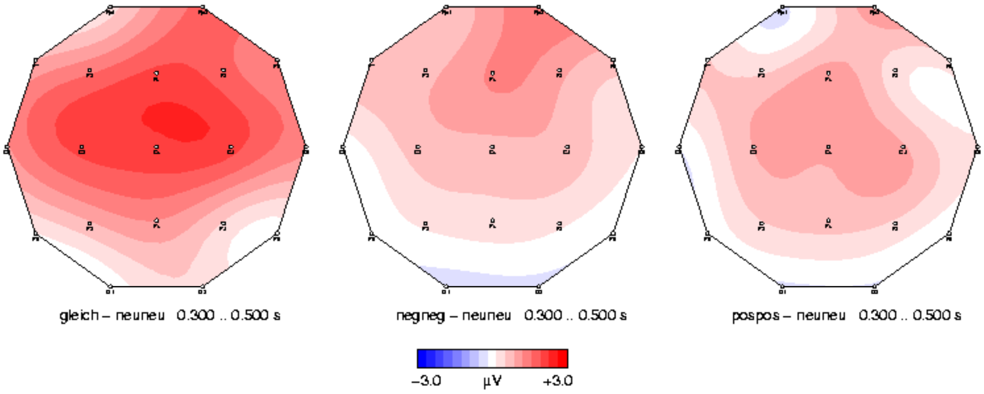

Figure 1. Topographic maps illustrating the distribution of the differences between the second presentation of an identical (left panel), negative (middle panel) and positive (right panel) face and the second presentation of a neutral face in the 300-500 ms time window.

2.7 An ERP evaluation of the development of source memory in children and young adults

Daniela Czernochowski, Michael Brinkmann, Mikael Johansson & Axel Mecklinger

While neuropsychological correlates of memory in adults have been studied extensively, there is not much information available on the development of these processes. Vargha-Khadem et al. (1997) found selective anterograde amnesia for episodic events but preserved semantic knowledge following perinatal bilateral hippocampal damage. These findings challenge the prevailing concept of declarative memory and raise the question if semantic and episodic memory rely on at least partly dissociable neural structures that may mature independently.

Since ERPs have provided valuable insights into memory processes of adults, we decided to investigate the effects of ongoing brain maturation on recognition memory by means of ERPs. We are comparing source and item memory in children of various ages (3 groups: 6-8 yrs; 10-12 yrs; 14-16 yrs) and young adults. In exclusion and inclusion recognition memory tasks, participants are asked to remember items and their context while their EEG is recorded. In order to maximize recollection for source, the two study conditions will differ simultaneously in modality of presentation, temporal order of presentation and background color (e.g. photos in first study set with blue background).

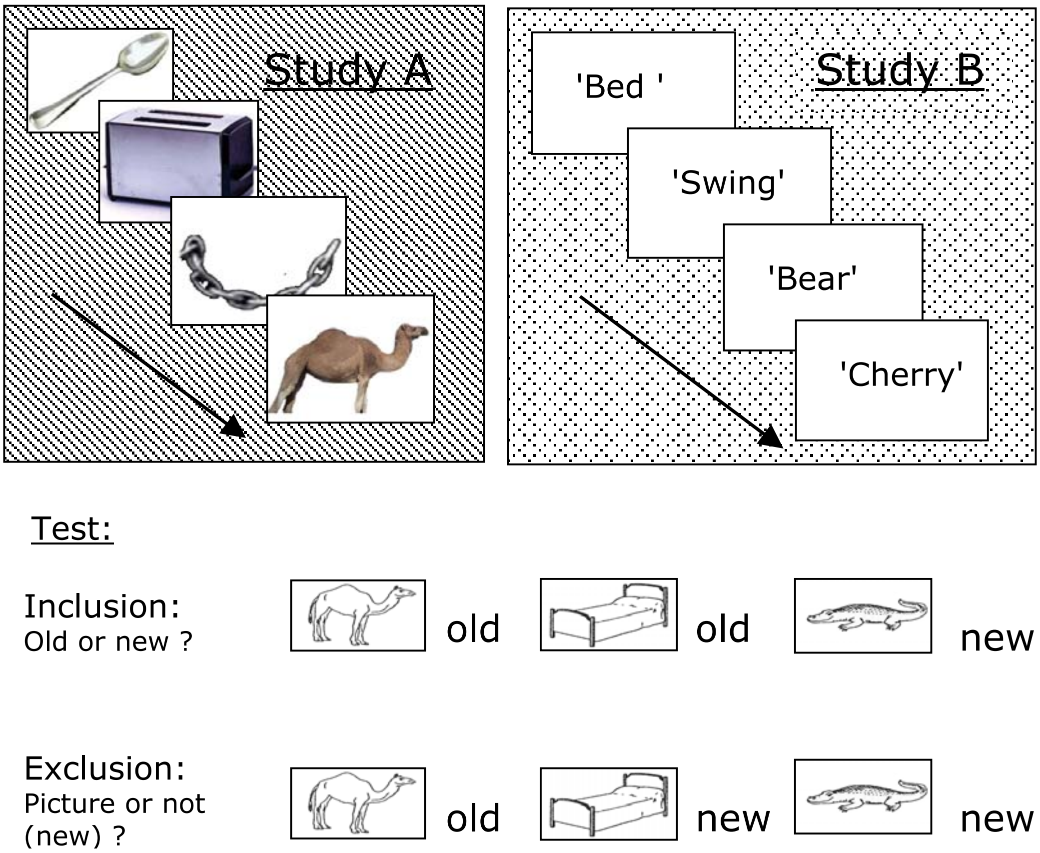

Figure 1. Study items are presented either as photographs of everyday objects (toys, animals, body parts etc.) or their spoken names in two different cover stories. During recognition, participants are shown black and white drawings of the same objects and are asked to indicate whether they correspond to any item in the study phase or not (inclusion) or whether they appeared in a target condition (exclusion).

We expect younger participants to perform worse than older participants (as evident in longer reaction times and worse recognition performance). Although this result is expected for the inclusion as well as the exclusion condition, it should be more pronounced in the exclusion condition as a function of either more familiarity-based decisions or less frontal lobe involvement or a combination of both.

In a related project, we develop diagnostic criteria for developmental amnesia. Normative data on healthy children (i.e. how often they show different types of everyday memory problems, forget things around the house, fail to recognize faces or names etc.) are collected in a parental questionnaire.

2.8 Dissociable brain mechanisms for inhibitory control: Effects of interference content and working memory capacity

Axel Mecklinger, Kerstin Weber, Thomas C. Gunter & Randall W. Engle

In this study, event-related fMRI was used to examine whether the resolution of interference arising from two different information contents activates the same or different neuronal circuitries. In addition, we examined the extent to which these inhibitory control mechanisms are modulated by individual differences in working memory capacity. Two groups of participants with high and low working memory capacity (HS and LS participants, respectively) performed two versions of an item recognition task with familiar letters and abstract objects as stimulus materials. Interference costs were examined by means of the recent negative probe technique with otherwise identical testing conditions across both tasks. While the behavioral interference costs were of similar magnitude in both tasks, the underlying brain activation pattern differed between tasks: in the object task, interference-related activity was restricted to the anterior intraparietal sulcus (IPS). Interference arising from familiar letters additionally activated the left postero-ventral and the right dorsolateral prefrontal cortex (PFC) as well as the precuneus (Fig. 1). As the letters were more discernible than the objects, the results suggest that the critical feature for PFC and precuneus involvement in interference resolution is the saliency of stimulus-response mappings.

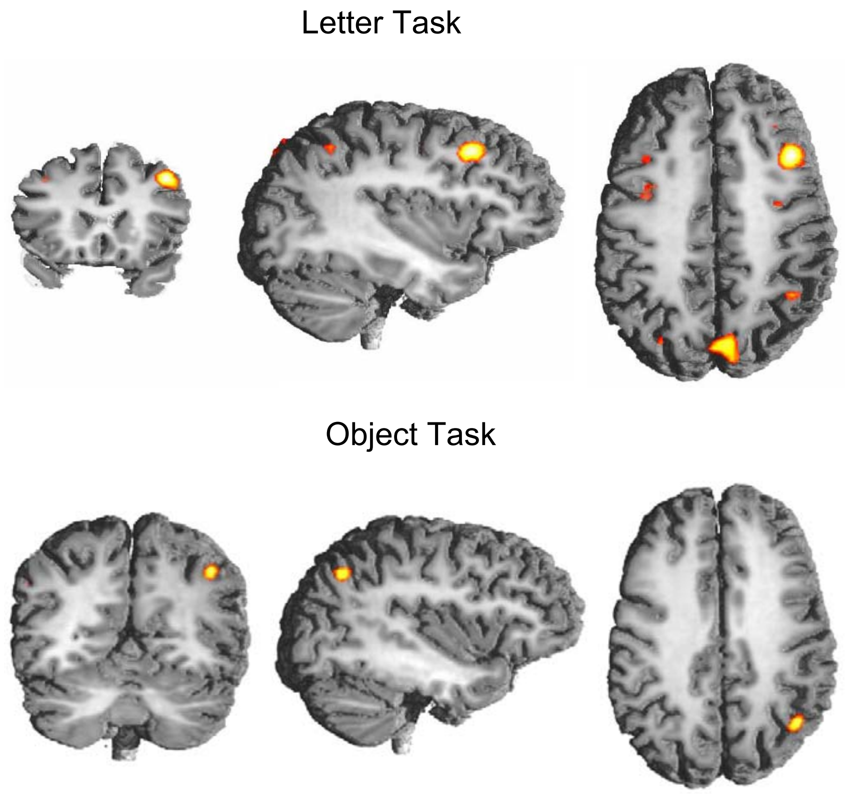

Figure 1. Brain regions that show larger hemodynamic activation in interference trials than in control trials in the letter task (upper panel) and in the object task (lower panel). The right anterior IPS is the only region showing interference-related activity in the object task. In contrast, interference resolution in the letter task is associated activity in the ventro- (left) and dorsolateral (right) PFC, the precuneus and the right IPS.

The interference effects in the letter task were modulated by working memory capacity: LS participants showed enhanced activation for interference trials only, whereas for HS participants, who showed better performance and lower interference costs in the letter task, the above-mentioned neuronal circuitry was activated irrespective of trial type. This latter result supports the view that HS individuals allocate more attentional resources for the maintenance of task goals in the face of interfering information from preceding trials.

2.9 Motor schemata for object use: Lateral premotor cortex activation depends on input formats and task demands

Christin Grünewald, Axel Mecklinger & Angela D. Friederici

Previous research has shown that the lateral premotor cortex (PMC) is activated when participants name man-made objects or their use (Martin et al., 1996, Grafton et al., 1997), image movements with the dominant hand (Decety et al., 1994) or perform manipulations with an object (Binkofski et al., 1999). It was therefore suggested that motor schemas for object use are represented in the lateral premotor area and that these schemata are activated automatically by appropriate stimuli. Here we examined the relevance of input format (line drawings vs. real world objects) and of task parameters (mnemonic and perceptual processing) for motor schemata activation. In a first study, we found a coactivation of the left ventral PMC and the anterior intraparietal sulcus (IPS) when information about manipulable objects (line-drawings) was held in working memory (Mecklinger et al., 2002). We assumed that this circuitry, that mediates the transformation of sensory information into hand actions, may allow to maintain information about manipulable objects in working memory. This pattern of results, however, could not be replicated in a second study using real world objects and a modified working memory task. It was assumed that in this latter task, the initial ventral PMC-IPS circuitry was overridden by an activation pattern evoked by spatial processing characteristics of the task. To clarify this issue, a further fMRI study was conducted, requiring simple classifications of real world objects. Here, the initial left lateral PMC activation could be replicated (cf. Fig. 1). The combined results suggest that motor programs for objects use are not automatically activated by manipulable real world objects. Rather, their activation depends on particular task and processing demands.

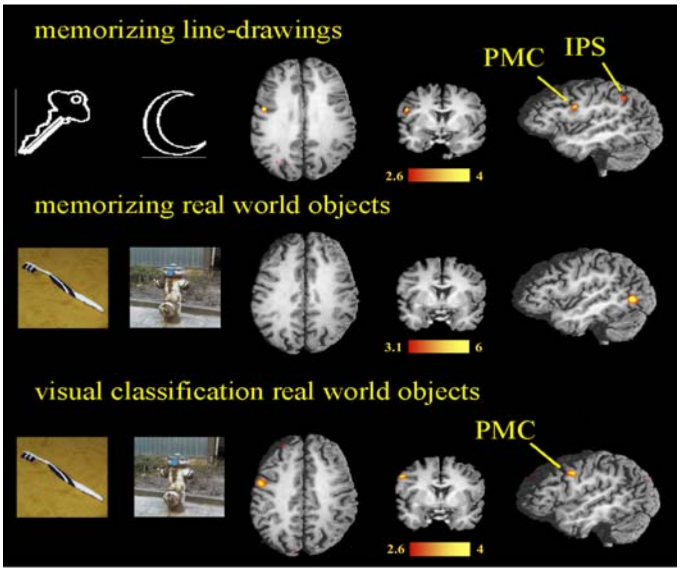

Figure 1. The figure shows examples of manipulable and non-manipulable objects used in the above-mentioned experiments. The brain images show direct contrasts of brain activation patterns to manipulable and non-manipulable objects revealed by different tasks and stimuli.

2.10 Prefrontal cortex involvement in preattentive auditory deviance detection: Neuroimaging and electrophysiological evidence

Christian Döller, Bertram Opitz, Christoph Krick, Wolfgang Reith, Axel Mecklinger & Erich Schröger

Previous electrophysiological and neuroimaging studies suggest that the mismatch negativity (MMN) is generated by a temporofrontal network subserving preattentive auditory change detection. In a cooperation with the Department of Neuroradiology at Saarland University Hospital, we employed event-related brain potentials (ERP) and event-related functional magnetic resonance imaging (fMRI) to examine neural and hemodynamic activity related to deviance processing, using three types of deviant tones (small, medium, and large) in both, a pitch and a space condition. In the pitch condition, hemodynamic activity in the right superior temporal gyrus (STG) increased linearly as a function of deviance. Small relative to medium and small relative to large deviants activated the right prefrontal cortex in the inferior frontal gyrus (IFG; BA 44/45) and in the middle frontal gyrus (MFG; BA 46; see Fig. 1a/b). Large relative to medium deviants led to bilateral activation in the IFG (BA 44/45; see Fig. 1c), that was more pronounced in the right hemisphere. In the ERP experiment, the peak amplitude of the early MMN (90-120 ms) increased linearly as a function of deviance and by this resembled the STG activation in the fMRI experiment (see Fig. 2a). An U-shaped relationship between MMN amplitude and the degree of pitch deviance was observed in a late time window (140-170 ms; see Fig. 2b), by this paralleling the right IFG activation pattern. In a subsequent source analysis constrained by fMRI activation foci, early and late MMN activity could be modeled by dipoles seeded in the STG and IFG, respectively. In the spatial condition, the MMN amplitude was substantially smaller than in the pitch condition for all three deviants. In contrast to the pitch condition, it increased linearly as a function of deviance in the early as well as in the late time window (see Fig. 2a/b).

We argue that the right IFG mediates auditory deviance detection in case of low discriminability between a sensory memory trace and auditory input. As the left IFG was activated solely by the large (octave-equivalent) deviant, it could be speculated that left IFG mediates processing of musical features inherent in the auditory stream. Both prefrontal mechanisms might be part of the top-down modulation of the deviance detection system in the STG.

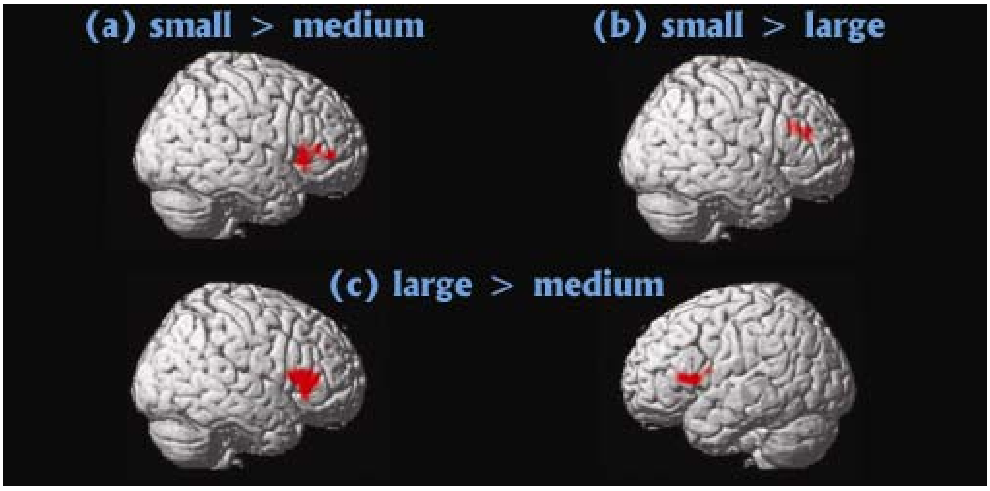

Figure 1. Lateral views of significantly activated voxels within the prefrontal cortex overlaid onto the surface-rendered MNI standard brain for the contrasts comparing (a) small and medium deviants (small > medium; x, y, z: 54mm, 24mm, 6mm), (b) small and large deviants (small > large; x, y, z: 50mm, 38mm, 22mm), and (c) large and medium deviants (large > medium; x, y, z: 50mm, 24mm, 6mm [right], x, y, z: -54mm, 26mm, 8mm [left]). In all comparisons, SPMs were thresholded at p<0.001 uncorrected for multiple comparisons, with an extent threshold of 100 voxels.

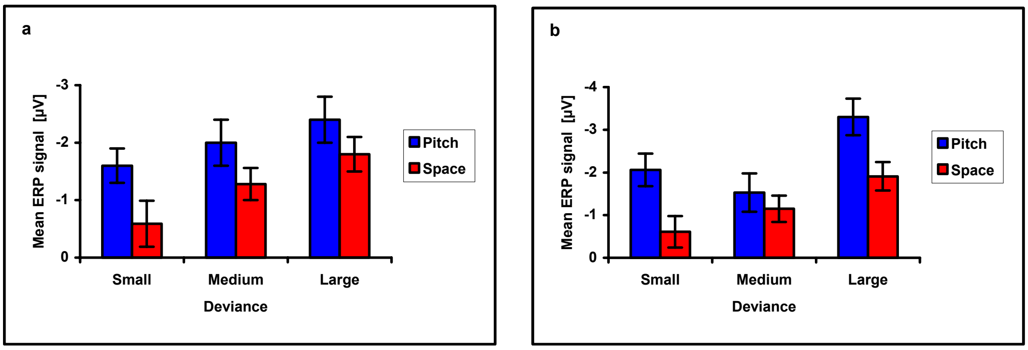

Figure 2. Mean MMN amplitudes for the (a) early and (b) late time window plotted as a function of deviance for the pitch (blue) and space (red) condition.

2.11 Interactions of the hippocampal system and the prefrontal cortex in pattern-based and rule-based learning

Bertram Opitz, Christian Döller, Sonia Cornell & Angela D. Friederici

One of the most influential views on hippocampal function suggests that this brain region is critically involved in relational memory processing, i.e. binding converging inputs to mediate the representation of relationships among the constituents of episodes. Two levels of bindings have been proposed: (i) entities occurring in the event are bound to the roles they fill in the event, and (ii) all role-entity bindings pertaining to the event are grouped together in order to distinguish them from role-entity bindings of other events (Shastri, 2002). It has been proposed that binding is automatic and obligatory during learning and remembering. These fast processes are followed by a slow consolidation process transferring an episodic memory trace to the neocortex (Alvarez, Squire, 1994; McClelland et al. 1995). Neuropsychological and neuroimaging studies have highlighted the importance of the interaction between the hippocampal system and prefrontal cortex in these binding processes. However, it is an open issue how prefrontal areas implicated in learning, memory and language processing do interact with the hippocampal system.

The present study uses functional magnetic resonance imaging (fMRI) and event-related potential (ERP) recordings to examine in detail the interaction of the hippocampal system with prefrontal areas by assessing learning-related changes in hemodynamic and electrophysiological activity during artificial grammar (AG) acquisition. It has previously been proposed that the learning mechanisms underlying language acquisition are of a domain-general, associative nature (Bates & Elman, 1996). According to this view, language learning can be understood as a stochastic process evaluating pattern-based relations in word sequences and generalizing beyond specific word order (Gomez & Gerken, 2001). Across multiple occurrences of different entities bound to the same role, a taxon representation of the rules underlying the grammar can be learned by generalization.

In a first fMRI experiment, we investigated the neural basis of AG learning with a focus on language-like rules. Participants (n=21, 12 male) with profound knowledge of the AG system of BROCANTO, as established by a training procedure, were presented with a slightly modified version of this AG. For one group, the superficial similarity was changed by introducing a new word order without changing the underlying rules (WORD condition). For the other half of the group, the new word order also implied a new grammatical rule (RULE condition). This latter condition led to a significant decrease in grammaticality judgment immediately after the change with subsequent learning of the new rule. In the WORD condition, increasing performance was observerd throughout the entire session.

Increased proficiency in AG use, as revealed by rule-conforming task performance, resulted in a gradual decrease of left anterior hippocampal activity in the WORD condition only. In contrast, a gradual increase of activity in the left inferior precentral gyrus was observed solely for the RULE condition (Fig. 1). These findings agree well with previous studies demonstrating that changes in superficial features of an AG modulate activation in the left anterior hippocampus whereas bilateral anterior prefrontal cortices are selectively engaged following abstract rule change.

In a related ERP study, we expected that proficient use of the AG, as exemplified in a comparison of two subsequent learning sessions, should be manifested in a shift from domain-general to more domain-specific waveforms elicited by items violating the AG. Likely candidates are slow positive components such as P3 and P6 respectively (cf. Baldwin & Kutas, 1997; Friederici et al., 2002). Preliminary results (cf. Figure 2) of 21 participants show greater frontal positivities for ungrammatical sentences around 500 ms in the second as compared to the first learning session.

These results point to a differentiation between similarity-based learning and rule abstraction during language acquisition with similarity-based learning playing a non-obligatory role during the initial phase and rule-based abstraction during a later phase.

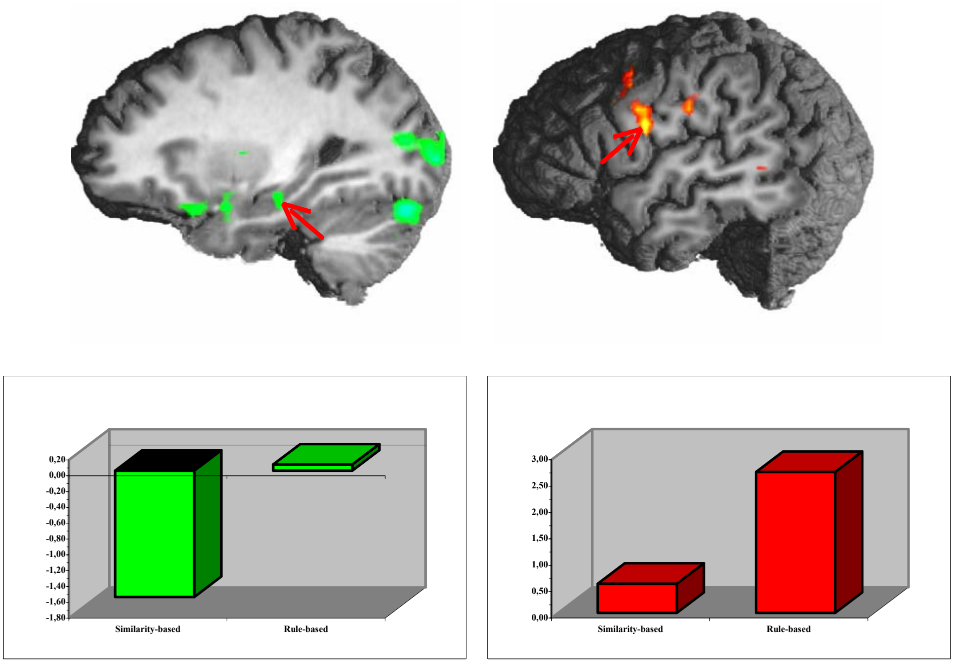

Figure 1. Brain regions in which a significant Condition by Time interaction was observed. Sagital section at x = -26 mm (left panel) and x = -48 mm exhibit brain areas with changes of activity during learning relative to control. Decreased activity in left anterior hippocampus (left panel, indicated by an arrow) was noted for similarity-based learning only (bottom left). Regions demonstrating increased activity during learning included the left precentral gyrus (right panel). It was predominant for rule-based learning (bottom right).

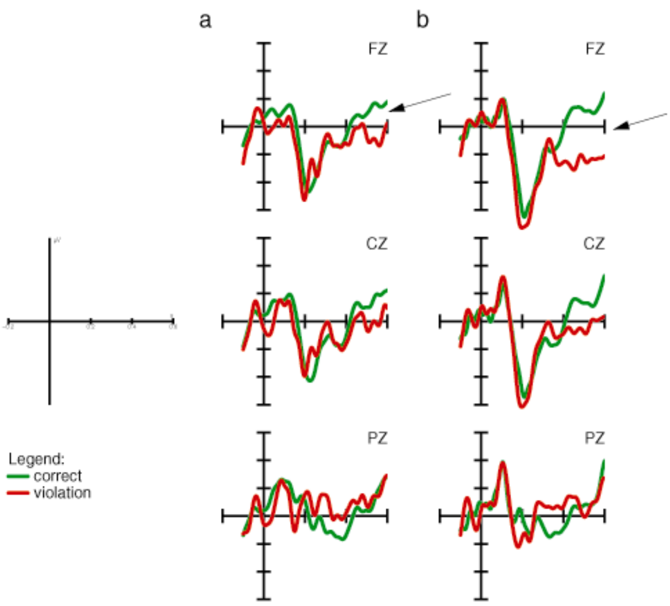

Figure 2. Grand average ERP wave forms for (a) Session 1 and (b) Session 2. Mean signals are plotted separately for correct sentences (green) and syntactic violations(red) at selected electrode sites of the 10-20 system.

2.12 Towards the neural correlates of context-specific and decontextualized knowledge

Christian Döller, Bertram Opitz, Christoph Krick, Wolfgang Reith & Axel Mecklinger

There has been much recent interest in identifying brain circuitries responsible for episodic memory and, in particular, uncovering the functional role of the *hippocampus* during the acquisition and consolidation of new information. An influential view on hippocampal function (Shastri, 2002; see also O'Reilly & Norman, 2002) proposes that hippocampal episodic memory traces encode relational structures wherein entities occurring in the event are bound to the respective roles they fill in the event. Additionally, the model suggests that information transfer from the hippocampal system to cortical structures is based on the gradual formation of new and the fine-tuning of existing taxon-facts in the cortex. Unlike episodic facts that encode specific events, taxon-facts encode statistical summaries of multiple events, i.e. decontextualized knowledge by extracting regularities among episodes. Here we use event-related functional magnetic resonance imaging (fMRI) to assess the time course of interaction between the hippocampus and the prefrontal cortex in the initial formation of episodic memory traces and the gradual transition into decontextualized knowledge. To further examine whether the learning-related brain systems operate in a domain-general or in a domain-specific way, two learning conditions (space vs. object) were contrasted with an episodic memory condition.

During four behavioral pre-studies, participants learned four sequential relations among items and positions within a 4x4 matrix and were required to recognize these relations after a short delay. In the spatial and object condition, positions or objects, respectively, were held constant within one experimental block whereas in the episodic memory condition, object to position assignments were random. In addition, learning was evaluated using an implicit memory test (perceptual discrimination task) and an explicit recognition memory test at the end of the experiment. Hit rates increased continuously within task blocks in both the spatial and object condition, but not in the episodic memory condition (see Fig. 1a). In the perceptual discrimination task, participants were faster for the invariant relations than for new relations in the space and object blocks, indicating the formation of decontextualized knowledge (see Fig. 1b).

FMRI data acquisition is currently ongoing. We expect a hippocampal-prefrontal shift of activity during the course of the learning blocks. Consistent with the domain-general view, we expect highly similar prefrontal-hippocampal activation pattern in both learning conditions.

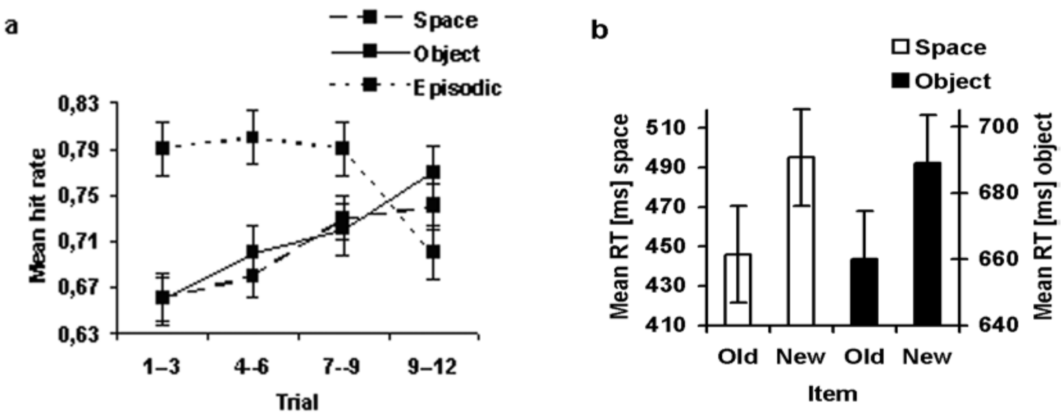

Figure 1. (a) Mean hit rates plotted as a function of trial number within an experimental block for the object (solid), space (dashed), and episodic (dotted) condition. (b) Mean reaction times for the perceptual discrimination task depicted separately for old (invariant) and new relations for the object (black) and space (white) condition.

2.13 Hypertension and vascular dementia

Stefanie König, Eva-Maria Röll, Axel Mecklinger, Georg Becker & Gilbert Mohr

In an ongoing cooperation with the Neurology Department at Saarland University Hospital, we are examining risk factors for vascular dementia in patients suffering from hypertension. To identify these patients prematurely and non-invasively, several neuropsychological and neurophysiological measurements are employed. Neuropsychological testing includes the HAWIE, the WMS-R and a verbal memory test including recall and recognition measurements, the VGT-16. At Saarland University Hospital, cerebral duplex sonography is employed to measure the arteriovenous cerebral transit time (cTT).

Previous studies have shown a prolongation of cTT in patients with cerebral microangiopathy. As neurophysiological procedures, we conduct two ERP memory experiments with a false memory task and an auditory oddball task. As indicated by previous studies, the patients' ERP components should differ from those of the healthy controls with regard to latency, amplitude and topography (Mecklinger et al. (1998); Ullsperger, Mecklinger et al. (2000); Yamaguchi et al. (1999)).

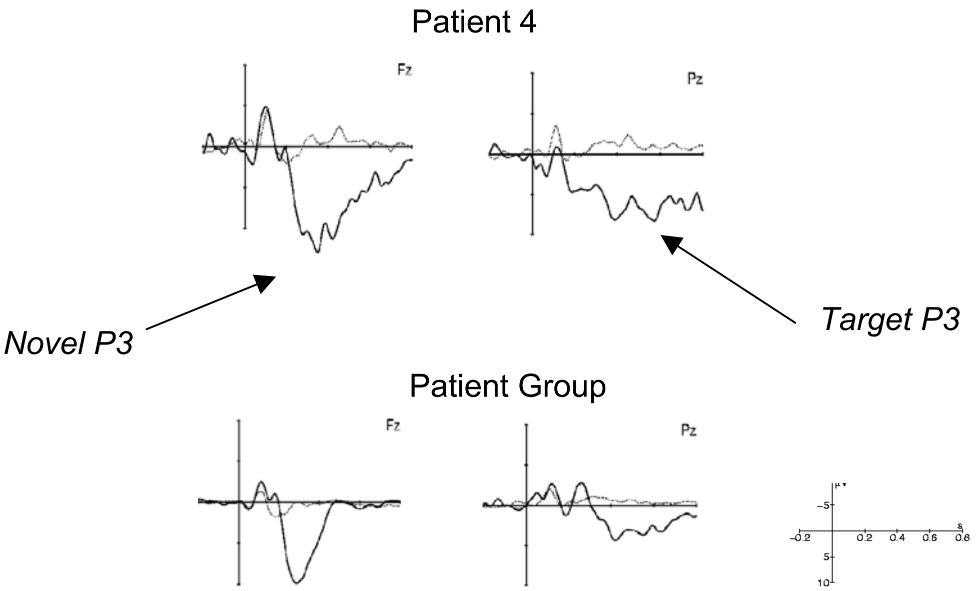

Figure 1. Novel (Fz) and target (Pz) P3 for patient 4 (top row) and the remaining group of hypertension patients (bottom row). Thin line: standards, Thick line: deviants (Pz), novels (Fz).

So far, 10 patients, age range 33-67 (4 females) have been investigated. Some of them exhibited noticeable impairments in neuropsychological testing and physiological parameters. One patient showed a pronounced pattern of results, as he had a low memory index, poor recall performance in combination with prolonged novel and target P3 latencies (see Fig. 1). In addition, the cTT was also prolonged, pointing to the phenomenon of vascular dementia. As the patient group so far is still too heterogeneous with regard to age, onset of disease, medication, neurological and neuropsychological status, testing will continue to obtain more homogenous and reliable results.

2.14 On the relevance of the mesiotemporal lobes in language comprehension

Patric Meyer, Axel Mecklinger, Thomas Grunwald & Angela D. Friederici

Despite the diversity of theories on the MTL memory system, the essential role of the hippocampus in verbal memory performance remains undisputed. However, its hypothetical involvement in particular processes of language comprehension has been less investigated. Moreover, the few hints on the role of the MTL in language comprehension are not clear cut. Therefore, they do not allow to identify the hippocampus as the source of language relevant event-related-potential (ERP) component, such as the P600. So far, there is only one study that has investigated the possible hippocampal language-computation capacities with intracranial electrodes during sentence comprehension (Mecklinger et al., in preparation). They found a double dissociation between the hippocampus and the rhinal cortex concerning the sensitivity to semantic versus syntactic violations in natural speech with the hippocampus being more sensitive to violations of grammar (MTL-P600) and the rhinal cortex being more sensitive to semantic processes (AMTL-N400).

Here we examined, in one patient with a left lateralized selective amygdala-hippocampectomy, the extent to which amnesics show particular syntactic-processing deficits during sentence comprehension. The patient listened to sentences with early and late syntactic disambiguation and to wrong sentences.

He showed a specific deficit in understanding of garden-path sentences. In a follow-up ERP study (with scalp-electrodes) using the same paradigm as in the Mecklinger et al. study, the patient showed a selective attenuation of the P600 amplitude in the syntactic violation condition over the lesioned left hemisphere area. Taking these two studies together, the results could hint to a specific involvement of the hippocampus proper in language comprehension. The exact function of that structure might be best explained by a restructuring of connections (between pre-existing nodes) supporting repair and reanalysis. An additional analysis of coherence between the rhinal cortex and the hippocampus proper is currently conducted. This will allow us to examine condition-specific coupling and decoupling processes in the mesiotemporal lobes in the service of language comprehension.

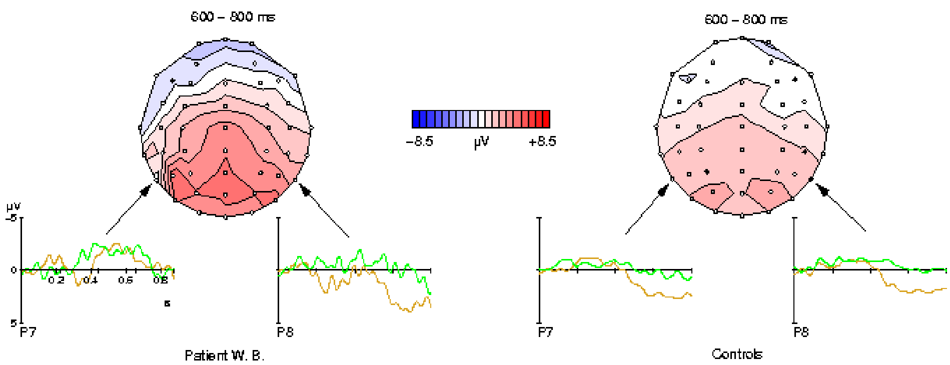

Figure 1. Upper panel: Topographical maps illustrating the distribution of the differences between correct sentences and sentences with syntactic violations. ERPs elicited by correct sentences (green line) and syntactic violations (brown line). Left: Patient W. B., showing no P600 component over the lesioned left hemisphere area (i.e. the P7 electrode of the 10-20 system). Right: Controls.

3 Publications

3.1 Journal articles

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Heim, S., Opitz, B., Müller, K. & Friederici, A. (in press) Phonological processing during language production: fMRI evidence for a shared production-comprehension network. *Cognitive Brain Research.*

Johansson, M., Stenberg, G., Lindgren, M., & Rosén, I. (2002). Memory for perceived and imagined pictures: An event-related potential study. *Neuropsychologia, 40*, 986-1002.

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Lövdén, M., & Johansson, M. (in press). Are covert verbal responses mediating false implicit memory? *Psychonomic Bulletin & Review*.

Mecklinger, A., Gruenewald, C., Besson, M., Magnié, & von Cramon, D.Y. (2002) Separable neuronal circuities for manipulable and non-manipulable objects in working memory. *Cerebral Cortex, 12, 1115-1123.*

Nessler, D. & Mecklinger, A.. (2003). ERP correlates of true and false recognition after different retention delays: Stimulus and response related processes. *Psychophysiology, 40*, 146-159.

Opitz, B., Rinne, T., Mecklinger, A., von Cramon, D.Y. & Schröger, E. (2002). The frontal generator of the mismatch negativity. Its role in deviancy processing. *NeuroImage, 15, 167-174.*

Penney, T.B., Maess, B. Busch, N., Derrfuss, J. & Mecklinger, A. (in press) Cortical activity reduction with stimulus repetition: A whole head MEG analysis. *Cognitive Brain Research.*

3.2 Books and book chapters

Döller, C. (2002). Die Rolle des Stirnhirns bei der Generierung der Mismatch Negativity [The role of the frontal MMN generator]. Unpublished master thesis. University of Bonn, Germany.

Grünewald, C. (2002). Die Rolle motorischer Schemata bei der Objektpräsentation: Untersuchungen mit funktioneller Magnetresonanztomographie. Unpublished doctoral thesis. Saarland University, Germany.

Johansson, M. (2002). Memory illusions and memory attributions: Behavioural and electrophysiological data. Unpublished doctoral thesis. Lund University, Sweden.

Mecklinger, A. Elektrophysiologie des Wiedererkennens (in press). In T. Goschke & M. Eimer. *Kognitive Neurowissenschaften. Enzyklopädie der Psychologie.*

3.3 Papers submitted

Döller, C., Opitz, B., Krick, C., Reith, W., Mecklinger, A., and Schröger, E. (2003). Prefrontal cortex involvement in preattentive auditory deviance detection: Neuroimaging and electrophysiological evidence.

Johansson, M. & Mecklinger, A. (2002). The late posterior negativity in ERP studies of episodic memory: a selective review and a functional account.

Johansson, M., Stenberg, G., & Rosén, I. (2002). Susceptibility to false recognition: An event-related potential study.

Mecklinger, A., Weber, K., Gunter, T.C. & Engle, R.W. Dissociable brain mechanisms for interference control: Effects of interference content and working memory capacity.

Opitz, B. & Friederici, A. D. (2002). Interactions of the hippocampal system and the prefrontal cortex in learning language-like rules. Neuroimage.

3.4 Published abstracts

Berti, S., Schröger, E., Mecklinger, A., Herrmann, C ., & Maeß, B. (2002): A magnetic correlate of pre-attentive periodicity analysis. In: Nowack, H., Haueisen, J., Gießler, F. & Huonker, R. (Hrsg.*): Proceedings of the 13th International Conference on Biomagnetism,* p. 143, VDE Verlag, Berlin, Offenbach.

Döller, C., Opitz, B., Waldhauser, G., Mecklinger, A. & Schröger, E (2002). Die Rolle des Stirnhirns bei der Generierung der Mismatch Negativity. In M. Baumann, A. Keinath & J.F. Krems (Hrsg). Experimentelle Psychologie, *Beiträge zur 44. Tagung experimentell arbeitender Psychologen (TeaP)*. Regensburg: Roder. p. 96.

Grünewald, C., Mecklinger, A., Friederici, A. D., & von Cramon, D. Y. (2002). Motor schemas for object use are not automatically activated by pictures of real world objects: an fMRI investigation. *Journal of Cognitive Neuroscience (Supplement).*

Heim, S., Opitz, B. & Friederici, A. D. (2002) The role of Broca's area in processing syntactic information: An fMRI study. *Journal of Cognitive Neuroscience (Supplement)*.

Mecklinger, A., & Nessler, D. (2002). Familiarity is more than recency: an electrophysiological dissociation. *Journal of Cognitive Neuroscience (Supplement).*

Opitz, B. & Friederici, A. D. (2002) Artificial language acquisition: Changes in brain activity during the course of learning. J*ournal of Cognitive Neuroscience (Supplement)*.

Waldhauser, G., Mecklinger, A., & Gruenewald, C. (2002). Arbeitsgedächtnis und Expertise: Enkodierung und Rehearsal komplexer visueller Stimuli. In M. Baumann, A. Keinath & J.F. Krems (Hrsg). Experimentelle Psychologie, *Beiträge zur 44. Tagung experimentell arbeitender Psychologen (TeaP)*. Regensburg: Roder. p. 230.

3.5 Presentations

Johansson, M.
Distortions of memory: behavioral and electrophysiological data. *Department of Psychology, Umeå University, Sweden. Nov. 2002.*

Lundstrom, B. N., Johansson, M., Petersson, K. M., Fransson, P., Andersson, J., & Ingvar, M.
Remembering the context sometimes activates left prefrontal cortex: Imagined more than perceived*. Poster presented at the International Conference on Functional Mapping of the Human Brain, Sendai, Japan.*

Mecklinger, A.
Performance monitoring and Recognition Memory. *Information Processing and Error Analysis. A meeting to honor Professor Michael Coles' contribution to Psychology and Neuroscience. Champaign, Illinois, April 2002.*

Mecklinger, A.

ERP Correlates of Dual Processes in Recognition Memory. *8th International Conference on Cognitive Neuroscience, Porquerolles, France, September 2002.*

Mecklinger, A.

Differential Encoding and Retrieval of Emotional and Non Emotional events: Evidence from Neuroimaging. *Conference "Clinical Emotion Research. The State of the Art. Saarbrücken, October, 2002.*

Mecklinger, A.

Arbeitsgedächtnis: Neuronale Korrelate kurzfristiger Speicher- und Kontrollprozesse. *47. Jahrestagung der Deutschen Gesellschaft für Klinische Neurophysiologie und funktionelle Bildgebung. Lübeck, October, 2002.*

Mecklinger, A.

Combined fMRI and ERP indices of recognition memory processes. *Institute of Child Health, University College London Medical School, London, July, 2002.*

Opitz, B.

Spracherwerb nur im Kindesalter? Neurowissenschaftliche Ergebnisse zur 'critical period hypothesis'. *PISA - auch ein Fall für deutsche Hochschulen ? Seminar der Universität Leipzig, Juni 2002.*

4 Degrees

Diploma:

Christian Döller	(Bonn University)

Doctoral Degrees:

Christin Grünewald	(Saarland University)
Mikael Johansson	(Lund University)

5 Teaching

Wintersemester 2001/2002

Vorlesung: Biologische Psychologie I
(Axel Mecklinger)

Proseminar: Ereigniskorrelierte Potentiale und kognitive Prozesse
(Axel Mecklinger)

Emiriepraktikum
(Bertram Opitz)

Hauptseminar: Neurokognition des Gedächtnisses
(Axel Mecklinger)

Hauptseminar: Neuropsychologie der Handlung
(Christin Grünewald)

Forschungsseminar
(Axel Mecklinger)

Sommersemester 2002

Vorlesung: Biologische Psychologie II
(Axel Mecklinger)

Proseminar: Stress
(Axel Mecklinger)

Proseminar: Neuropsychologie des Kindes und Jugendalters
(Gilbert Mohr)

Empiriepraktikum
(Bertram Opitz)

Hauptseminar: Klassische Befunde der Neuropsychologie
(Axel Mecklinger)

Hauptseminar: Neuropsychologische Diagnostik
(Gilbert Mohr)

Forschungsseminar
(Axel Mecklinger)

Wintersemester 2002/2003

Vorlesung: Biologische Psychologie I
(Axel Mecklinger)

Proseminar: Lernen und Gedächtnis
(Bertram Opitz)

Empiriepraktikum
(Bertram Opitz)

Hauptseminar: Kognitive Neurowissenschaften
(Axel Mecklinger)

Hauptseminar: The Cognitive Neuroscience of Emotion
(Mikael Johansson)

Hauptseminar: Psychophysiologische Methoden
(Axel Mecklinger)

Hauptseminar: Funktionelle Symptomatiken nach Schädigung des Stirnhirns
(Gilbert Mohr)

Forschungsseminar
(Axel Mecklinger)