Quirks: Levels-of-Processing Effect:

The following text borrows from Wikipedia, which offers a helpful synopsis.

The levels-of-processing effect, identified by Fergus I. M. Craik and Robert S. Lockhart in 1972, describes memory recall of stimuli as a function of the depth of mental processing. Deeper levels of analysis produce more elaborate, longer lasting, and stronger memory traces than shallow levels of analysis. Depth of processing falls on a shallow to deep continuum. Shallow processing (e.g., processing based on phonemic and orthographic components) leads to a fragile memory trace that is susceptible to rapid decay. Conversely, deep processing (e.g., semantic processing) results in a more durable memory trace.

Repetition powerfully strengthens memories but has diminishing returns. Each repetition adds less strength than the last.[3] More processing is better, but the type of processing is also critical in determining memory strength. In the "levels of processing" theory, "deeper" cognitive processes support better memory.[4] Craik and Tulving had participants judge words in a list and then administered an unexpected memory test for the words.[5] Those judging visual appearance (e.g. "Is this word in all capitals?) remembered few words. Acoustic judgments ("Does this word rhyme with dog?") yielded better memory. Semantic judgments (e.g. "Does this word complete the sentence?") yielded the best memory. **Memory seems to be optimized to retain meaning, not the sensory information itself.** Deeper (semantic) processes improve memory regardless of whether the subject intends to remember. Motivation effects do not directly affect recall. Rather, higher motivation causes more and deeper processing, improving recall.

Related Research

Baddeley, A.; Warrington, E. (1970). "**Amnesia and the distinction between long- and short-term memory**". *Journal of Verbal Learning and Verbal Behavior* 9: 176–189.

Abstract

Evidence for a dichotomy between long-term memory (LTM) and short-term memory (STM) comes from: (*a*) amnesic patients with a normal digit span but defective LTM, and (*b*) tasks comprising two components, one labile (STM) and the other stable (LTM). This study examines the compatibility of (*a*) and (*b*) by comparing the performance of amnesic and control *S*s on immediate and delayed free recall, the Peterson short-term forgetting task, development of PI in STM, minimal paired-associate learning, digit span, and the Hebb repeated digit-sequence technique. Results suggest that amnesic *S*s have normal STM but defective LTM. There is some evidence of a stable component in certain STM tasks, on which amnesic *S*s are also unimpaired. Implications for the dichotomy between STM and LTM are discussed.

Bertone, A; Mottron L; Jelenic P; Faubert J (2005-10-01). **"Enhanced and diminished visuo-spatial information processing in autism depends on stimulus complexity"** (abstract). *Brain* 128 (10): 2430–2441.

Abstract

Visuo-perceptual processing in autism is characterized by intact or enhanced performance on static spatial tasks and inferior performance on dynamic tasks, suggesting a deficit of dorsal visual stream processing in autism. However, previous findings by Bertone *et al*. indicate that neuro-integrative mechanisms used to detect complex motion, rather than motion perception *per se*, may be impaired in autism. We present here the first demonstration of concurrent enhanced and decreased performance in autism on the same visuo-spatial static task, wherein the only factor dichotomizing performance was the neural complexity required to discriminate grating orientation. The ability of persons with autism was found to be superior for identifying the orientation of simple, luminance-defined (or first-order) gratings but inferior for complex, texture-defined (or second-order) gratings. Using a flicker contrast sensitivity task, we demonstrated that this finding is probably not due to abnormal information processing at a sub-cortical level (magnocellular and parvocellular functioning). Together, these findings are interpreted as a clear indication of altered low-level perceptual information processing in autism, and confirm that the deficits and assets observed in autistic visual perception are contingent on the complexity of the neural network required to process a given type of visual stimulus. We suggest that atypical neural connectivity, resulting in enhanced lateral inhibition, may account for both enhanced and decreased low-level information processing in autism.

Blaxton, TA (1989). "**Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework**" (pdf). *Journal of Experimental Psychology: Learning, Memory and Cognition* 15 (4): 657–

668.
Abstract
In three experiments subjects performed one of five tasks after an initial study phase. Results showed that performance on conceptually driven retention tasks (those requiring the processing of meaning) was consistently dissociated from that on data-driven tasks (those relying more on analysis of physical features). Performance on conceptually driven tasks of free recall, semantic cued recall, and a task of answering general knowledge questions was enhanced most when target items had been generated rather than read at study (Experiment 1) and when subjects formed mental images of item referents at study (Experiment 3). Conversely, the data driven tasks of word fragment completion and recall using graphemic cues were performed best when subjects read rather than generated items at input (Experiment 1) and when the physical features of study and test items matched in terms of modality (Experiment 2) and typography (Experiment 3). These findings indicate that dissociations among memory tasks are better explained in terms of the degree of overlap between mental operations at study and test than in terms of various memory systems underlying different tasks.

Cloitre, M; Liebowitz MR (1991). "**Memory bias in panic disorder: An investigation of the cognitive avoidance hypothesis**". *Cognitive Therapy and Research* 15 (5): 371–386.
Abstract
Individuals with panic disorder (n = 14) and normal controls (n = 14) performed two different memory tasks: a high-speed recognition task that measured perceptual memory (memory for the sensory/perceptual features of a stimulus) and a free recall task that measured semantic memory (memory for the meaning associated with the stimulus). Subjects' memory for threatening, positive, and neutral words was evaluated. In contrast to normal controls, panic disorder patients showed better perceptual memory and better semantic memory for threat words compared to positive and neutral words. These results suggest that the panic disorder individuals engaged in preferential processing of threat information at both a perceptual and semantic level of analysis. The results do not support a "cognitive avoidance" hypothesis which predicts the inhibition of more elaborate and meaningful processing of threat stimuli in anxious subjects. The conditions under which cognitive avoidance might occur are outlined.

Craik, FIM; Lockhart RS (1972). "**Levels of processing: A framework for memory research**". *Journal of Verbal Learning & Verbal Behavior* 11 (6): 671–84.
Abstract
This paper briefly reviews the evidence for multistore theories of memory and points out some difficulties with the approach. An alternative framework for human memory research is then outlined in terms of depth or levels of processing. Some current data and arguments are reexamined in the light of this alternative framework and implications for further research considered.

Eysenck, M. (2006). **Learning and Long-term memory**. In Fundamentals of cognition (Second ed.). Hove, England: Psychology Press

Fletcher, PC; Shallice T; Dolan RJ (1998). **"The functional roles of prefrontal cortex in episodic memory. I. Encoding"** (pdf). *Brain* 121 (7): 1239–1248.
Abstract
Functional neuroimaging studies of episodic memory consistently report an association between memory encoding operations and left prefrontal cortex (PFC) activation. Encoding-related activation has been described in dorsolateral, ventrolateral and anterior prefrontal regions. We tested the hypothesis that a specific component of this left PFC activation reflects organizational processes necessary for optimal memory encoding. Subjects underwent PET scans while learning auditorily presented word lists under dual task conditions. The degree to which they were required to organize word lists semantically was systematically varied across three experimental conditions. A task in which words were already organized produced the least degree of left PFC activity whereas a task requiring subjects to generate an organizational structure was associated with maximal activity in this region. This activation was localized to a region just above the inferior frontal sulcus. The functional specificity of this increased activity for organizational processes was tested using a concurrent distracting task known to disrupt these processes. Distraction resulted in a significant attenuation of this activation during the task emphasizing organizational processes but not other encoding tasks. In contrast, the distraction task resulted in reduced activity in a more ventral/anterior PFC region expressed equally for all memory tasks. The findings indicate that a key function of left dorsolateral PFC at encoding relates specifically to the use of executive processes necessary for the creation of an organizational structure. Activity in more ventral and anterior left PFC regions would appear to reflect a less specific component of episodic memory encoding.

Friederici, AD; Opitz B; Yves von Cramon D (2000). "**Segregating semantic and syntactic aspects of processing in the human brain: an fMRI investigation of different word types**" (pdf). *Cereb. Cortex* 10 (7): 698–705.

Abstract

The processing of single words that varied in their semantic (concrete/abstract word) and syntactic (content/function word) status was investigated under different task demands (semantic/ syntactic task) in an event-related functional magnetic resonance imaging experiment. Task demands to a large degree determined which subparts of the neuronal network supporting word processing were activated. Semantic task demands selectively activated the left pars triangularis of the inferior frontal gyrus (BA 45) and the posterior part of the left middle/superior temporal gyrus (BA 21/22/37). In contrast, syntactic processing requirements led to an increased activation in the inferior tip of the left frontal operculum (BA 44) and the cortex lining the junction of the inferior frontal and inferior precentral sulcus (BA 44/6). Moreover, for these latter areas a word class by concreteness interaction was observed when a syntactic judgement was required. This interaction can be interpreted as a prototypicality effect: non-prototypical members of a word class, i.e. concrete function words and abstract content words, showed a larger activation than prototypical members, i.e. abstract function words and concrete content words. The combined data suggest that the activation pattern underlying word processing is predicted neither by syntactic class nor semantic concreteness but, rather, by task demands focusing either on semantic or syntactic aspects. Thus, our findings that semantic and syntactic aspects of processing are both functionally distinct and involve different subparts of the neuronal network underlying word processing support a domain-specific organization of the language system.

Grady, CL; Craik FIM (2000). "**Changes in memory processing with age**". *Current Opinion in Neurobiology* 10 (2): 224–231.

Abstract

Over the years, a large body of literature has shown that humans display losses in memory with age, but that not all types of memory are affected equally. Similarly, recent evidence from functional neuroimaging experiments has revealed that, depending on the task, older adults can display greater or lesser activity in task-relevant brain areas compared with younger adults. Recent behavioral and neurophysiological experiments are furthering our understanding of the effects of aging on cognition. It appears that some brain changes seen with age may be compensatory.

Habib, R; Nyberg L (1997). **"Incidental retrieval processes influence explicit test performance with data-limited cues"** (pdf). *Psychonomic Bulletin & Review* 4 (1): 130–133.

Abstract

In two experiments, the influence of incidental retrieval processes on explicit test performance was tested. In Experiment 1, subjects studied words under four conditions (auditory-shallow, auditory-deep, visual-shallow, and visual-deep). One group of subjects received auditory and visual word-fragment completion; another group received auditory and visual word-fragment cued recall. Results indicated that changes in sensory modality between study and test reduced both recall and priming performances; levels of processing significantly affected only the cued recall test. These results indicated that incidental retrieval processes might affect explicit test performance when retrieval cues are data limited. Experiment 2 supported this conclusion by showing an effect of matching study and test modalities on explicit test performance with fragment but not with copy cues. Taken together, these results support Roediger and McDermott's (1993) suggestion that explicit test performance is influenced by incidental retrieval processes when data-limited retrieval cues are used.

Intraub, H; Nicklos S (1985). "**Levels of processing and picture memory: the physical superiority effect**". *Journal of experimental psychology. Learning, memory, and cognition* 11 (2): 284–98.

Abstract

Conducted 6 experiments with 230 undergraduates to study the effect of physical-orienting questions (e.g., "Is this angular?") and semantic-orienting questions (e.g., "Is this edible?") on memory for unrelated pictures at stimulus durations ranging from 125–2,000 msec. Results ran contrary to the assumption of semantic superiority, which is based primarily on verbal memory experiments. Physical questions were associated with better free recall and cued recall of a diverse set of visual scenes (Exps I, II, and IV). This occurred both when general and highly specific semantic questions were used (Exps I and II). Similar results were obtained when more simplistic visual stimuli (photographs of single objects) were used (Exps V and VI). As in the case of the semantic superiority effect with words, the physical superiority effect for pictures was eliminated or reversed when the same physical questions were repeated throughout the session (Exps IV and VI). Conflicts with results of previous levels of processing experiments with words and nonverbal stimuli (e.g., faces) are explained in terms of the sensory-semantic model by D. L. Nelson

Kapur, S; FIM Craik; E Tulving; AA Wilson; S Houle; GM Brown (1994). **"Neuroanatomical Correlates of Encoding in Episodic Memory: Levels of Processing Effect**". *Proceedings of the National Academy of Sciences* 91 (6): 2008–2011.

Abstract

Cognitive studies of memory processes demonstrate that memory for stimuli is a function of how they are encoded; stimuli processed semantically are better remembered than those processed in a perceptual or shallow fashion. This study investigates the neural correlates of this cognitive phenomenon. Twelve subjects performed two different cognitive tasks on a series of visually presented nouns. In one task, subjects detected the presence or absence of the letter a; in the other, subjects categorized each noun as living or nonliving. Positron emission tomography (PET) scans using 15O-labeled water were obtained during both tasks. Subjects showed substantially better recognition memory for nouns seen in the living/nonliving task, compared to nouns seen in the a-checking task. Comparison of the PET images between the two cognitive tasks revealed a significant activation in the left inferior prefrontal cortex (Brodmann's areas 45, 46, 47, and 10) in the semantic task as compared to the perceptual task. We propose that memory processes are subserved by a wide neurocognitive network and that encoding processes involve preferential activation of the structures in the left inferior prefrontal cortex.

Kelley, WM; Macrae CN; Wyland CL; Caglar S; Inati S; Heatherton TF (2002). "**Finding the Self? An Event-Related fMRI Study**". *Journal of Cognitive Neuroscience* 14 (5): 785–794.

Abstract

Researchers have long debated whether knowledge about the self is unique in terms of its functional anatomic representation within the human brain. In the context of memory function, knowledge about the self is typically remembered better than other types of semantic information. But why does this memorial effect emerge? Extending previous research on this topic (see Craik et al., 1999), the present study used event-related functional magnetic resonance imaging to investigate potential neural substrates of self-referential processing. Participants were imaged while making judgments about trait adjectives under three experimental conditions (self-relevance, other-relevance, or case judgment). Relevance judgments, when compared to case judgments, were accompanied by activation of the left inferior frontal cortex and the anterior cingulate. A separate region of the medial prefrontal cortex was selectively engaged during self-referential processing. Collectively, these findings suggest that self-referential processing is functionally dissociable from other forms of semantic processing within the human brain.

Rhodes, MG; Anastasi JS (2000). "**The effects of a levels-of-processing manipulation on false recall"** (pdf). *Psychonomic Bulletin & Review* 7 (1): 158–62.

Abstract

The present study attempted to determine the effect of a levels-of-processing manipulation on the incidence of false recall. In Experiment 1, participants engaged in either a vowel counting task or a concrete/abstract rating task; in Experiment 2, participants engaged in either a vowel counting task or a category sorting task. Results of both experiments demonstrated that participants who engaged in a deeper level of processing (i.e., concrete/abstract ratings or category sorting) recalled significantly more list items and critical lures. The present findings thus lend support to theories that attribute false memories to activation-based factors.

Roediger, HL (1990). "**Implicit memory: Retention without remembering**". *American Psychologist* 45 (9): 1043–1056.

Abstract

Explicit measures of human memory, such as recall or recognition, reflect conscious recollection of the past. Implicit tests of retention measure transfer (or priming) from past experience on tasks that do not require conscious recollection of recent experiences for their performance. The article reviews research on the relation between explicit and implicit memory. The evidence points to substantial differences between standard explicit and implicit tests, because many variables create dissociations between these tests. For example, although pictures are remembered better than words on explicit tests, words produce more priming than do pictures on several implicit tests. These dissociations may implicate different memory systems that subserve distinct memorial functions, but the present argument is that many dissociations can be understood by appealing to general principles that apply to both explicit and implicit tests. Phenomena studied under the rubric of implicit memory may have important implications in many other fields, including social cognition, problem solving, and cognitive development.

Roediger, HL; Stadler ML; Weldon MS; Riegler GL (1992). "**Direct comparison of two implicit memory tests: word fragment and word stem completion**". *Journal of experimental psychology. Learning, memory, and cognition* 18 (6): 1251–1269.

Abstract

In 3 experiments, the implicit memory tests of word fragment and word stem completion showed comparable effects over several variables: Study of words produced more priming than did study of pictures; no levels-of-processing effect occurred for words; more priming was obtained from pictures when Ss imaged the pictures' names than when they rated them for pleasantness; and forgetting rates were generally similar for the tests. A different pattern of results for the first 3 variables occurred under explicit test conditions with the same word fragments or word stems as cues. It is concluded that the 2 implicit tests are measuring a similar form of perceptual memory. Furthermore,

it is argued that both tests are truly implicit because they meet the D. L. Schacter et al (1989) retrieval intentionality criterion: Levels of processing of words have a powerful effect on explicit versions of the tests but no effect on implicit versions.

Rose, N. S.; Craik, F. M. (2012). "**A processing approach to the working memory/long-term memory distinction: Evidence from the levels-of-processing span task**". *Journal Of Experimental Psychology: Learning, Memory, And Cognition* 38 (4): 1019–1029.

Abstract

Recent theories suggest that performance on working memory (WM) tasks involves retrieval from long-term memory (LTM). To examine whether WM and LTM tests have common principles, Craik and Tulving's (1975) levels-of-processing paradigm, which is known to affect LTM, was administered as a WM task: Participants made uppercase, rhyme, or category-membership judgments about words, and immediate recall of the words was required after every 3 or 8 processing judgments. In Experiment 1, immediate recall did not demonstrate a levels-of-processing effect, but a subsequent LTM test (delayed recognition) of the same words did show a benefit of deeper processing. Experiment 2 showed that surprise immediate recall of 8-item lists did demonstrate a levels-of-processing effect, however. A processing account of the conditions in which levels-of-processing effects are and are not found in WM tasks was advanced, suggesting that the extent to which levels-of-processing effects are similar between WM and LTM tests largely depends on the amount of disruption to active maintenance processes.

Schab, FR (1991). "**Odor memory: taking stock**". *Psychological Bulletin* 109 (2): 242–51.

Abstract

Reviews the state of knowledge in odor memory within the framework of mainstream memory research. Experimental findings are structured around prevailing theoretical distinctions in the study of memory proper, including semantic-episodic memory and implicit–explicit memory. Unaided odor-identification performance is found to be approximately 40–50% of the total stimulus set presented, although performance approaches the limit of memorial discrimination if Ss are given label training with feedback. Odor identification is conceptualized as a task with 3 major components and where performance falls on a continuum ranging from nonverbal feelings of familiarity to specific object names. Odor recognition is shown to be relatively stable over long retention intervals, and more than 1 explanation can account for this effect. It is also suggested that name recognition may contribute to the results obtained in odor-recognition experiments. Avenues for future research on both explicit and implicit memory for odors are mentioned. Although much is known already about memory for odors, many questions still remain.

Schacter, DL; McGlynn SM (1989). "**Implicit memory: Effects of elaboration depend on unitization**". *The American Journal of Psychology* (University of Illinois Press) 102 (2): 151–181.

Abstract

Previous research has demonstrated that performance on implicit memory tests such as word completion and identification does not require elaborative study processing, whereas performance on explicit memory tests such as recall and recognition is strongly dependent on elaborative study processing. We examined the effects of elaborative and nonelaborative study tasks on implicit memory for unitized and nonunitized word pairs. Unitized pairs were represented by common idioms (e.g., SOUR GRAPES) and highly related paired associates (e.g., TABLE-CHAIR). Nonunitized pairs were represented by British idioms (e.g., CURTAIN LECTURE) and unrelated paired associates (e.g., SALT-CHAIR). Implicit memory was assessed with a free-association test. Results of four experiments indicated that implicit memory for unitized pairs was independent of several, though not all, types of study processing that affected explicit recall. In contrast, implicit memory for nonunitized pairs was dependent on the same types of elaborative study processing that influenced explicit recall. The findings are discussed in the context of activation and episodic views of implicit memory.

Scott, L. C.; G. K. Wright; G. S. Rai; A. N. Exton-Smith; J. M. Gardiner (1991). "**Further evidence of preserved memory function in Alzheimer's disease**". *International Journal of Geriatric Psychiatry* 6 (8): 583–588.

Abstract

Individuals with panic disorder (n = 14) and normal controls (n = 14) performed two different memory tasks: a high-speed recognition task that measured perceptual memory (memory for the sensory/perceptual features of a stimulus) and a free recall task that measured semantic memory (memory for the meaning associated with the stimulus). Subjects' memory for threatening, positive, and neutral words was evaluated. In contrast to normal controls, panic disorder patients showed better perceptual memory and better semantic memory for threat words compared to positive and neutral words. These results suggest that the panic disorder individuals engaged in preferential processing of threat information at both a perceptual and semantic level of analysis. The results do not support a “cognitive avoidance” hypothesis which predicts the inhibition of more elaborate and meaningful processing of threat stimuli in anxious subjects. The conditions under which cognitive avoidance might occur are

outlined.

Srinivas K, Kavitha; Greene AJ; Easton RD (1997). **"Visual and tactile memory for 2-D patterns: Effects of changes in size and lef-right orientation"** (pdf). *Psychonomic Bulletin & Review* 4 (4): 535–540.
Abstract

Examined whether the finding that visual identification of 3-D objects depends on representations that are invariant across changes in size and left-right orientation reflects the unique demands of processing 3-D objects, or whether it generalizes to 2-D patterns and to the tactile modality. In Exp 1, 96 undergraduates were presented with 20 3-line shapes and described the orientation of the lines (vertical, horizontal, or diagonal) and the type of functions they formed (endpoints, touching intersections, or one line touching between end points). Ss also performed visual identification and episodic recognition tests. In Exp 2, 120 undergraduates took part in tactile identification and recognition tests in the size and orientation change conditions. Findings suggest that object representation for identification is influenced greatly by the processing demands of stimulus materials and stimulus modality (touch vs vision). Identification of 2-D patterns in vision is adversely affected by left-right orientation changes, but not size changes. Identification of the same patterns in touch is adversely affected by both changes. Together, the results suggest that the unique processing demands of stimulus materials and modality shape the representation of objects in memory.

Symons, CS; Thompson BT (1997). "**The self-reference effect in memory: A meta-analysis**" (pdf). *Psychological Bulletin* 121 (3): 371–394.
Abstract

In this review, the authors examine the basis for the mnemonic superiority that results from relating material to the self. A meta-analysis confirms the expected self-reference effect (SRE) in memory, with self-referent encoding strategies yielding superior memory relative to both semantic and other referent encoding strategies. Consistent with theory and research that suggest self-reference (SR) produces both organized and elaborate processing, the SRE was smaller (a) when SR is compared with other-reference (OR) rather than semantic encoding and (b) when the comparison tasks promote both organization and elaboration. Thus, the SRE appears to result primarily because the self is a well-developed and often-used construct that promotes elaboration and organization of encoded information. The authors discuss the implications of these and other findings for theories of the SRE and for future research.

Toichi, M; Kamio Y (2002). "**Long-term memory and levels-of-processing in autism**". *Neuropsychologia* 40 (7): 964–969.
Abstract

Prior studies reported that long-term memory (LTM) was basically unimpaired in individuals with autism. However, people with autism have been found to perform worse than ability-matched controls when verbal materials to be remembered are semantically related. In normal subjects, semantic processing of verbal materials facilitates LTM better than 'shallow' (phonological or perceptual) processing, which is known as the levels-of-processing effect. In this study, the relationship between LTM and semantic processing was investigated using a levels-of-processing task. In Study 1, a levels-of-processing task was conducted on healthy volunteers, which confirmed the levels-of-processing effect with our task. In study 2, the same task was conducted on autistic subjects with mild or no mental retardation and ability-matched controls. The levels-of-processing effect was confirmed in the control group. Although overall performance in the two groups was comparable, the levels-of-processing effect was not found in the autistic group. LTM resulting from perceptual processing was better in the autistic group than in the control group, indicating superior 'rote memory' in individuals with autism. Furthermore, the pattern of correlations between LTM performance and cognitive measures differed greatly between the two groups. The lack of the levels-of-processing effect, which has not been reported in other psychiatric or neuropathological conditions, suggests an abnormal relationship between semantic memory and episodic memory in individuals with autism.

Toth, JP (1996). "**Conceptual automaticity in recognition memory: Levels-of-processing effects on familiarity**". *Canadian Journal of Experimental Psychology* 50 (1): 123–38.
Abstract

Examined the effect of level of processing (LP) on recognition memory using 2 response-signal delays (RSD; 500 and 1500 msec). In Exp 1, LP (semantic or nonsemantic) and RSD were manipulated between 24 college students. In Exp 2, orienting task (pleasantness rating or letter judgment) and RSD were manipulated among 32 Ss. In Exp 3, study orientation and test instructions (inclusion or exclusion) were within-S factors, and RSD was a between-S factor. 32 Ss were included in Exp 3. In Exp 1, a modality effect was found for fast responses. The LP was reliable at both points in time. In Exp 2, fast responses were associated with significantly more "false-alarms" to words encoded semantically than those encoded nonsemantically. In Exp 3, both recollection and familiarity estimates were elevated by prior conceptual processing. Estimates of recollection were affected by RSD.

Vaidya, CJ; Zhao M; Desmond JE; Gabrieli JDE (2002). **"Evidence for cortical encoding specificity in episodic memory: memory-induced re-activation of picture processing areas"** (pdf). *Neuropsychologia* 40 (12): 2136–2143.

Abstract

Functional magnetic resonance imaging (fMRI) was used to examine whether neural pathways used to encode pictures into memory were re-activated during retrieval of those memories. At encoding, subjects semantically classified common objects presented as pictures or words. At retrieval, subjects performed yes/no recognition memory judgments on words that had been encoded as pictures or as words. The retrieval test probed memory for the encoded item, but not memory for the modality of the encoded item (picture/word). Results revealed that a subset of the brain regions involved specifically in encoding of pictures were also engaged during recognition memory for the encoded pictures. Specifically, encoding of pictures relative to words engaged bilateral extrastriate visual cortex, namely fusiform, lingual, middle occipital, and inferior temporal gyri (Broadman area (BA) 18/19/37). Recognition memory judgments about words that were encoded as pictures relative to those that were encoded as words activated fusiform and inferior temporal gyri primarily in the left hemisphere. Thus, cortical areas originally involved in perception of a visual experience become part of the long-term memory trace for that experience. These findings suggest a neural basis for encoding specificity and transfer appropriate processing in human memory.