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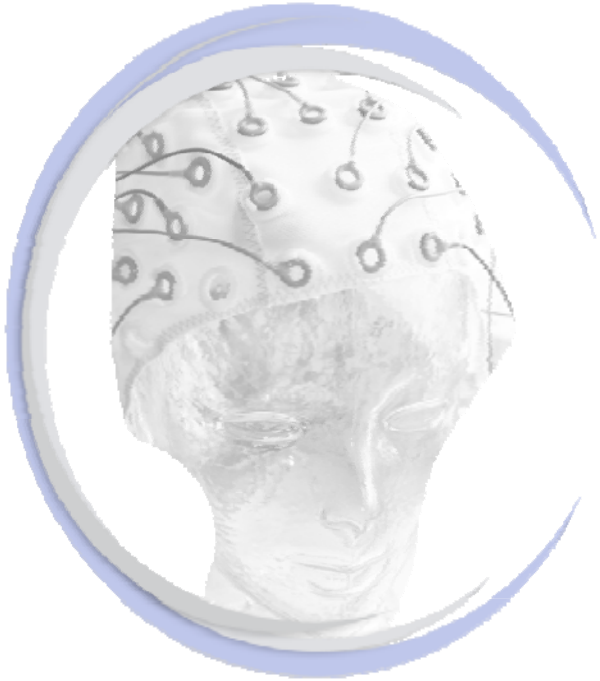
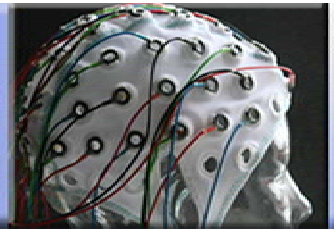


Kognitive Kontrolle

Gazzaniga, Kap 12.

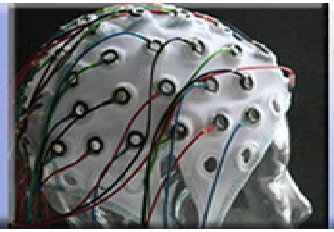

www.3BP.com

Patient W.R.



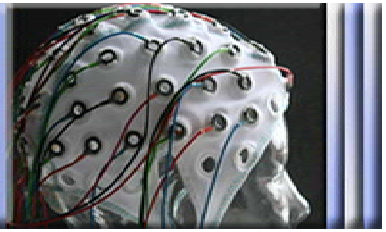
- Vom Tellerwäscher zum Millionär mit umgekehrten Vorzeichen.
- Lost ego, high distractability, no commitment
- Ziel-orientiertes Verhalten
- Übergeordnete Handlungsziele
- Exekutive Funktionen

Inhalt



- Funktionelle Neuroanatomie des frontalen Cortex
- **Lateraler PFC**
  - Arbeitsgedächtnis
  - Selektion
  - Inhibition
  - Multitasking
- **ACC**
  - Monitoring

Subregionen des Frontalen Cortex



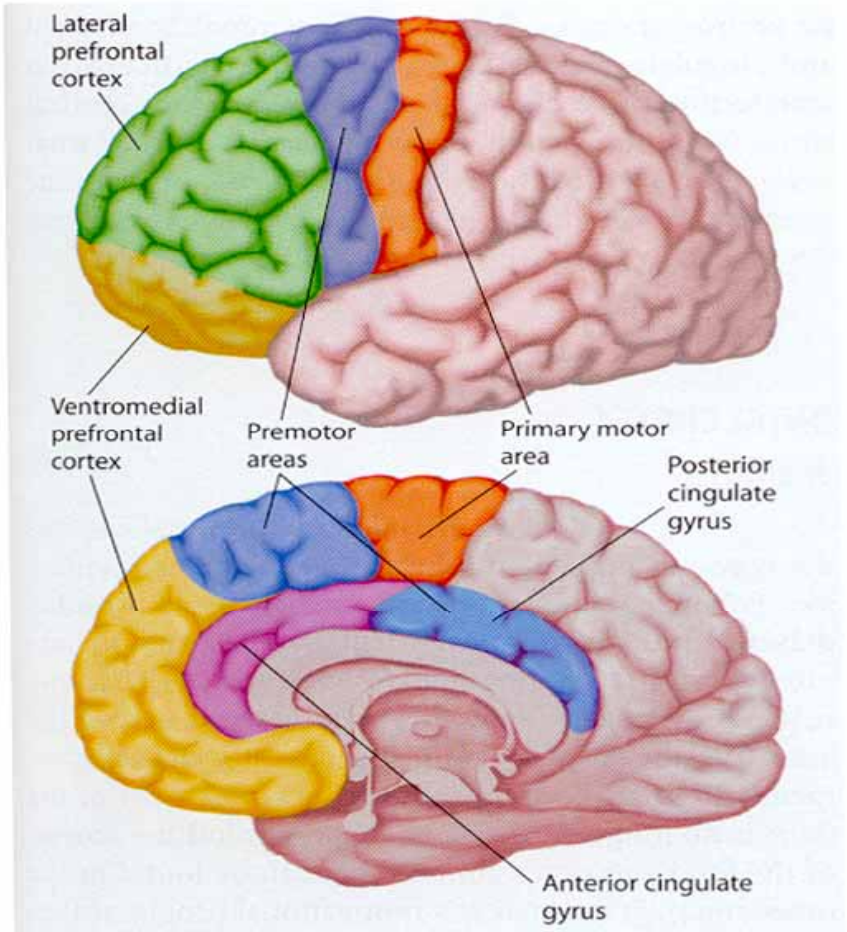
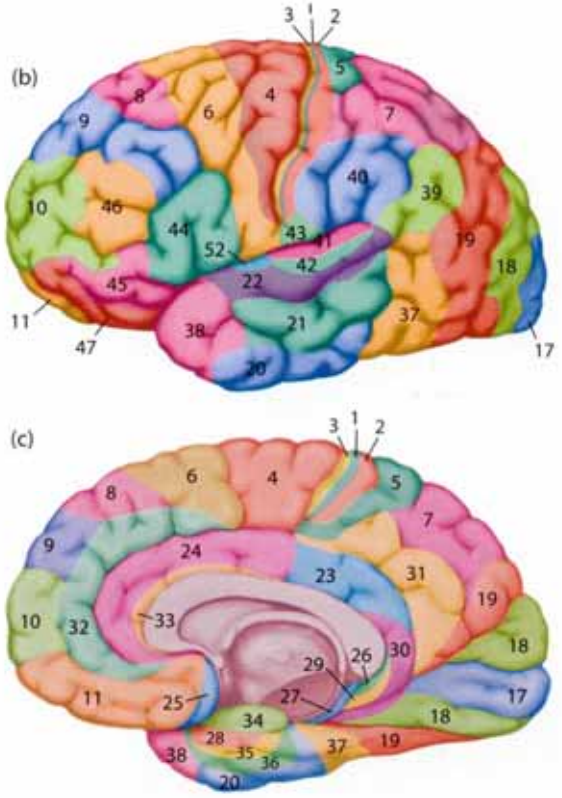
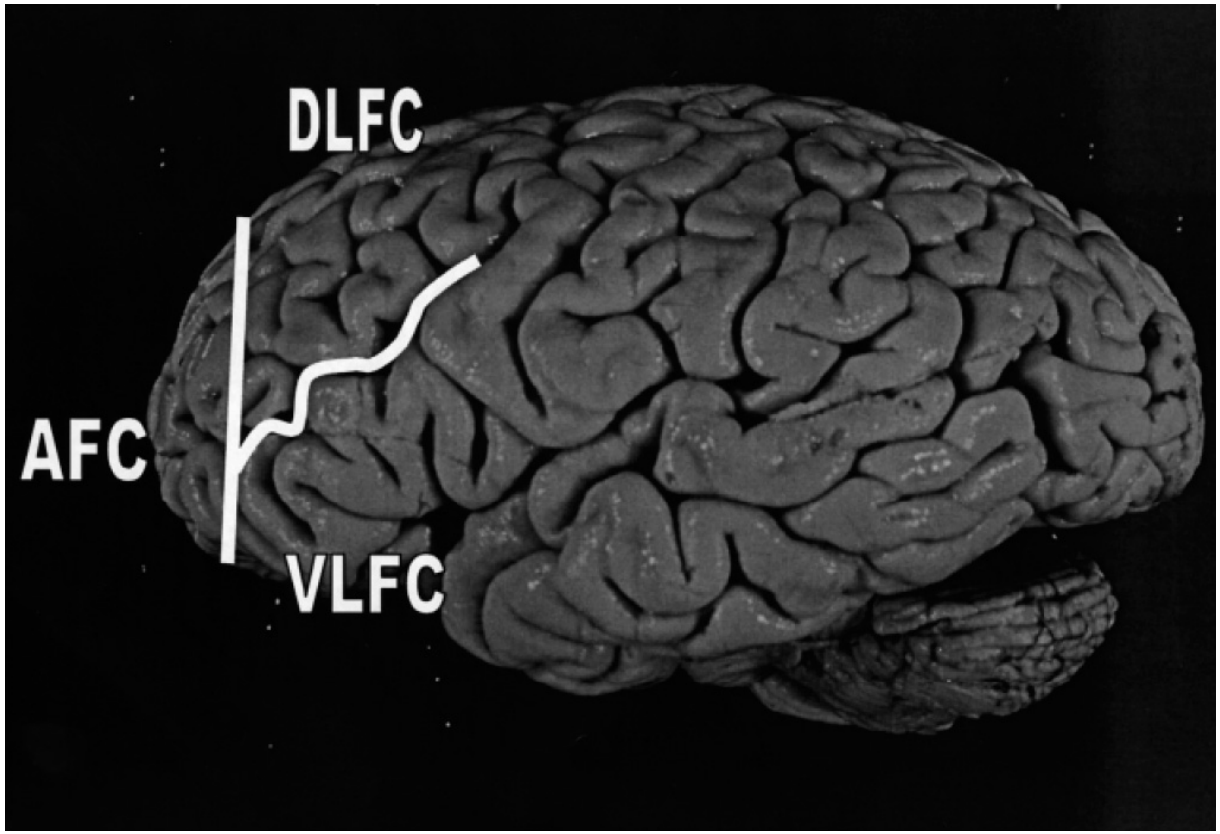


Figure 12.1 The areas of the frontal lobe. The prefrontal cortex includes all of the areas in front of the primary and secondary motor regions. The three major subdivisions of prefrontal cortex are the lateral prefrontal, ventromedial prefrontal, and the anterior cingulate cortex.



Subregionen des Frontalen Cortex



Subregionen des Frontalen Cortex

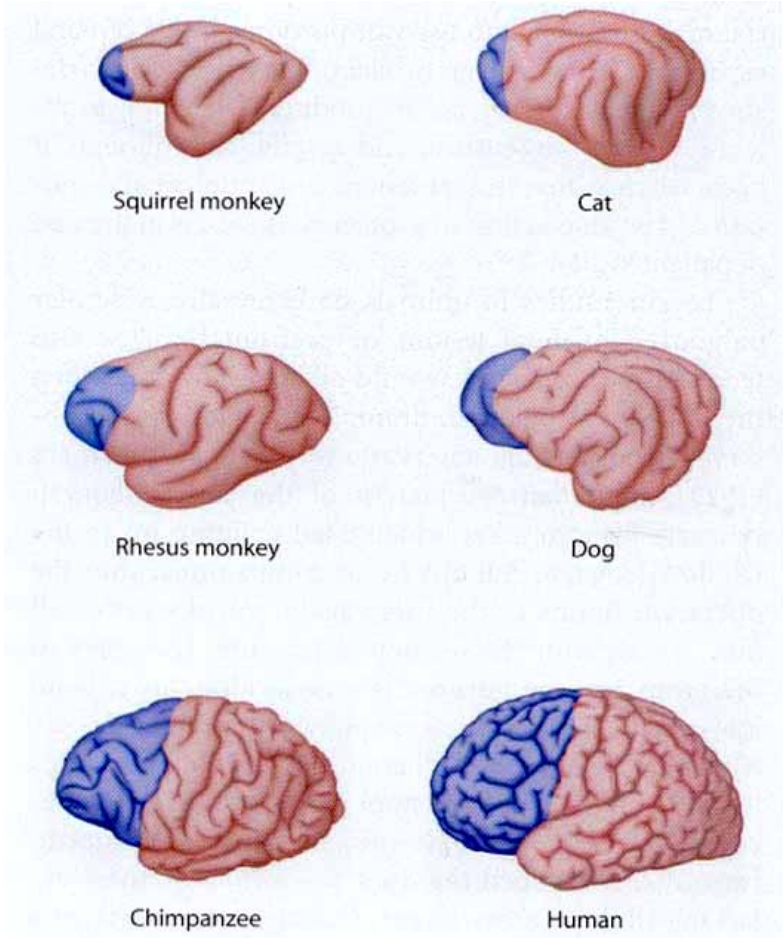
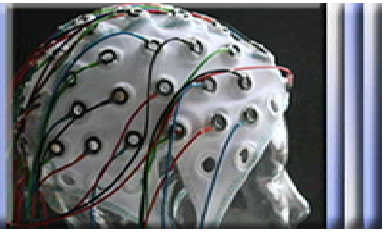


Figure 12.2 The shaded areas show the extent of prefrontal cortex in six species. Note how small this region is in the cat, dog, and squirrel monkey. It is greatly enlarged in humans. The brains are not drawn to scale. Adapted from Fuster (1989).

PFC Läsionen
Langzeit- vs. Arbeitsgedächtnis



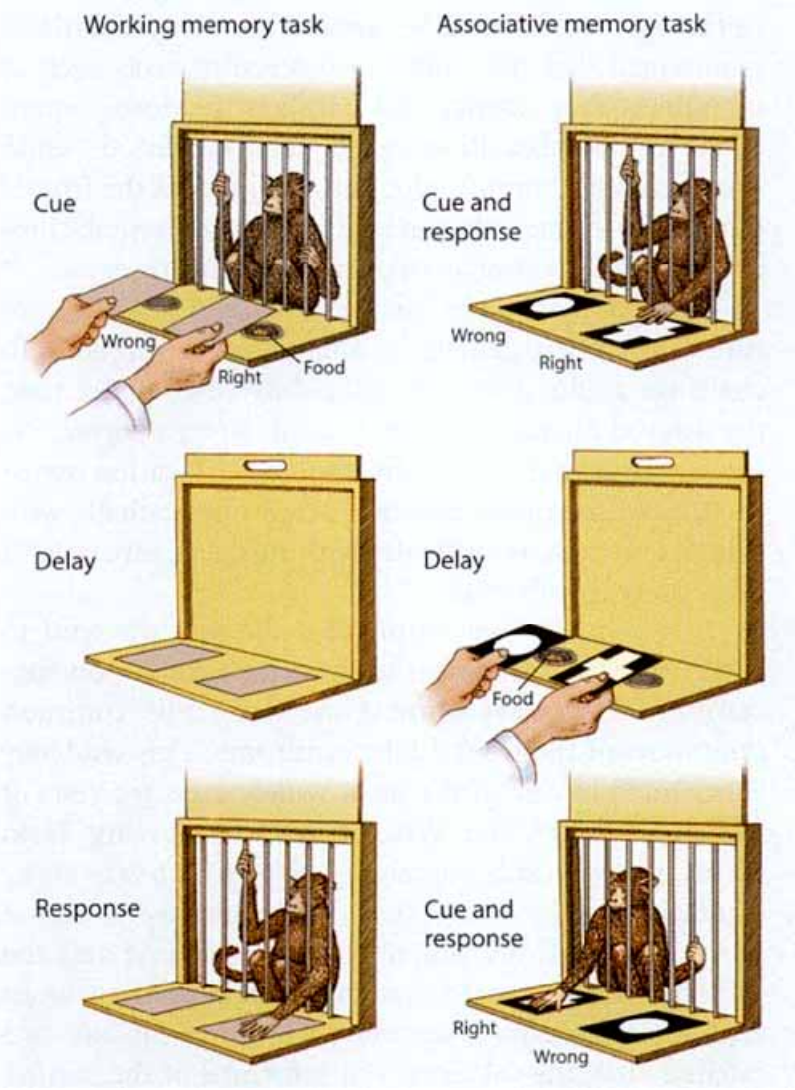
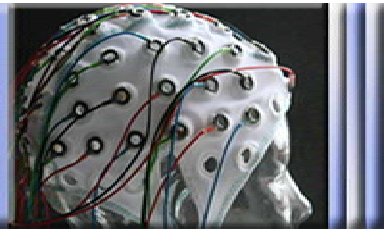
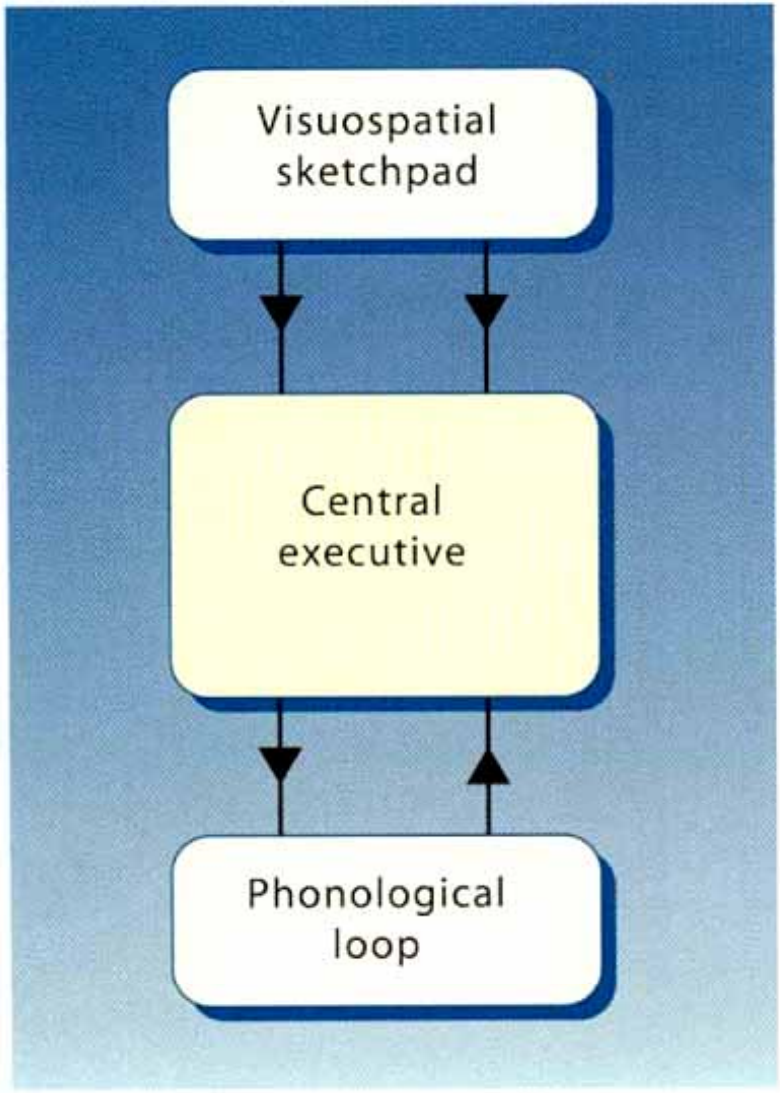


Figure 12.3 Monkeys with prefrontal lesions demonstrate selective impairment on the working memory delayed-response task. **(Left)** In the working memory task, the monkey sees one well baited with food. After a delay period, the animal retrieves the food. The location of the food is determined randomly. **(Right)** In the associative memory task, the food reward is always associated with one of the two visual cues. The location of the cues (and food) is determined randomly. Working memory is required in the first task because, at the time the animal responds, there are no external cues indicating the location of the food. Long-term memory is required in the second task since the animal must remember which visual cue is associated with the reward. Adapted from Goldman-Rakic (1992).

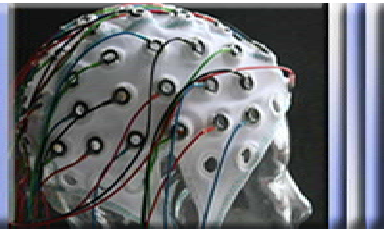
Arbeitsgedächtnis

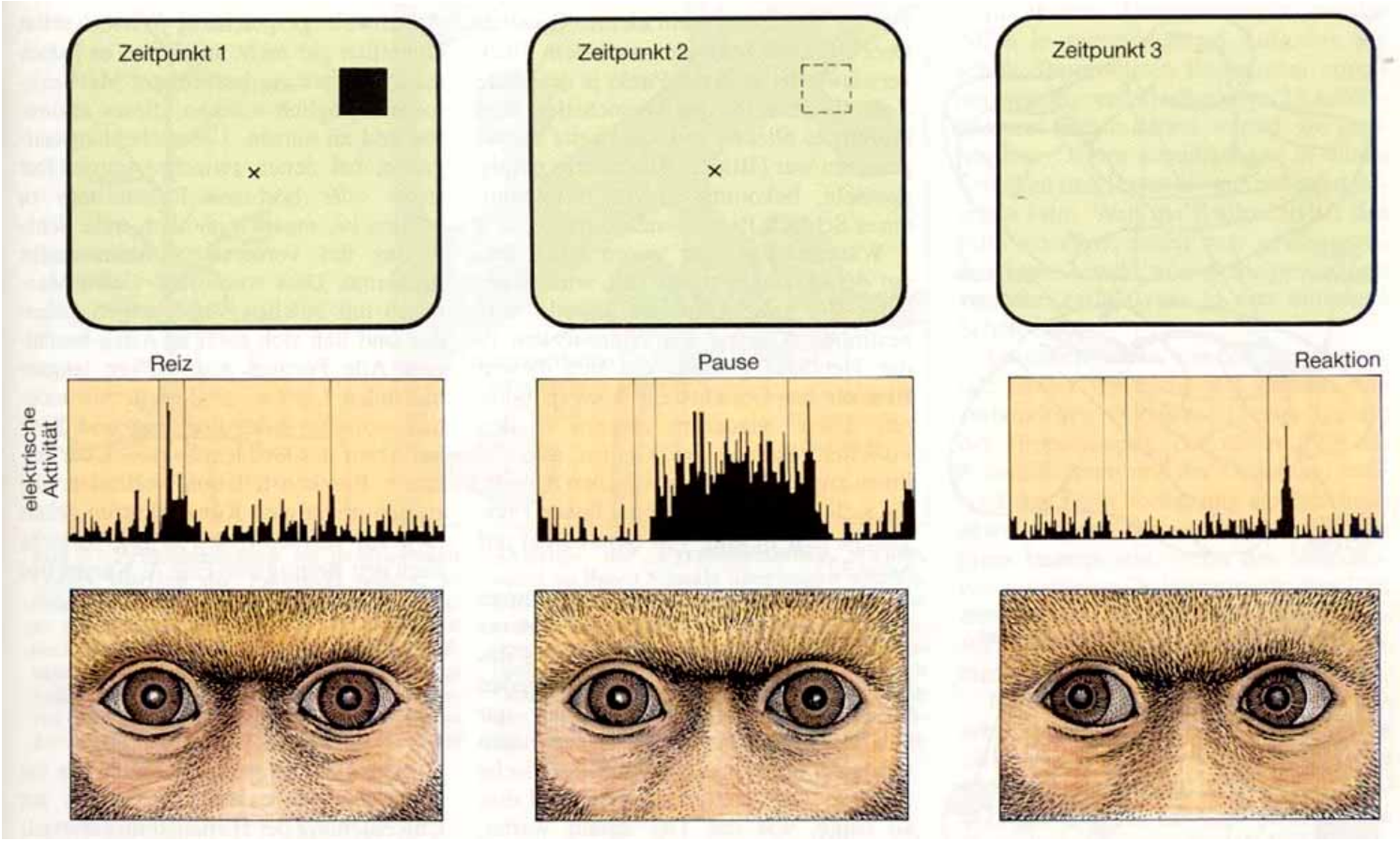




Alan Baddeley, 1995

Arbeitsgedächtnisaufgaben mit oculomotorischer Antwort





Einzelzellaktivität bei delayed-response tasks

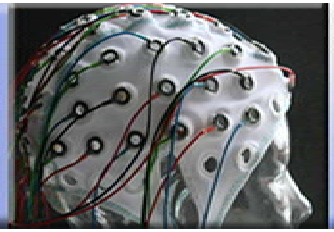
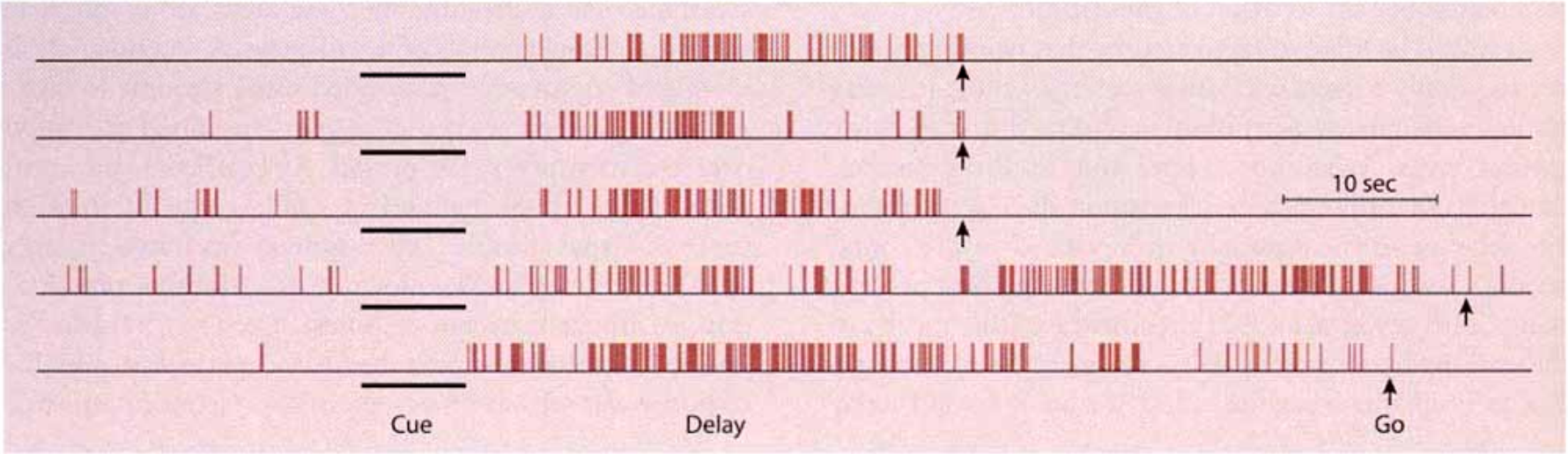
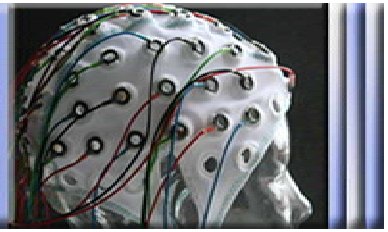


Figure 12.6 Prefrontal neurons can show sustained activity during delayed-response tasks. Each line represents a single trial. The cue indicated the location for a forthcoming response. The monkey was trained to withhold the response until a "Go" signal (arrows) appeared. Each vertical tick represents an action potential. This cell did not respond during the cue interval. Rather, its activity increased when the cue was turned off, and persisted until the response. Adapted from Fuster (1989).



Einzelzellaktivität bei delayed-response tasks: Inhaltsspezifität ?



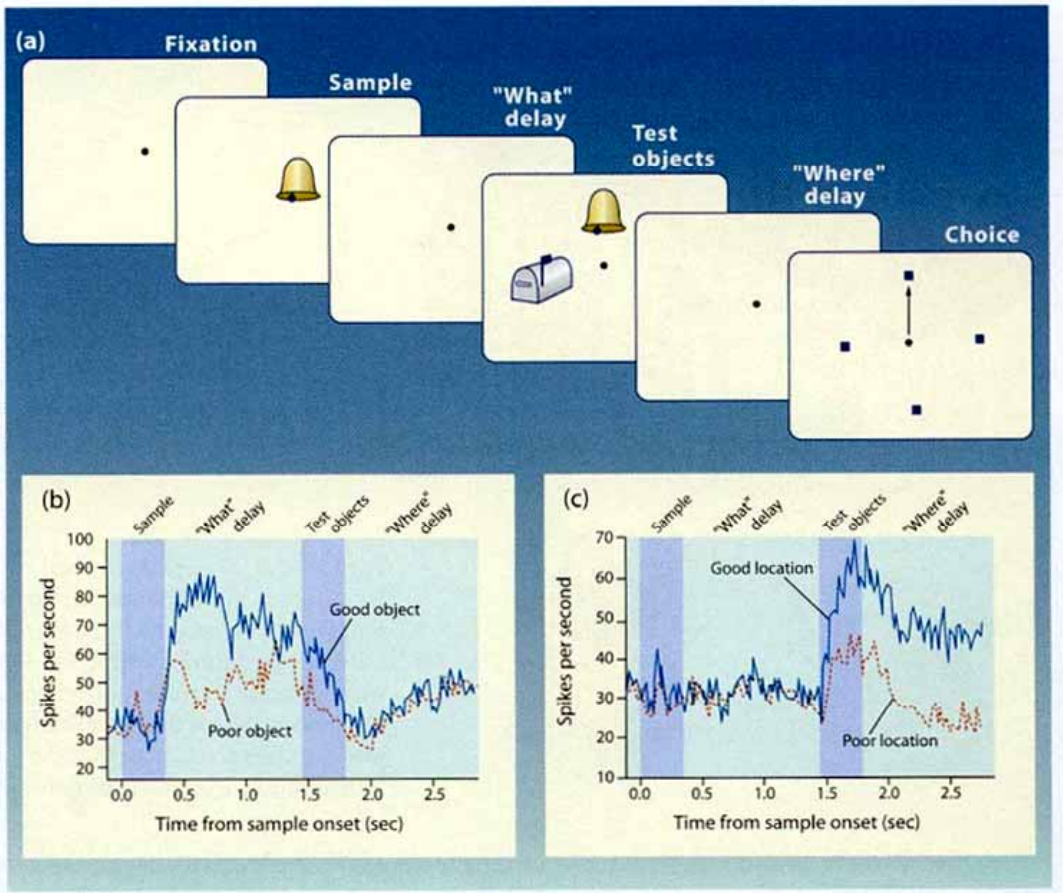
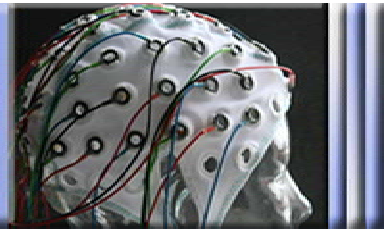
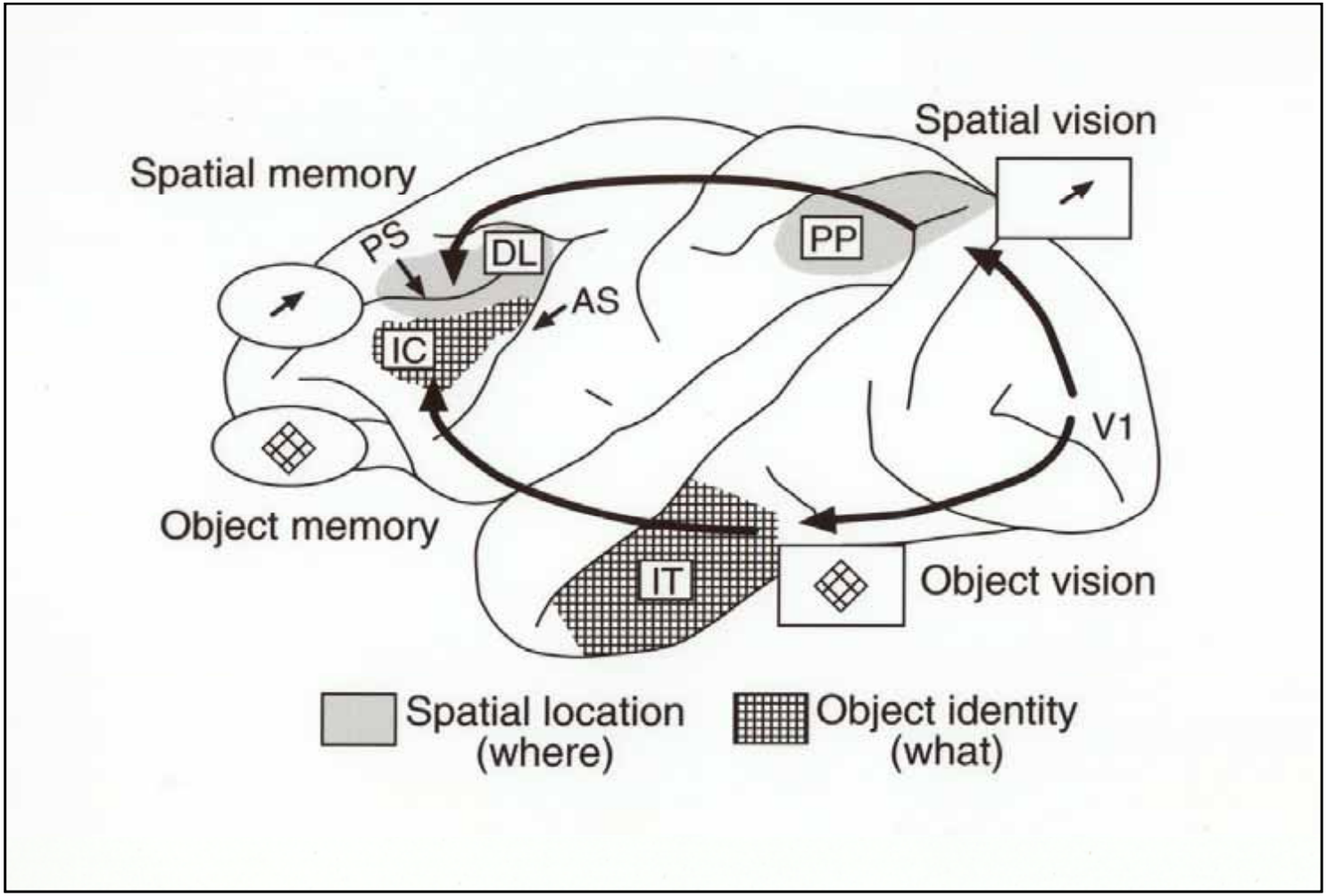


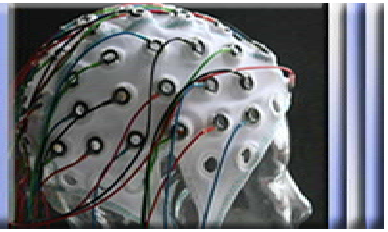
Figure 12.7 Coding of "what" and "where" information in single neurons of the prefrontal cortex in the macaque. **(a)** Sequence of events in a single trial. See text for details. **(b)** Firing profile of a neuron that shows a preference for one object over another during the "what" delay. The neural activity is low once the response location is cued. **(c)** Firing profile of a neuron that shows a preference for one location. This neuron was not activated during the "what" delay. Adapted from Rao et al. (1997).

Einzelzellaktivität bei delayed-response tasks: Inhaltsspezifität ?





BOLD-Signal bei delayed-response tasks: Inhaltsspezifität ?



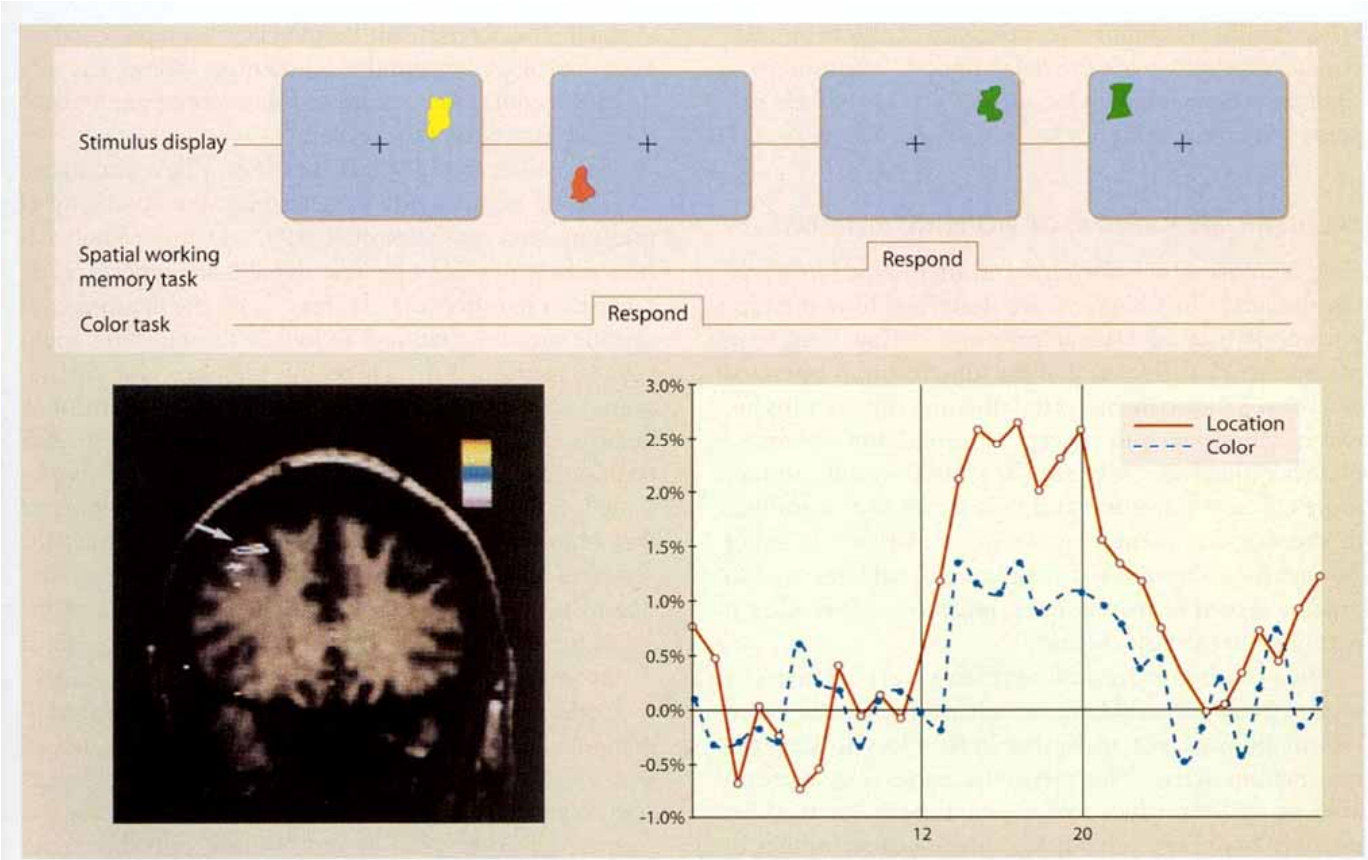
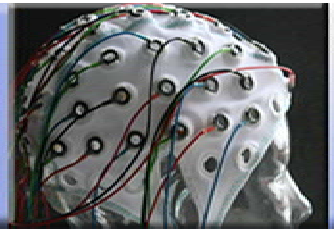


Figure 12.5 Lateral prefrontal activation revealed by functional magnetic resonance imaging (fMRI) in humans during a working memory task. **(Top)** Subjects viewed a series of colored, abstract shapes, appearing one at a time at various locations on the screen. In the spatial working memory condition, responses were required whenever a stimulus appeared at a location that had been used previously. In the control, color task, responses were required to all of the red objects. **(Bottom left)** During the spatial working memory task, there was a pronounced increase in activity in the lateral prefrontal cortex. This scan, obtained from a single subject, shows a prominent focus in the right prefrontal cortex (right hemisphere is on left). **(Bottom right)** The fMRI signal increased in the right prefrontal cortex during the 8-second stimulus period for both tasks. Most notable, the percentage increase in this area relative to the baseline was more pronounced during the spatial working memory task. Adapted from McCarthy et al. (1994).

Prozessspezifität des lateralen PFC? „Maintenance +“



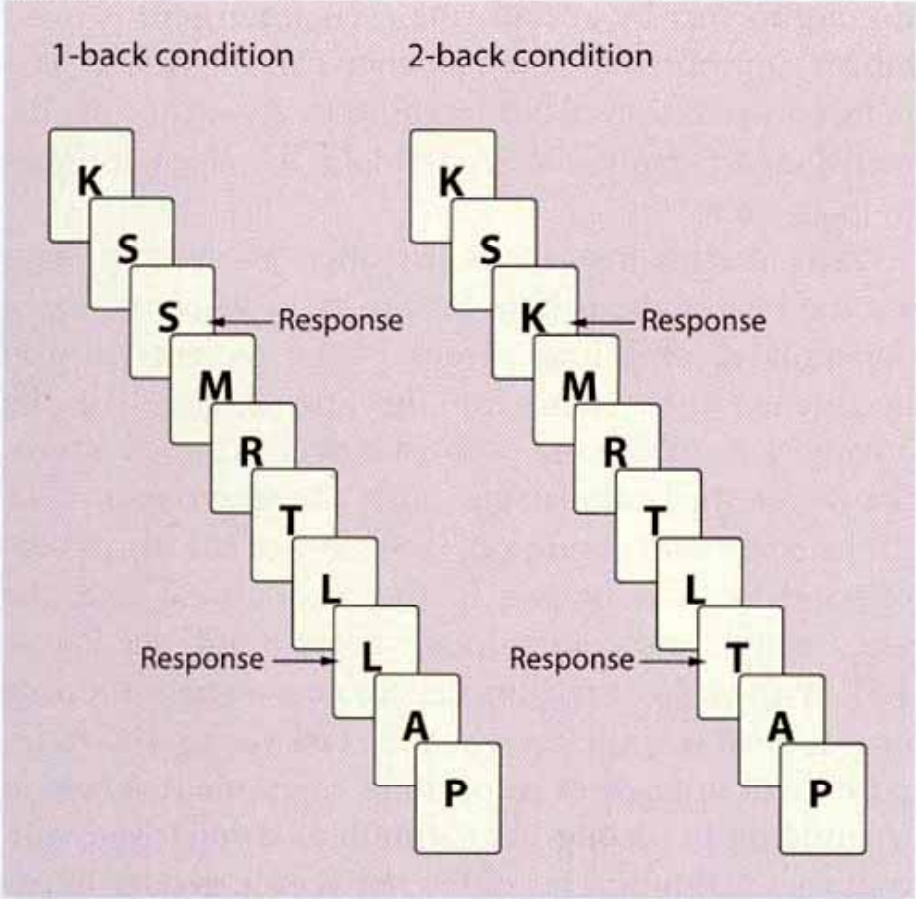
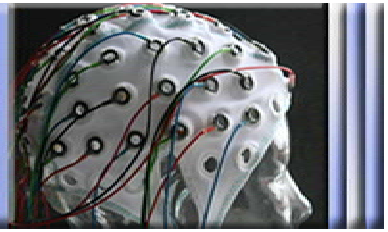


Figure 12.15 In *n*-back tasks, responses are required only when a stimulus matches one shown *n* trials before. The contents of working memory must be manipulated constantly as the target is updated on each trial.

Prozess- vs Inhaltsspezifität des lateralen PFC



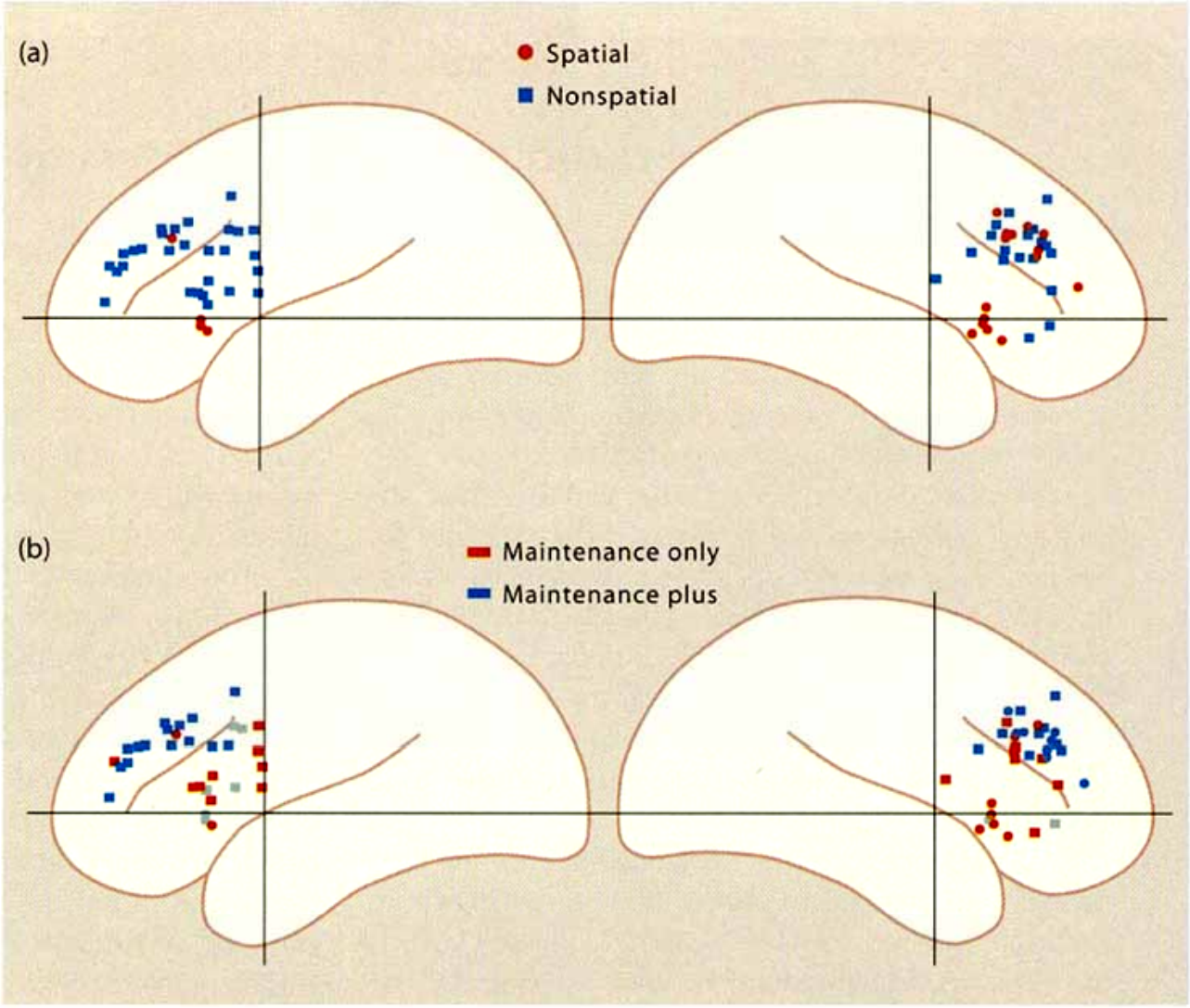
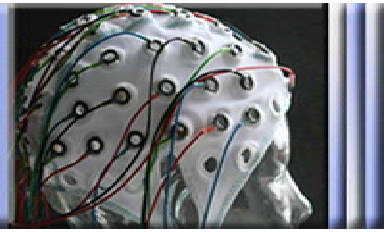


Figure 12.14 Functional organization within the lateral prefrontal cortex as revealed by meta-analysis of imaging studies. **(a)** Activation foci for tasks involving either spatial or nonspatial working memory. **(b)** The same data, coded to discriminate between tasks that involved maintaining information and those that also involved manipulating the information. The maintenance-manipulation dichotomy provides a more parsimonious account of the results than the spatial-nonspatial one. Gray symbols indicate foci activated during maintenance plus tasks that also led to activation in a more dorsal prefrontal region. From D'Esposito et al. (1998).

Arbeitsgedächtnis und cross-temporale Kontingenzen



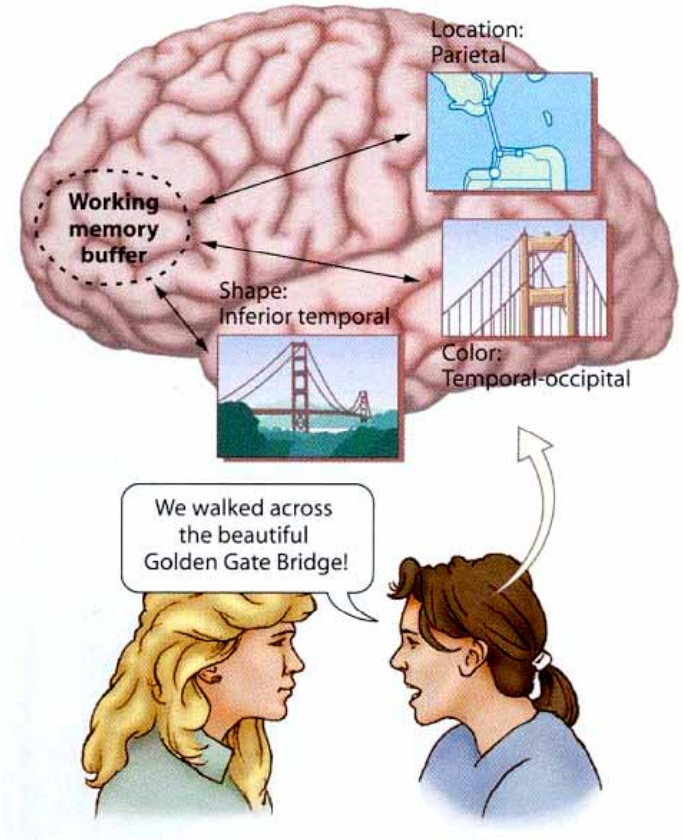


Figure 12.8 Lateral prefrontal cortex may provide a transient buffer for sustaining information stored in other cortical regions. In this example, the person is telling a friend about her walk across the Golden Gate Bridge during a visit to San Francisco. Long-term knowledge is reactivated and temporarily maintained through the reciprocal connections between the prefrontal cortex and the more posterior regions of the cortex. Note that the long-term memories of the Golden Gate Bridge are stored in dimensions-specific cortical regions.

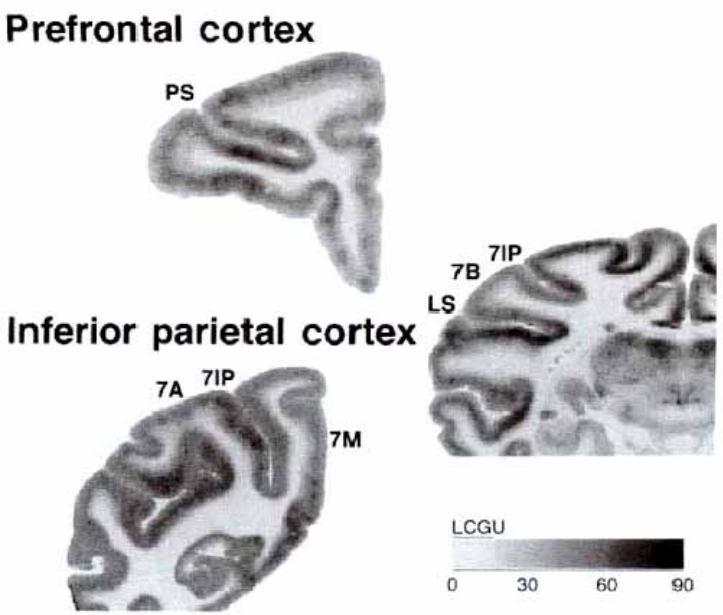
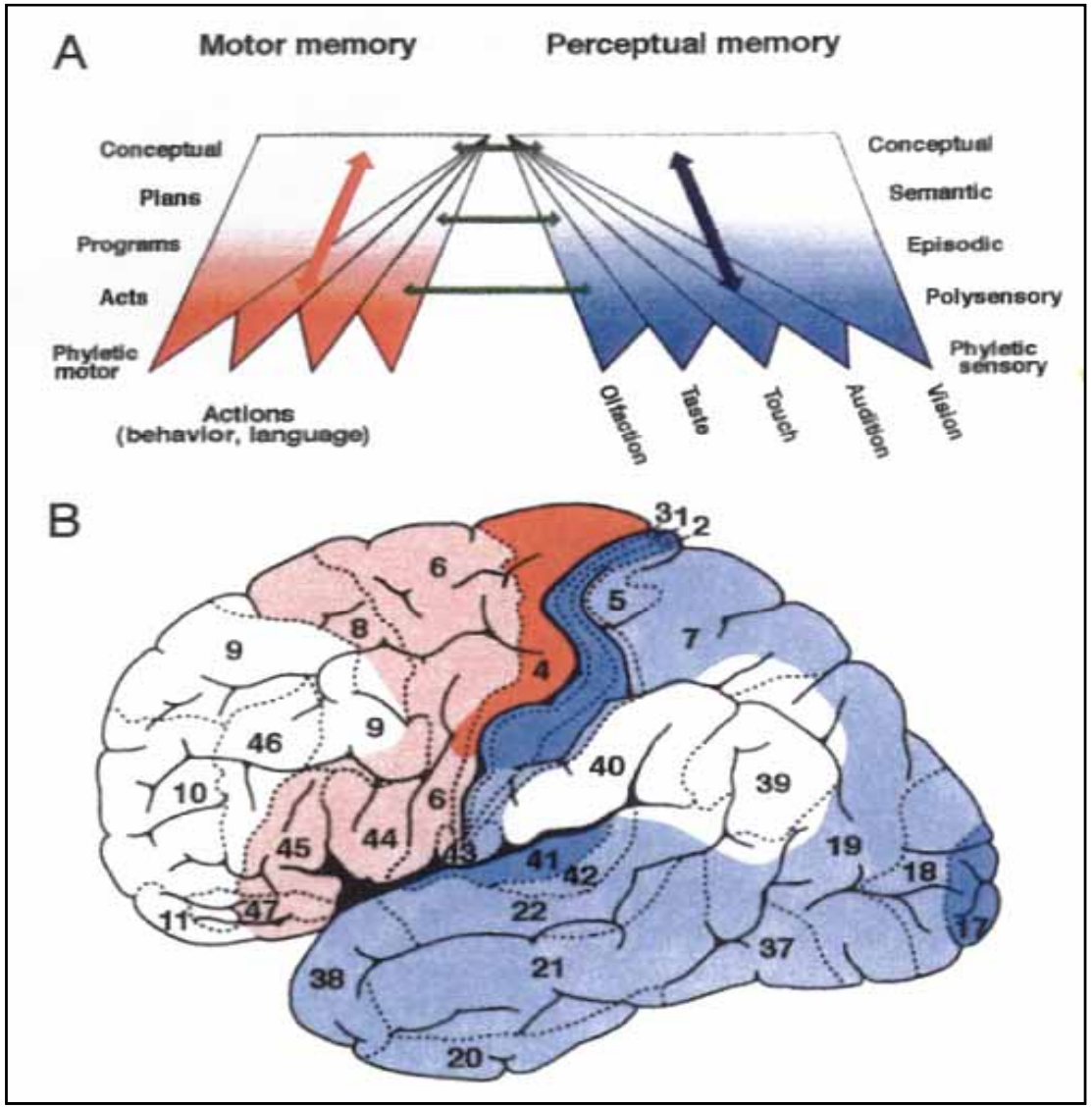


Figure 12.9 A radioactive tracer can reveal correlated activity in the prefrontal and inferior parietal cortex during a spatial working memory task. After being injected with the tracer, the animal performed the memory task. Upon completion, the animal was killed. Histological analysis revealed how the slow-decaying tracer was trapped in different brain regions. The results are coded on a gray scale in units of local cerebral glucose utilization (LCGU). PS in the top panel refers to the principal sulcus of the prefrontal cortex. The abbreviations with numeral 7 refer to area 7 regions of the parietal lobe. LS is the lateral sulcus, the division of parietal and temporal lobes. Embedded within this sulcus is the auditory cortex area measured for control purposes.

Arbeitsgedächtnis und cross-temporale Kontingenzen



Selektion aufgabenrelevanter Information

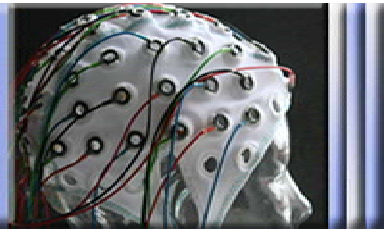
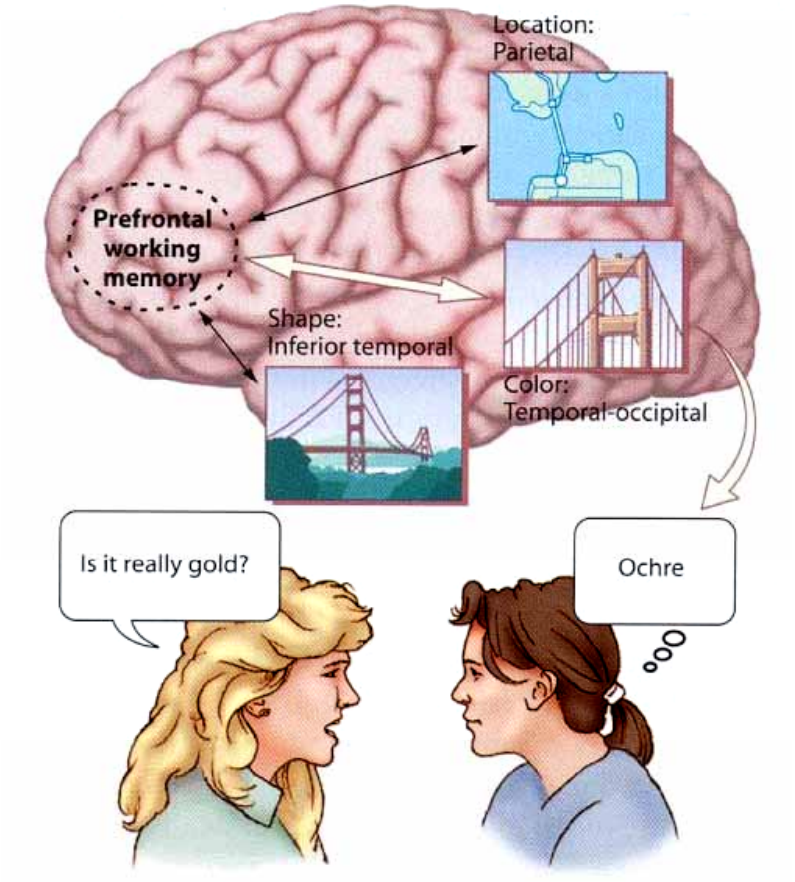


Figure 12.16 Prefrontal cortex not only provides a working memory buffer but also may use an inhibitory mechanism to highlight the information that is most relevant to the current task demands. When the subject is asked about the color of the Golden Gate Bridge, information regarding the location and shape of the bridge is inhibited.



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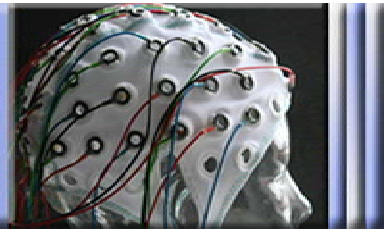


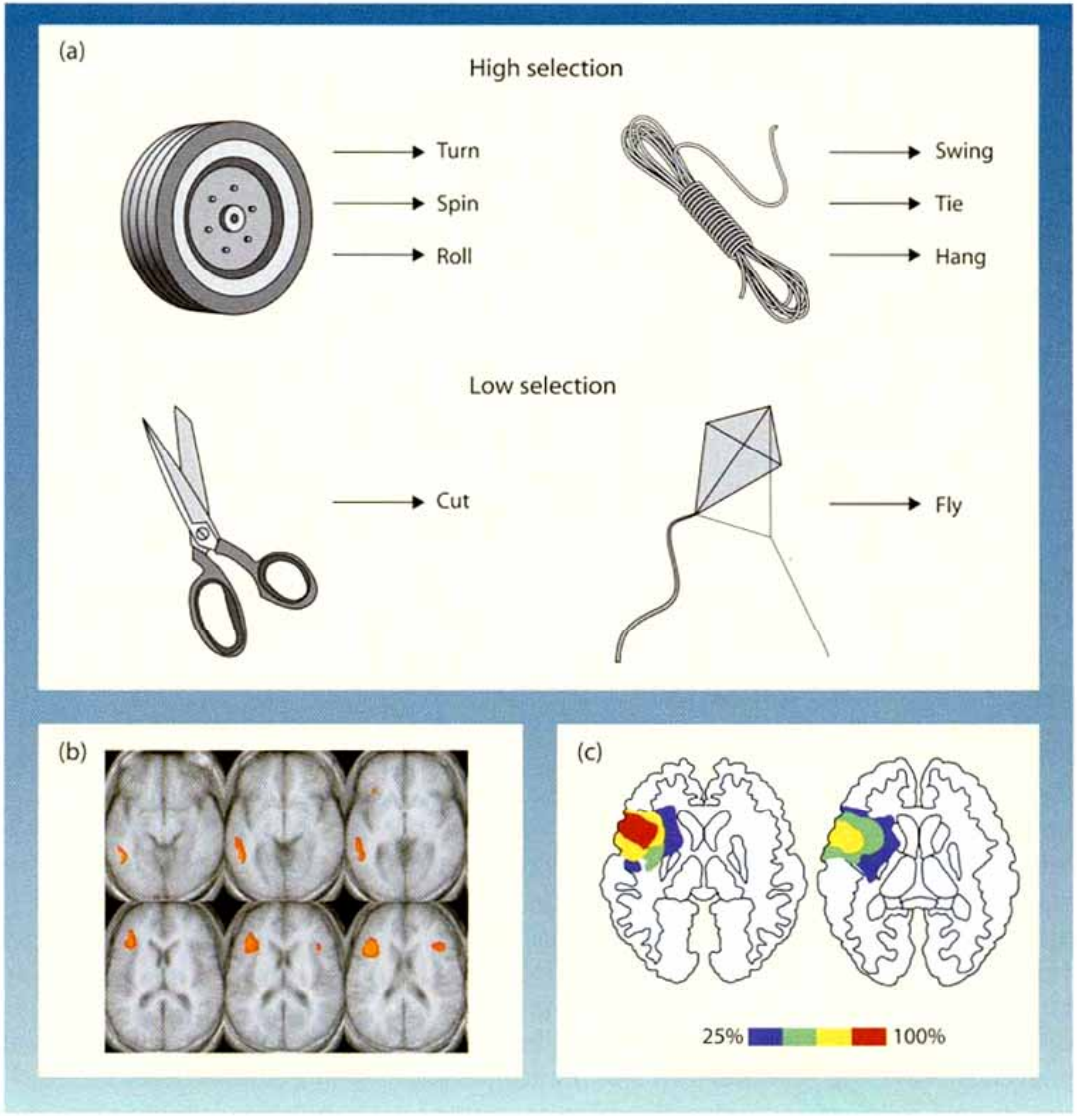
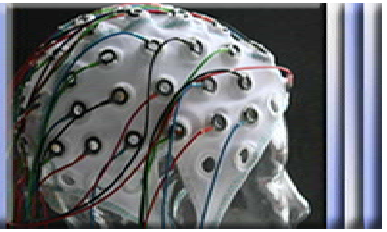
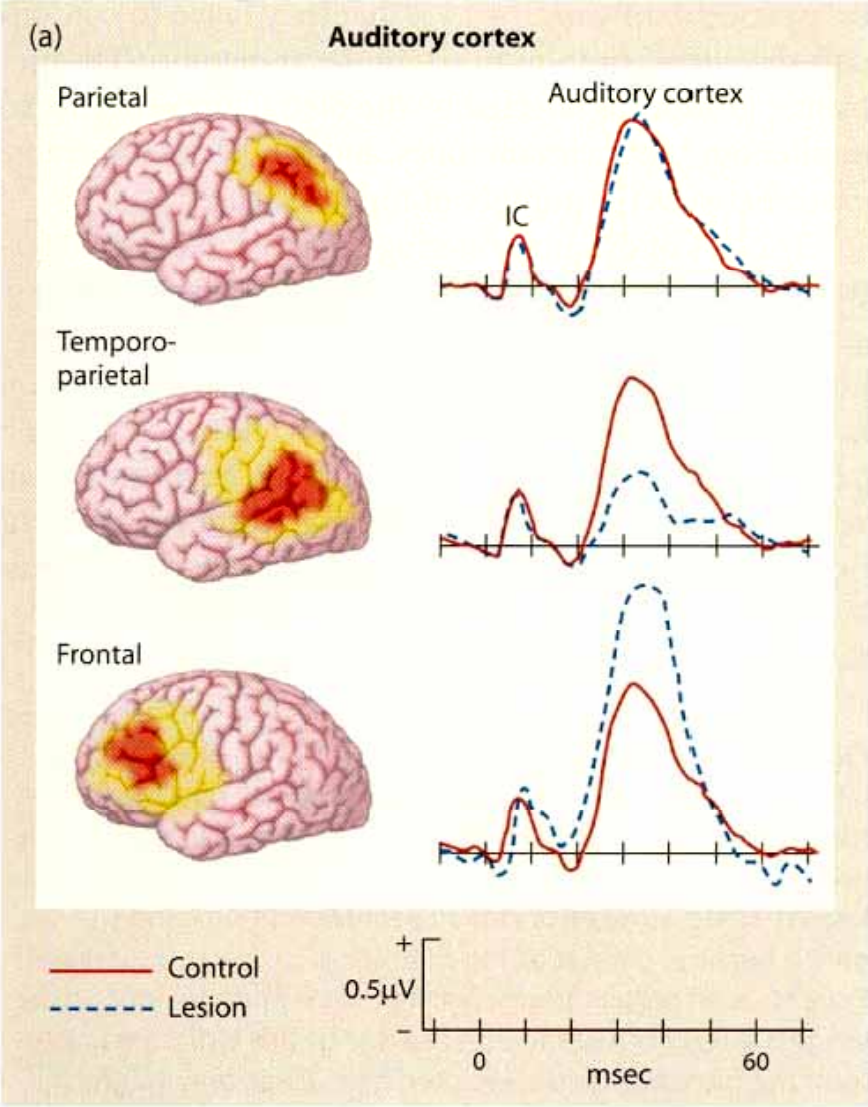


Figure 12.17 Involvement of inferior frontal cortex in response selection. **(a)** The verb generation task can be performed with nouns that are associated with many actions (high selection) or few actions (low selection). **(b)** Areas showing higher activity in the high-selection condition are shown in yellow. **(c)** Overlap in lesion location for patients who had difficulty in the high-selection condition. (b) From Thompson-Schill et al. (1997). (c) From Thompson-Schill et al. (1998).

Selektion aufgabenrelevanter Information

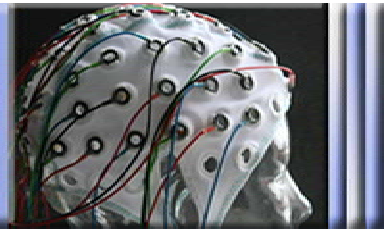


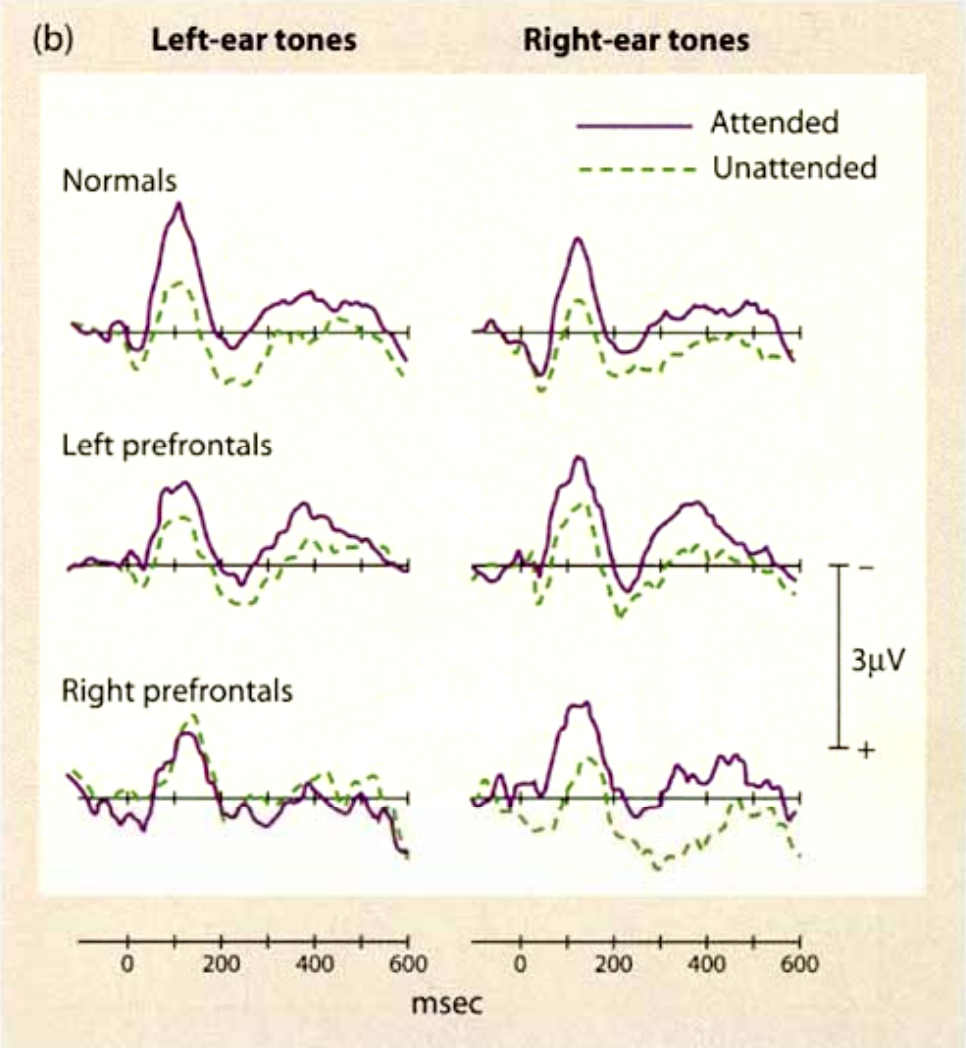


Filterung als inhibitorischer Prozess

Auditorische Antworten auf „Klicks“ → P30

Selektion aufgabenrelevanter Information





PFC Läsionen eliminieren den N100 Effekt kontralateral

Selektion aufgabenrelevanter Information: Inhibitorische Kontrolle ?

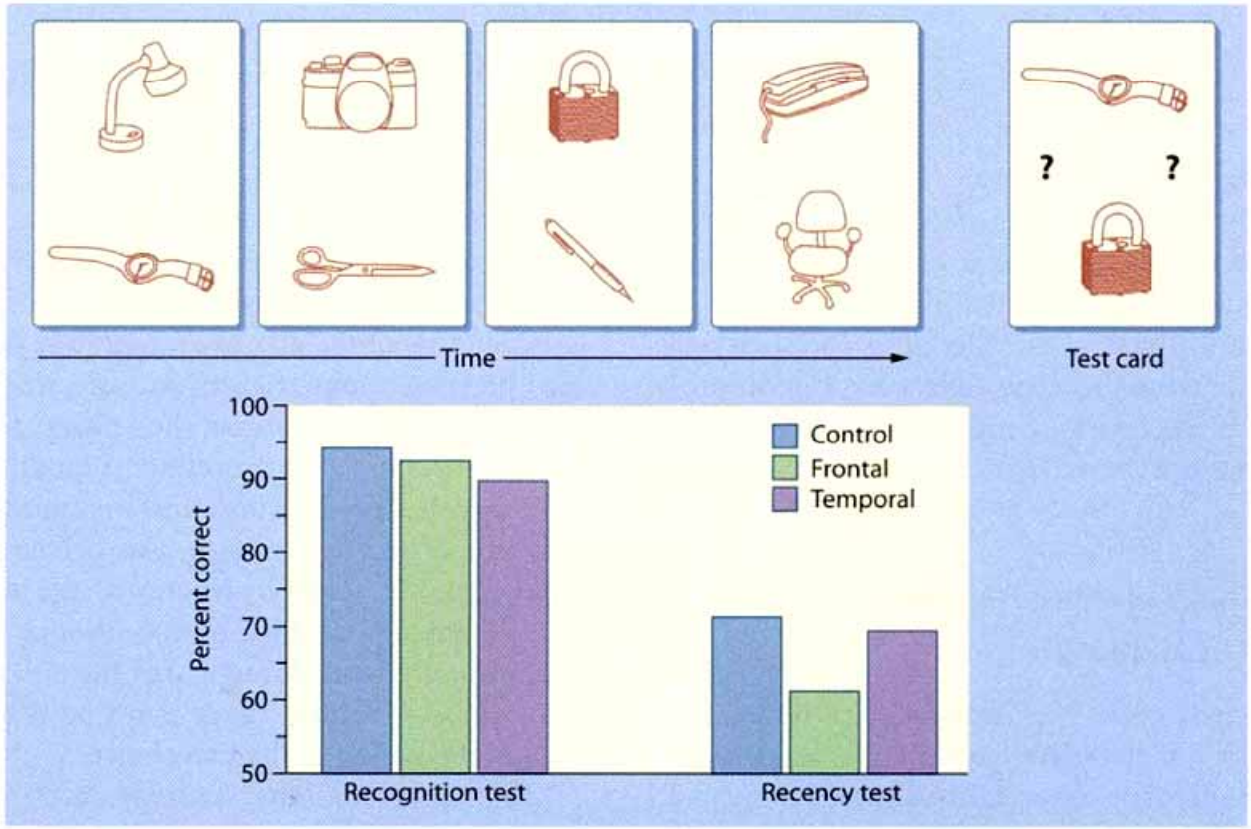
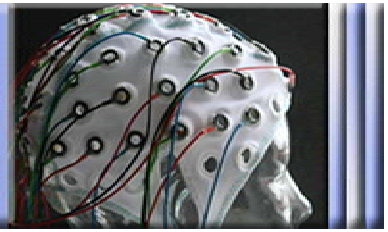


Figure 12.10 Recency memory is impaired in patients with prefrontal lesions. **(Top)** Subjects are presented with a series of cards, each one showing a pair of objects. On test cards, the objects are flanked by question marks, and the subject must indicate which object was seen most recently. In the recency test, both objects on the test cards had been seen previously. In the item recognition test, only one object had appeared previously. **(Bottom)** The results revealed a single dissociation. Patients who had had a frontal lobectomy performed more poorly on the recency task compared to both control subjects and patients who had had a temporal lobectomy. The frontal group was not impaired on the item recognition task. Adapted from Milner et al. (1991).

Inhibitorische Kontrolle bei Recency Judgements



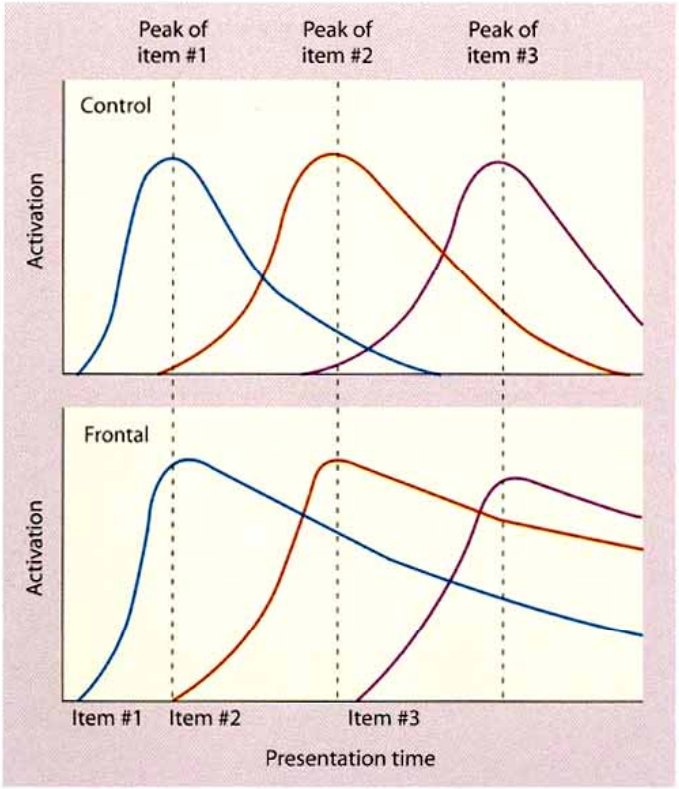


Figure 12.19 When a subject is presented with a series of items, activation for each item decays. A loss of inhibitory mechanisms following frontal lobe damage will lead to a slower decay process. Judgments on a recency memory task may be based on a comparison of the residual activation of the series of stimuli. In healthy people, the rapid decay of activation allows the temporal tag for each item to be distinct. In frontal lobe patients, the sustained activation leads to errors due to the similar activation states associated with successive items.

Abklingen der Aktivität des PFC nach Itemdarbietung

Recency → Vergleich der Restaktivierung im PFC

PFC-Läsionen:

Langsameres Abklingen → mehr Fehler

Selektion aufgabenrelevanter Information: Inhibitorische Kontrolle

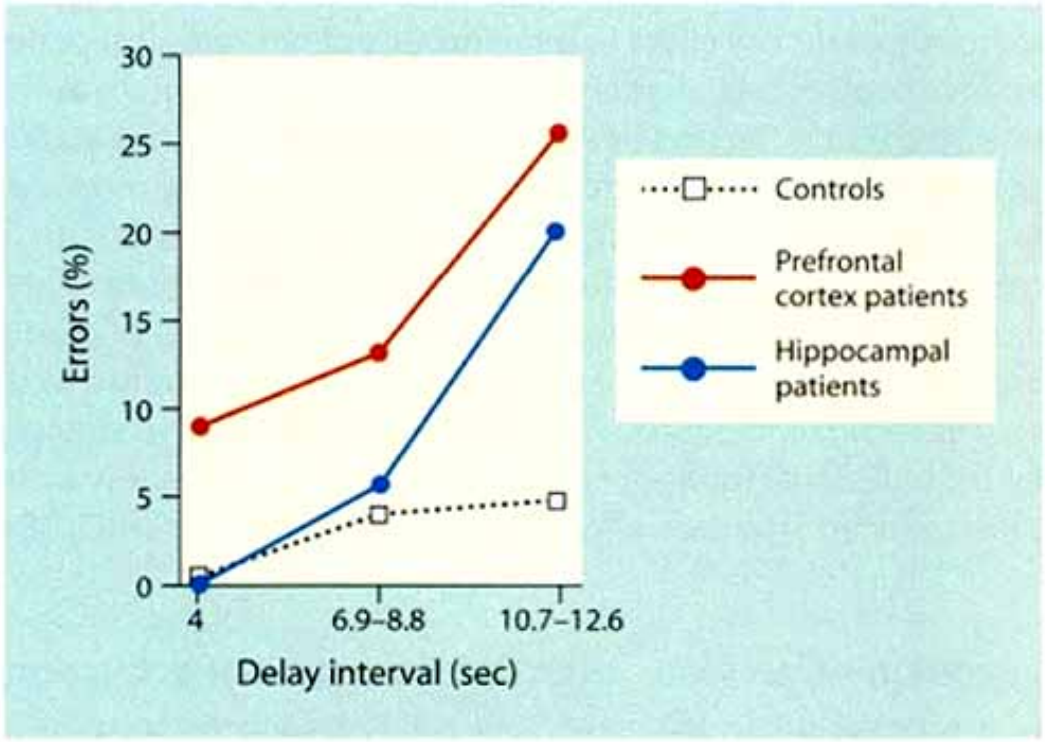


Figure 12.20 Susceptibility to distraction in patients with lateral prefrontal lesions. Subjects performed a delayed auditory matching to sample task. Unrelated distractor tones were presented during the delay period. The group with prefrontal lesions made more errors for all delay conditions, and the deficit became greater as the number of distractors increased. Patients with hippocampal damage were impaired only at the longest delay, consistent with the role of this structure in long-term memory formation. Adapted from Chao and Knight (1995).

PFC und „Multitasking“

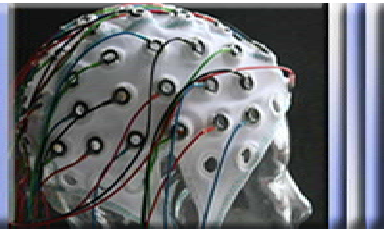
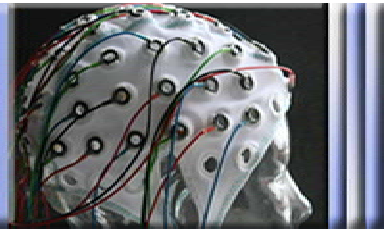


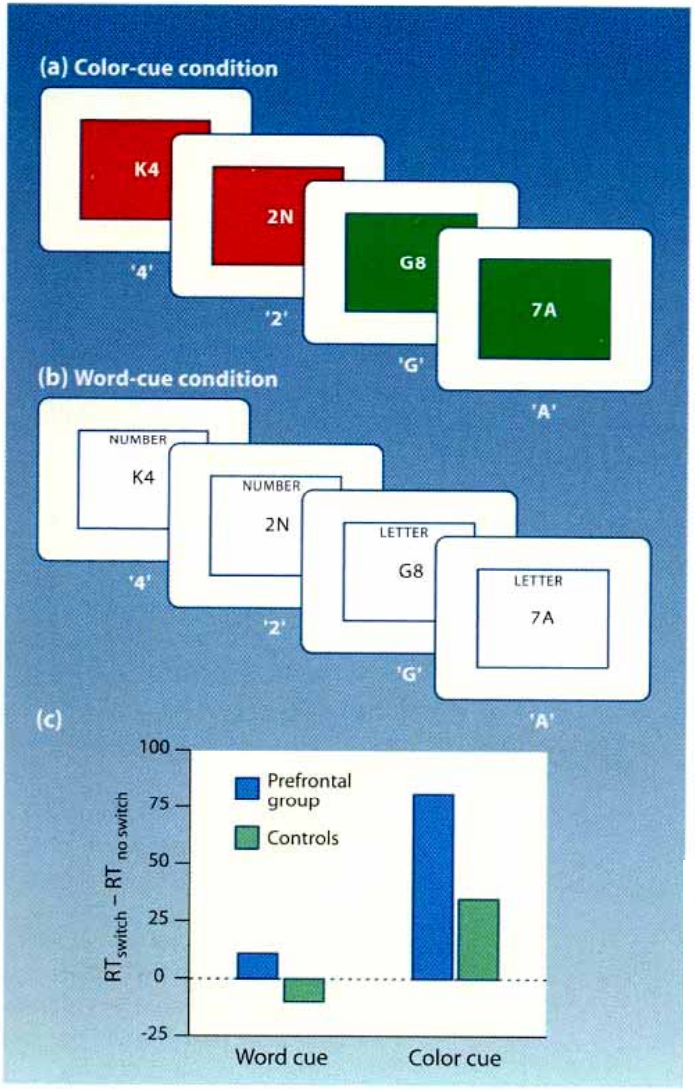
Figure 12.4 Patients with damage in the lateral prefrontal cortex have difficulty on the Wisconsin Card Sorting Task. On each trial, the subjects place the top card of the deck under one of the four target cards. The experimenter indicates whether the response is correct or incorrect, allowing the subject to learn the sorting rule by trial and error. The sorting rule changes whenever the subject makes ten consecutive correct responses.

Wisconsin Card Sorting:

Wechsel verschiedener Handlungsziele

PFC und „Multitasking“



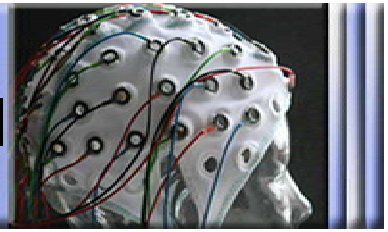


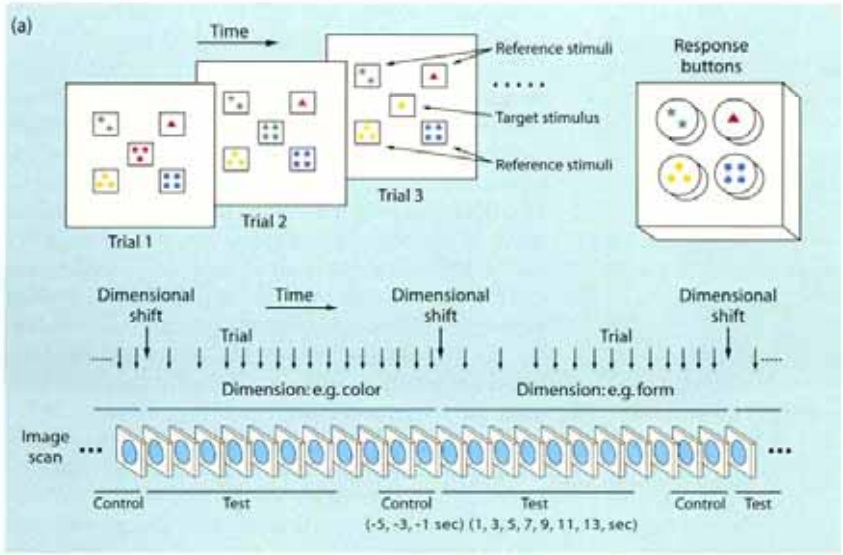
Task Switching:

Relevanz des Hinweisreizes!

Figure 12.22 Task-switching experiment, with the task cued by either **(a)** a color or **(b)** a word. **(c)** Switching cost, the time required to switch from one task to the other (e.g., from naming the digit to naming the letter), is measured as the difference in reaction time on switch trials and no-switch trials. Patients with prefrontal lesions showed impairment only on the color cue condition. (a), (b) From Rogers et al. (1998).

PFC Aktivität beim Aufgabenwechsel





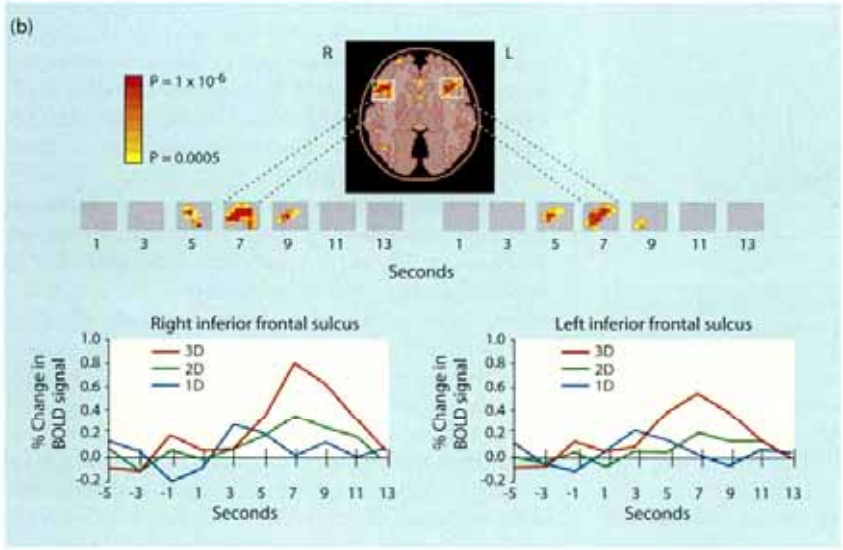
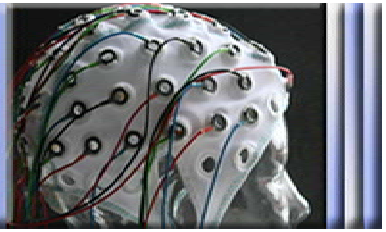


Figure 12.23 Modified Wisconsin Card Sorting Task for event-related fMRI. **(a)** Stimulus displays and response board. Subjects matched the center object to one of four objects in the corners, using the response board. The match could be made on the basis of color, form, or number. After ten correct responses, the matching rule would change, indicating a dimensional shift. **(b)** Increased activation was observed bilaterally in the inferior frontal cortex following the signal to shift dimensions. Note that the hemodynamic response peaks about 7 seconds after the shift. From Konishi et al. (1998).

bilaterale Aktivität im Gyrus Frontalis Inferior bei hohen Selektionsanforderungen

Handlungsselektion



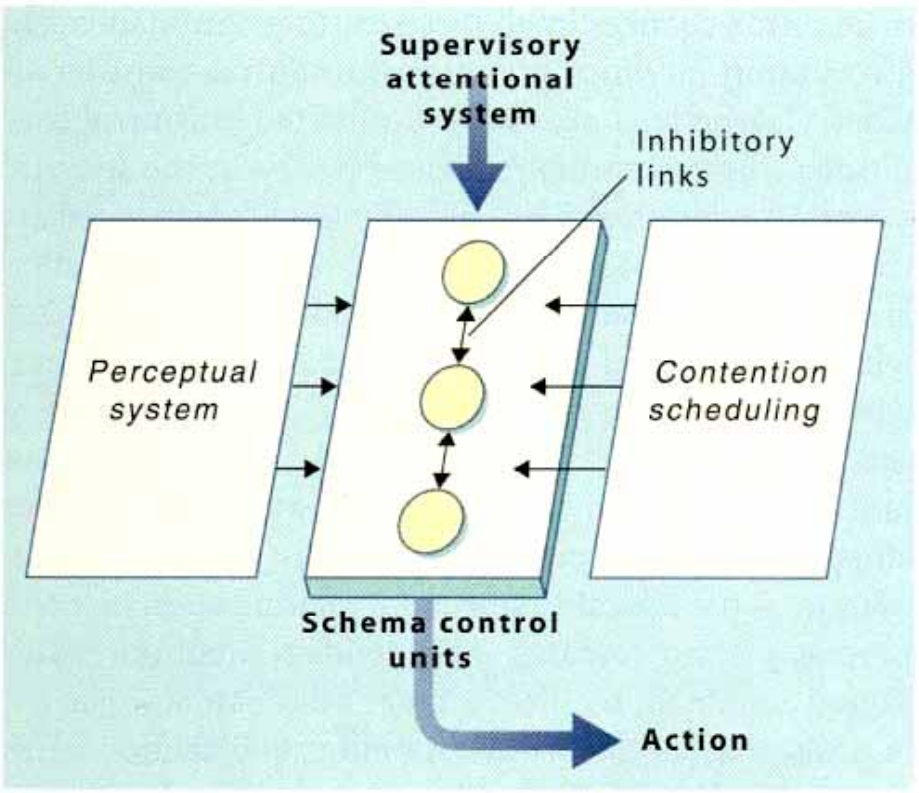


Figure 12.24 Norman and Shallice's model of response selection. Actions are linked to schema control units. The perceptual system produces input to these control units. However, selection of these units can be biased by the contention scheduling units and the supervisory attentional system (SAS). The SAS provides flexibility in the response selection system. Adapted from Shallice et al. (1989).

T. Shallice

Modell von Norman & Shallice

Supervisory Attentional System (SAS) und der anteriore Gyrus Cinguli

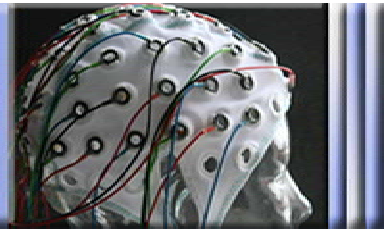
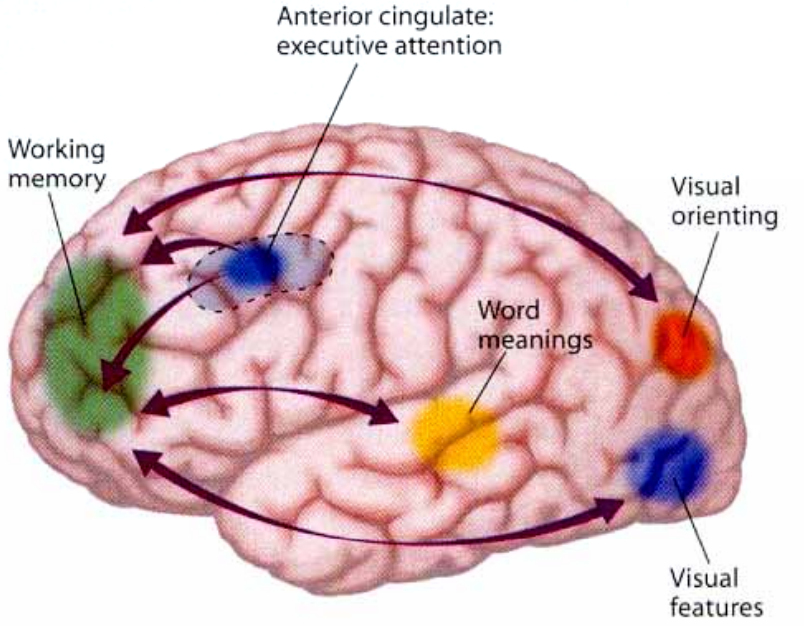
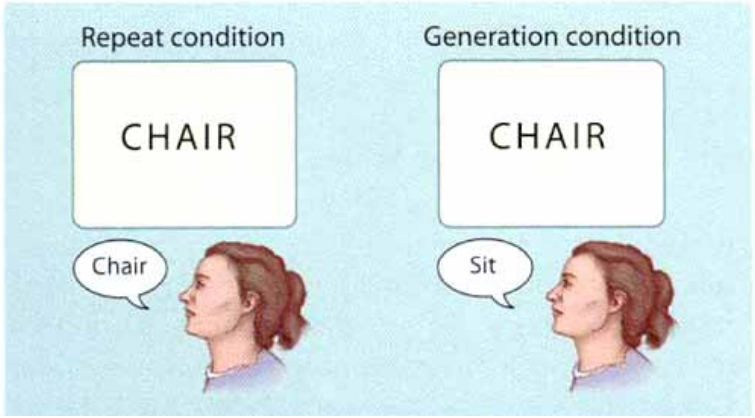


Figure 12.25 The anterior cingulate has been hypothesized to operate as an executive attention system. This system serves to ensure that processing in other brain regions is most efficient given the current task demands. Interactions with the prefrontal cortex may select working memory buffers; interactions with the posterior cortex can serve to amplify activity in one perceptual module over others. The interactions with the posterior cortex may be direct or they may be mediated by connections with the prefrontal cortex. Adapted from Posner and Raichle (1994).



SAS und der anteriore Gyrus Cinguli



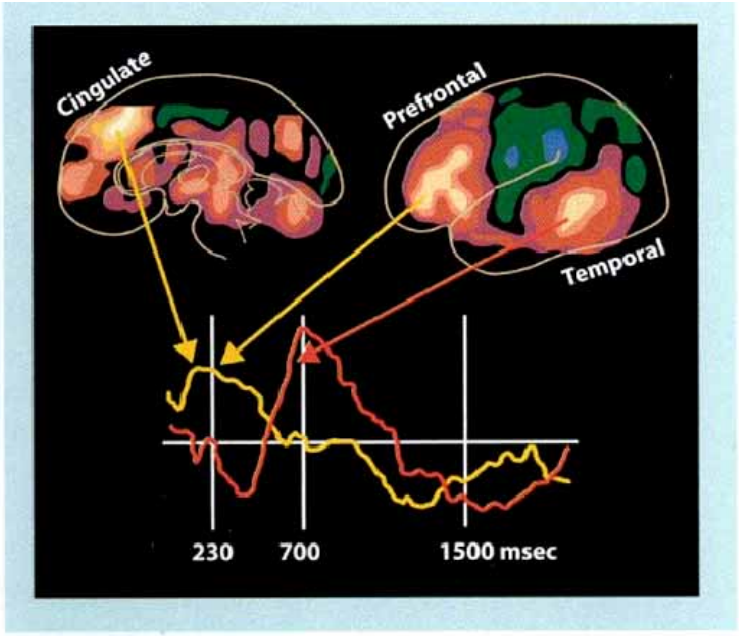
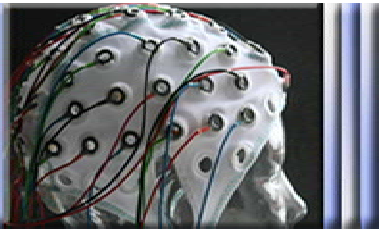
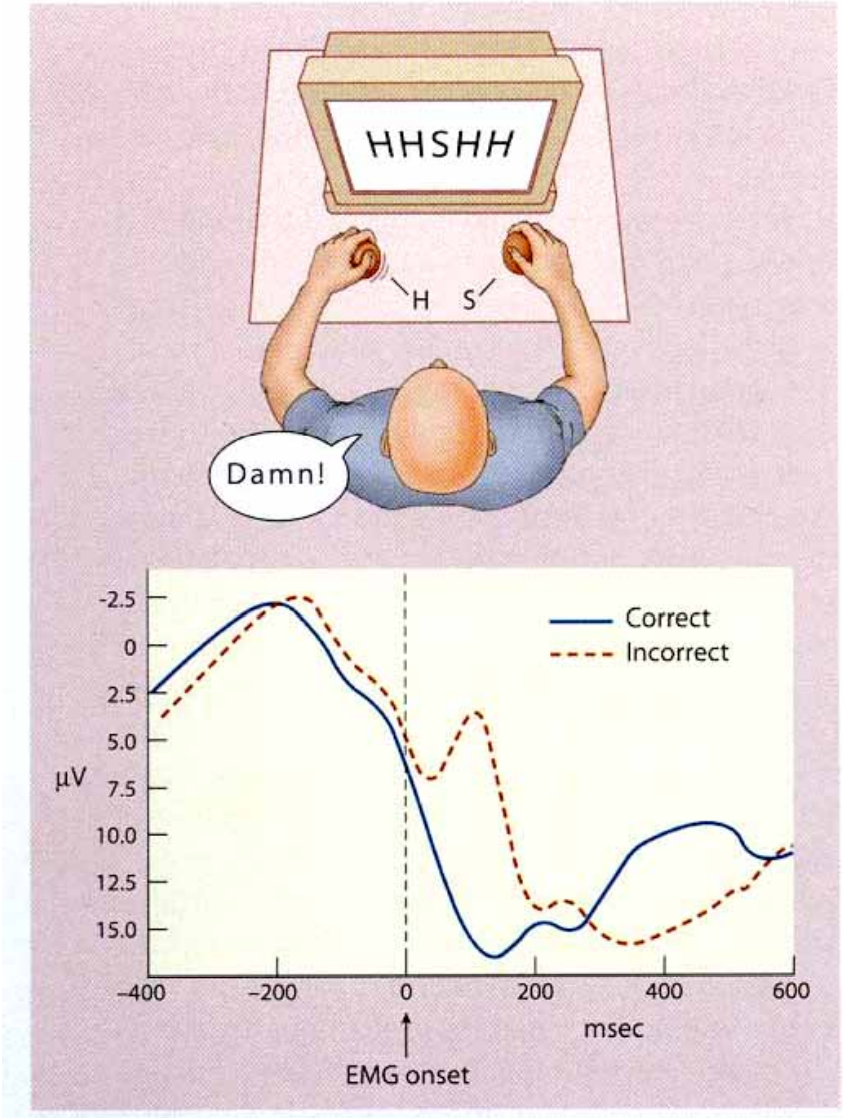


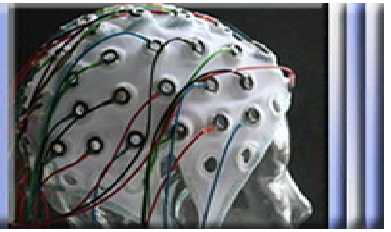
Figure 12.26 Neural generators associated with each peak in the difference waveform between generation and repeat tasks. **(Top)** Subjects hear a noun. In the repeat condition, they simply repeat the word; in the generation condition, they name a word that is a verb associate. To avoid including motor activity in the evoked potentials, subjects were instructed to withhold their responses until a "go" signal appeared, about 1500 msec after the stimulus. **(Bottom)** The difference waveform is obtained by subtracting the evoked potential in the repeat condition from the evoked potential in the generation condition. Dipole modeling techniques were used to identify the neural regions associated with each peak. Adapted from Snyder et al. (1995).

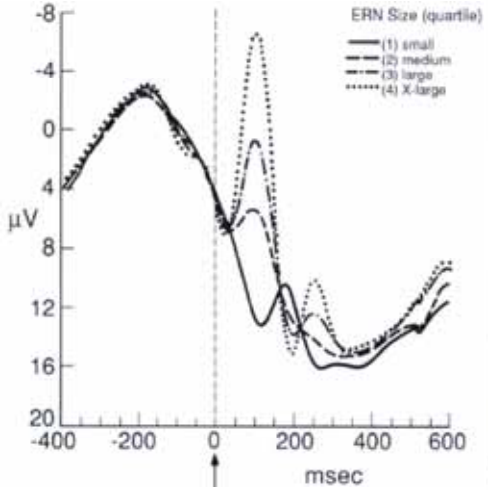
Der anteriore Gyrus Cinguli: Monitoring / Detektion von Fehlern

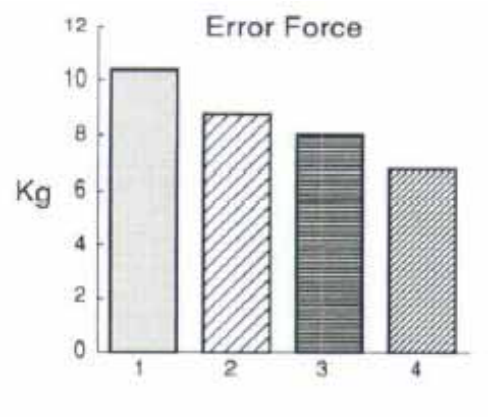




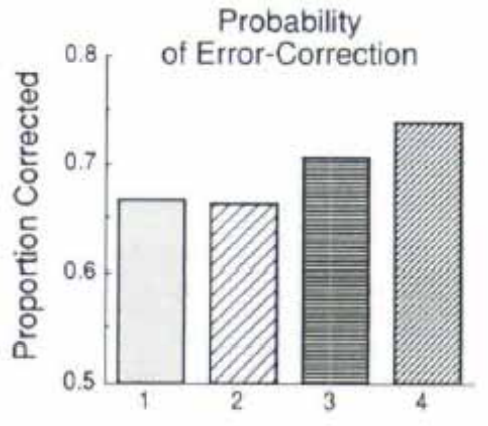
ERN und Fehlerkompensation





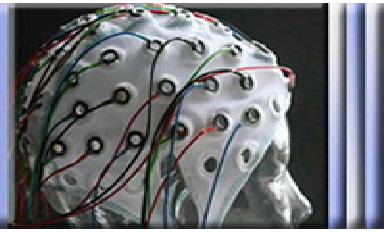


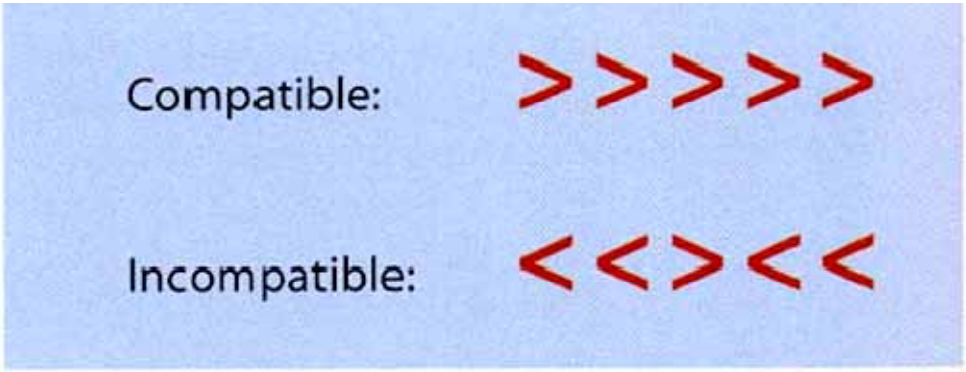
Stärke des Tastendrucks nimmt ab, je größer die ERN Amplitude



Wahrscheinlichkeit der Fehlerkorrektur proportional zu Größe der ERN-Amplitude

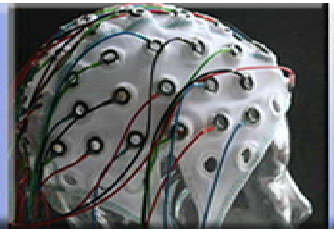
Der anteriore Gyrus Cinguli: Monitoring von Antwortkonflikten





(b)

große ACC-Aktivierung in inkompatiblen Trials auch bei korrekter Antwort



The Role of Working Memory in Visual Selective Attention

Jan W. de Fockert,[1]* Geraint Rees,[2] Christopher D. Frith,[3] Nilli Lavie[1]

The hypothesis that working memory is crucial for reducing distraction by maintaining the prioritization of relevant information was tested in neuroimaging and psychological experiments with humans. Participants performed a selective attention task that required them to ignore distractor faces while holding in working memory a sequence of digits that were in the same order (low memory load) or a different order (high memory load) on every trial. Higher memory load, associated with increased prefrontal activity, resulted in greater interference effects on behavioral performance from the distractor faces, plus increased face-related activity in the visual cortex. These findings confirm a major role for working memory in the control of visual selective attention.

Despite a vast body of research on visual attention and on working memory, the interaction between the two has seldom been addressed. There have been a few recent suggestions that working memory may play a role in the control of selective attention (*1*, *2*), but evidence for a specific role has been scarce. Here we show a direct causal role for working memory in the control of selective attention.

The most enduring issue in the study of attention is the extent to which distractor processing can be prevented (*3*). Lavie recently proposed that the level of perceptual load in a display is a crucial factor (*4*). Several studies have shown that distractors that could not be ignored in situations of low perceptual load (for example, when just a few task-relevant stimuli were presented) were successfully ignored in situations of high perceptual load (for example, when many relevant stimuli were present). Thus, less distrac-

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Politician vs pop star decision for written names

Fig. 1. Example of a high working memory load trial with two attention displays. After a 500-ms fixation display, the memory set for that trial was presented for 1500 ms. Under low working memory load, the digits were always in the following order: 0, 1, 2, 3, 4. After the memory set, a fixation display was presented for 850 ms, followed by two, three, or four attention displays. The number of attention displays was varied in order to make the onset of the memory probe unpredictable, thus ensuring that the current memory set was actively rehearsed throughout the trial. Each attention display was presented for 500 ms and was followed by a 1250-ms blank response interval. After the final attention display, a memory probe was presented for 3000 ms. Participants were requested to report the digit that followed this probe in the memory set (to press "4" in this example). In order to ensure that all four responses (including "1" in low working memory load trials) were used, we presented a "0" before the four-digit memory set. Thus, the correct response to memory probe "0" would have been "3" in this example.

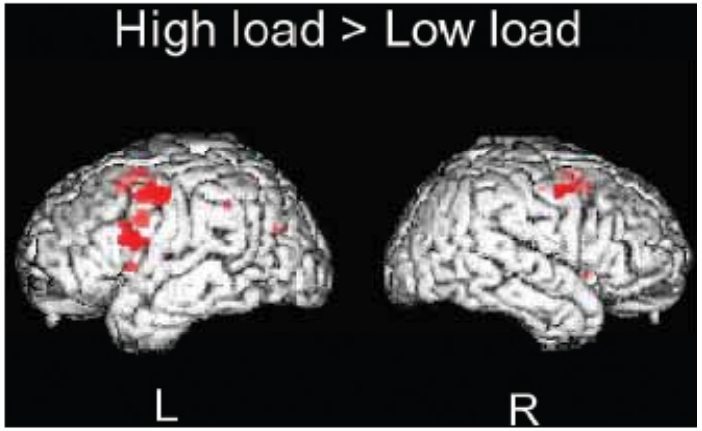


Fig. 2. Activity related to working memory load. Shown are left and right lateral views of a T1-weighted anatomical template image in Talairach space (*27*), on which are superimposed loci where activity was significantly greater ($P < 0.05$, corrected for multiple comparisons) during high working memory load than during low working memory load.

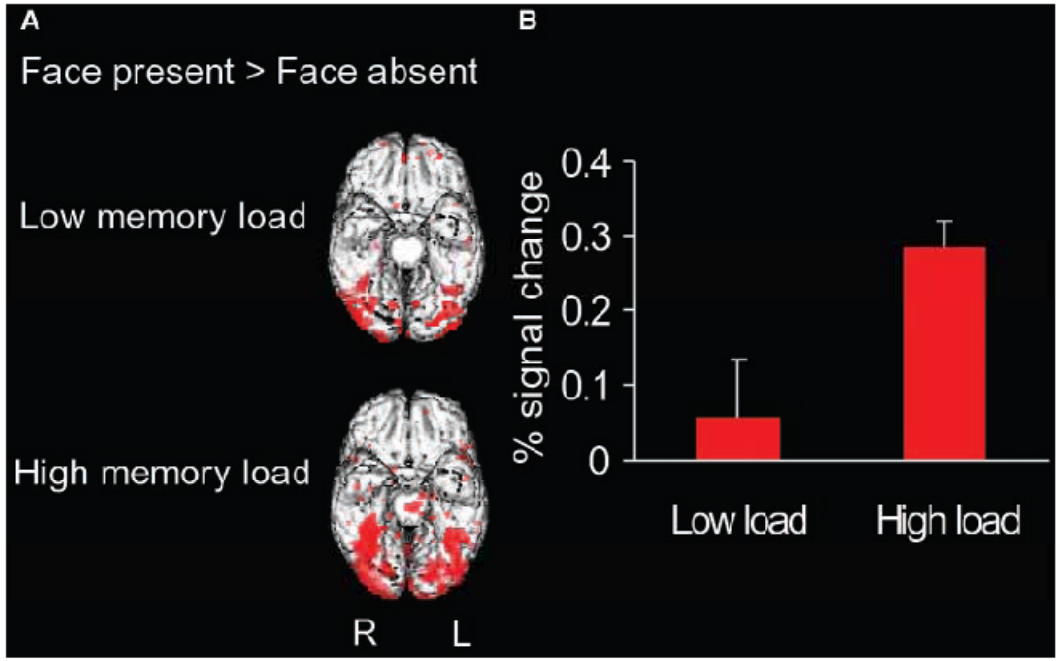
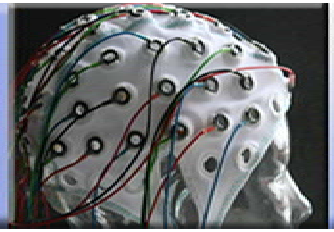


Fig. 3. Distractor-related activity in high versus low working memory. **(A)** Two views of the ventral surface of the template brain used in Fig. 2, on which are superimposed loci where activity was significantly greater in the presence than in the absence of distractor faces under conditions of low working memory load (top) and high working memory load (bottom). A threshold of $Z = 3.10$ (corresponding to $P < 0.001$, uncorrected) is used for display purposes. **(B)** Mean distractor-related activity (percent signal change for face presence minus face absence) for the maxima of the interaction in the right fusiform gyrus (36, −64, −16), plotted separately for low and high working memory load. Data are averaged across participants. Error bars represent interparticipant standard error.

Take home



- Rolle des lateralen PFC für zielgerichtetes Verhalten
- WM: Interaktion des aktuellen Ziels mit perzeptueller Information (die nicht mehr präsent ist)
  - Aufrechterhalten von Information
  - Selektion von Information
- Funktionelle Organisation (Inhalts- vs Prozessspezifisch)
- ACC → Monitoring System