Psychology and Neuroscience of Memory
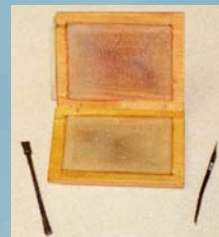

Mnemosyne

Some Traditional (and Misleading?) Metaphors of Memory

Aviary

Seal on a Wax Tablet

Library

Photograph or movie

A Bad Model for Human Memory: Computer Memory

- Why is storage of information in a computer called "memory"?
  - We think of memory as storage, putting something away but are able to recall it
  - Some of the problems in setting up computer memory seem to resemble those we face
    - When we put information into a memory system we need some way of getting it back out
    - Computers, like libraries, rely on indexes
- But there are major differences between human and computer memory
  - Much of our memory is "content addressable"
  - Much of our memory has emotional overtones
  - Much of our memory is reconstructive

The Importance of Getting the Phenomenon Right

Most accounts of science emphasize the importance of explanation (and perhaps prediction) as scientific activities. But explanations are only valuable if they explain real phenomena.

The phenomena are not always obvious, and we may need to seek data or evidence to determine just what the phenomena are.

Memory vs. Photography - 1

Compare Franco Magnani's paintings and Susan Schwartzenberg's photographs of Magnani's childhood hometown, Pontito, in Italy
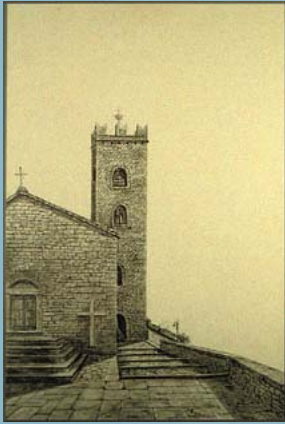
Memory vs. Photography - 2

Magnani's childhood home

He and his mother appear in the painting

Memory vs. Photography - 3

Magnani could see the *campanile* (bell tower) from his bedroom window. It was a major part of his life

Compare the perspective
Compare the height of the tower

Memory vs. Photography - 4

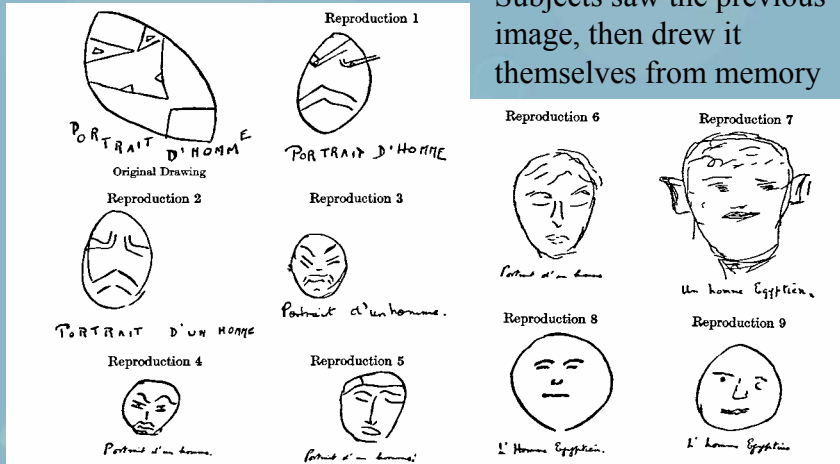The painting and photograph are from Magnani's bedroom window

The painting shows more than can be seen from any one point of view
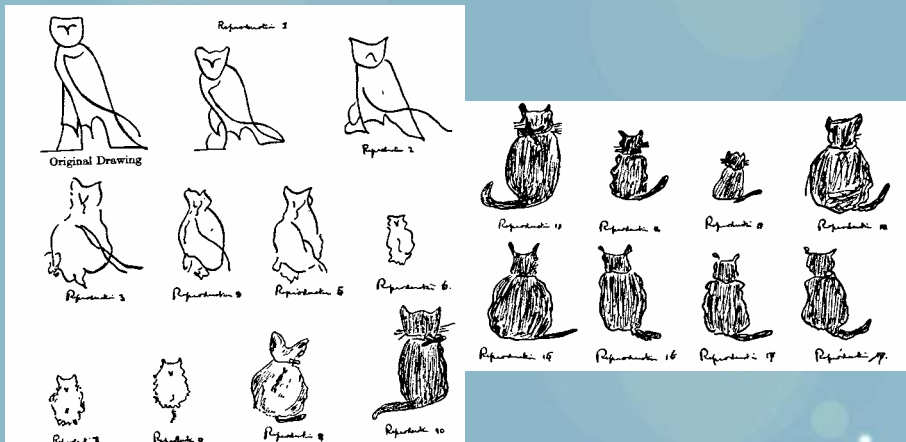
Bartlett's Transformed Memories of Drawings

Method of Serial Reproduction or Game of Telephone

Subjects saw the previous image, then drew it themselves from memory

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Transformed Memory of Drawings II

Bartlett's Analysis of the Changes

1. Transformations in the direction of accepted conventional representations
2. Elaboration of features that cannot be labeled until a recognized form is produced
3. Multiplication of details not readily assimilated
4. Once a recognizable form is produced, simplification into conventionalized representation
5. Assignment of a name influences what is reproduced
6. Preservation of detached details once recognized form is achieved

The War of the Ghosts

One night two young men from Egulac went down to the river to hunt seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought: "Maybe this is a war-party". They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men m the canoe, and they said:

"What do you think? We wish to take you along. We are going up the river to make war on the people".

One of the young men said: "I have no arrows".

"Arrows are in the canoe", they said.

"I will not go along. I might be killed. My relatives do not know where I have gone. But you", he said, turning to the other, "may go with them."

So one of the young men went, but the other returned home.

And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water, and they began to fight, and many were killed. But presently the young man heard one of the warriors say: "Quick, let us go home: that Indian has been hit". Now he thought: "Oh, they are ghosts". He did not feel sick, but they said he had been shot.

So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said: " Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick".

He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried.

He was dead.

Serial Reproduction of The War of the Ghosts

Reproduction 10

The War of this Ghosts

Two Indians were out fishing for seals in the Bay of Manpapan, when along came five other Indians in a war-canoe. They were going fighting. "Come with us," said the five to the two, "and fight."
"I cannot come," was the answer of the one, "for I have an old mother at home who is dependent upon me." The other also said he could not come, because he had no arms. "That is no difficulty" the others replied, "for we have plenty in the canoe with us"; so he got into the canoe and went with them.
In a fight soon afterwards this Indian received a mortal wound. Finding that his hour was come, he cried out that he was about to die. " Nonsense," said one of the others, "you will not die." But he did.

Transformations of Last Sentence

When the sun rose he fell down. And he gave a cry, and as he opened his mouth a black thing rushed from it.
When the sun again rose he suddenly felt faint, and when he would have risen he fell down, and a black thing rushed out of his mouth.
He felt no pain until sunrise the next day, when, on trying to rise, a great black thing flew out of his mouth.
He lived that night, and the next day, but at sunset his soul fled black from his mouth.
He lived through the night and the following day, but at sunset his soul fled black from his mouth.
He lived during the night and the next day, but died at sunset, and his soul passed out from his mouth.
Before the boat got clear of the conflict the Indian died, and his spirit fled.
Before he could be carried back to the boat, his spirit had left this world.
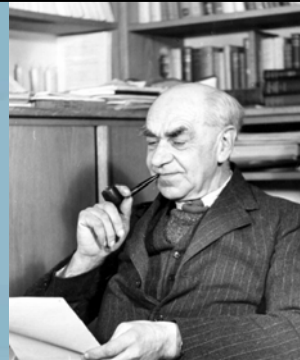His spirit left the world.
("Nonsense", said one of the others, "you will not die.") But he did.

Bartlett's Analysis of the Changes

The story became shorter and more coherent
    "No trace of an odd, or supernatural
        element is left: we have a perfectly
        straightforward story of a fight and
        a death."

Achieved by:

- Omissions: ghosts omitted early; the wound became a matter of flesh, not spirit
- Rationalization: growing coherence among parts
- Transformational of details into more familiar and conventional
- Changing order of events

Method of Repeated Reproduction

Now individual subjects are asked to repeat the story after various intervals after reading the story twice

The War of the Ghosts

Two men from Edulac went fishing. While thus occupied by the river they heard a noise in the distance.

"It sounds like a cry ", said one, and presently there appeared some men in canoes who invited them to join the party on their adventure. One of the young men refused to go, on the ground of family ties, but the other offered to go.

"But there are no arrows", he said.

"The arrows are in the boat", was the reply.

He thereupon took his place, while his friend returned home. The party paddled up the river to Kaloma, and began to land on the banks of the river. The enemy came rushing upon them, and some sharp fighting ensued. Presently some one was injured, and the cry was raised that the enemy were ghosts.

The party returned down the stream, and the young man arrived home feeling none the worse for his experience. The next morning at dawn he endeavoured to recount his adventures. While he was talking something black issued from his mouth. Suddenly he uttered a cry and fell down. His friends gathered round him.

But he was dead.

SUBJECT H: 20 hours

The War of the Ghosts

Subject P (a painter), first reproduction and 30 months later

Two youths were standing by a river about to start seal-catching, when a boat appeared with five men in it. They were all armed for war.

The youths were at first frightened, but they were asked by the men to come and help them fight some enemies on the other bank. One youth said he could not come as his relations would be anxious about him; the other said he would go, and entered the boat.

. . . .

In the evening he returned to his hut, and told his friends that he had been in a battle. A great many had been slain, and he had been wounded by an arrow; he had not felt any pain, he said. They told him that he must have been fighting in a battle of ghosts. Then he remembered that it had been queer and he was very excited.

In the morning, however, he became ill, and his friends gathered round; he fell down and his face became very pale. Then he writhed and shrieked and his friends were filled with terror. At last he became calm. Something hard and black came out of his mouth, and he lay contorted and dead.

****

Some warriors went to wage way against the ghosts. They fought all day and one of their number was wounded.

They returned home in the evening, bearing their sick comrade. As the day drew to a close, he became rapidly worse and the villagers came round him. At sunset he sighed: something black came out of his mouth. He was dead .

Stepwise Reconstruction after 6.5 Years

1. Brothers.
2. Canoe.
3. Something black from mouth.
4. Totem.
5. One of the brothers died.
6. Cannot remember whether one slew the other or was helping the other.
7. Were going on journey, but why I cannot remember.
8. Party in war canoe.
9. Was the journey a pilgrimage for filial or religious reasons?
10. Am now *sure* it was a pilgrimage.
11. Purpose had something to do with totem.
12. Was it on a pilgrimage that they met a hostile party and one brother was slain?
13. I think there was some reference to a dark forest.
14. Two brothers were on a pilgrimage, having something to do with a totem, in a canoe, up a river flowing through a dark forest. While on their pilgrimage they met a hostile party of Indians in a war canoe. In the fight one brother was slain, and something black came from his month.
15. Am not confident about the way brother died. May have been something sacrificial in the manner of his death.
16. The cause of the journey had both something to do with a totem, and with filial piety.
17. The totem was the patron god of the family and so was connected with filial piety.

Importance of Deficits in Studying Normal Function

- In complex systems the parts are often so integrated that they cannot be detected in normal operation

- Need to break the system to discover the components— not just physical components but functional ones

- "When functioning smoothly, the brain systems that support episodic and semantic memories allow us to recognize objects in the world, to travel in time, and to construct our life stories. But when they are disrupted by brain damage, we are afforded a glimpse of the building blocks from which we build the tales of our past that confer coherence and meaning on our day-to-day lives."

Encoding, Storage, and Retrieval

- Richard Semon (1878-1918) differentiated engraphy, engram, ecphory
  - Terminology preserved in Karl Lashley's reference to the engram he could not find in the brain
  - Modern terminology: encoding, storage and retrieval
    - Encoding: laying down of a memory
    - Storage: trace in the brain
    - Retrieval: accessing the memory

- Challenge for research: getting evidence about one process independently of the other—most measures of memory require all three

Short versus Long-term Memory

- Distinction between information that you can hold in mind if not disturbed and that which stays with you forever
- Capacity limitation of short-term memory: Miller's magic number 7 (plus or minus 2)
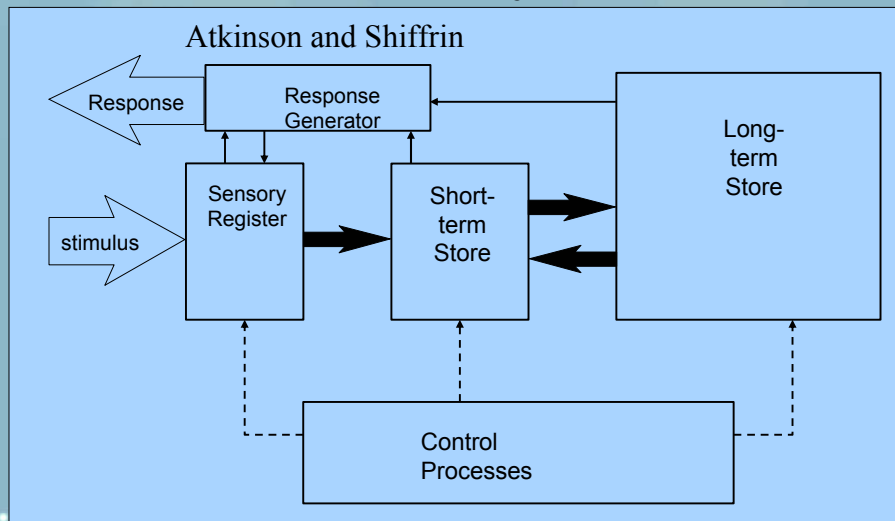- Long-term memory seems unlimited

Memory Exercise

Some rows of letters will appear. After they are gone, an arrow will direct you to remember a particular row. Right down as many letters from that row as you can, then any others that you remember

G	L	R	B
U	K	Q	O
C	M	I	W
N	X	D	J
S	F	Y	H

Long-term, short-term, and echoic memory

Atkinson and Shiffrin

Types of Long-Term Memory

- Semantic memory: conceptual and factual knowledge: dogs are mammals, birds fly, San Diego is in California

- Episodic or autobiographical memory: explicitly recalling previous experiences—belief that the memory is a true replica of the previous event and part of one's own past—mental time travel

- Procedural memory: skill memory, classical and operant conditioning, priming
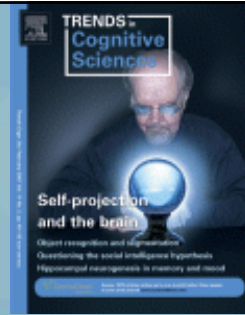
Memory Exercise

Remember a present you received on your last birthday
Do you remember actually receiving the present, or only that you received it?

Recall seeing this picture in a previous class:
Do you remember actually seeing it, or only remember that you saw it—you know that it was in the presentation?

Long-term Memory Systems

One response to identifying the variety of phenomena that constitute remembering is to
- Distinguish type of memory
- Propose different *systems* responsible for each type of memory

"Most important, we have now come to believe that memory is not a single or unitary faculty of the mind, as was long assumed. Instead, it is composed of a variety of distinct and dissociable processes and systems. Each system depends on a particular constellation of networks in the brain that involve different neural structures, each of which plays a highly specialized role within the system" (Schacter, 1996, p. 5).

Double dissociation between semantic and episodic deficits

- Frederick, HM, KC, etc.: loss of episodic memory but preservation of semantic or procedural memory
  - Gene (KC): loss of all episodic memory, but retains much semantic memory, including for episodes in his past—but he remembers these as we remember facts about other people's lives (lacking any sense that he had experienced the events).

- Semantic dementias—Pick's Disease: semantic deficit with little episodic deficit
  - Patient of Ennio De Renzi: damage to frontal parts of temporal lobe resulted in loss of meanings of common words, loss of knowledge of historical events, and of the basic attributes of animate and inanimate objects.

Semantic Memory and Semantic Networks
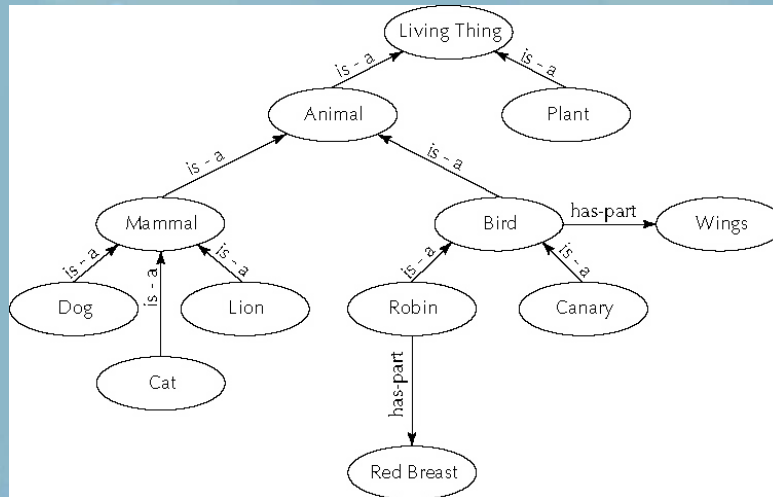
Dissociations within Semantic Memory

Warrington and Shallice (1984): category specific semantic memory deficits

SBY—problem defining living things terms, but not artifact terms

- Wheelbarrrow: object used by people to take material about
- Towel: material used to dry people

But

- Wasp: bird that flies
- Spider: a person looking for things; he was a spider for a nation or country

Living/Non living distinction

Double dissociation: other patients show deficit in identifying non-living things with spared recall of living things

Damasio: types of information used to identify particular categories

- Living things are most distinguished by their appearance

- Artifacts are most distinguished by their function or use—including the types of body motions we make in using them

What organizes semantic categories?

Allport: semantic memory divided into different sensorimotor modalities: visual knowledge, tactile knowledge, motor knowledge
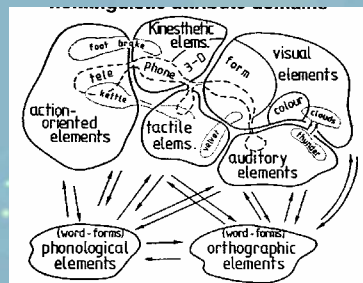
In PET studies by Alex Martin et al.
- Animals terms elicited activity in lower parts of temporal lobe
- Tools activated this area but also left prefrontal motor cortex

Frontal Lobe Deficits

Damage to prefrontal cortex generally does not produce general amnesia

Rather
- Source amnesia
- False recognition
- Confabulation

Results in patients not recognizing their deficit

Imaging does reveal activity in prefrontal cortex during encoding and retrieval
- Patient BG—more false recognition for items in the same category as the studied item.
- Suggests possible role of prefrontal areas in suppressing common category information so as to focus on item specific differences.

Memory and Learning

One of the kinds of memory Schacter describes is implicit:
> "we've opened up a whole new world of implicit, nonconscious memory that underlies our abilities to carry out effortlessly such tasks as riding a bicycle or playing a piano, without having to direct each movement consciously every time we attempt the task."

Traditionally, one would have spoken of *learning* to ride a bicycle or play the piano.

Likewise, we would have spoken of learning new facts rather than acquiring semantic memories

Priming

PRIMING: Recent exposure to stimulus (words) makes it easier to access the item on subsequent tasks
- Being presented with a word on a list (*couple*), and later asked to complete a stem (*COU*)

Long lasting effect—up to weeks, long after conscious recall has failed

Priming does not show depth of processing effect
But is sensitive to the modality of presentation

Distinct from episodic and semantic memory
The result of "the operation of some other, as yet little understood, memory system." (Schacter, p. 169)

Procedural Knowledge, *Knowing How*, and Implicit Memory

Ryle: Distinction between *knowing that* and *knowing how*

Cohen and Squire: amnesics can learn new abilities without any memory of previous experience
Learning such motor skill engages the basal ganglia and the cerebellum

Schacter and Graf introduced the term "implicit memory"
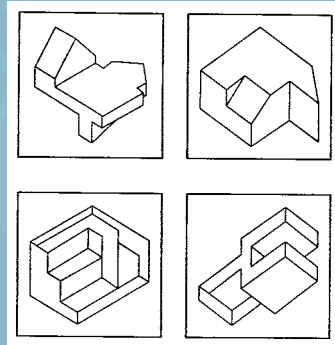
Priming and Perception

Priming is sensitive to the modality of stimulus and retrieval cue

> With visually presented words, even to the font in which the word is presented

Priming for shapes: Schacter and Cooper

> Possible shapes produce priming
> *Impossible shapes do not*

Possible shapes produced activation in inferior temporal gyrus and fusiform gyrus

Perceptual Representation System

"The PRS is specialized to deal with the form and structure of words and objects, but it does not "know" anything about what words mean or what objects are used for. Meaningful associations and concepts are handled by semantic memory, which cooperates closely with PRS." (Schacter, p. 184).

Summary of Memory Systems

Different systems operate semi-autonomously:

"While working memory operates on the incoming information . . . other memory systems in the complex, massively parallel computational machine that is the brain are also involved, separately from the process of working memory. Thus, PRS, the perceptual representation system, encodes and stores information about the features of the visual objects represented by the letter strings AARDVARKS EAT ANTS. The semantic memory system, or a set of its (presumably numerous) subsystems, encodes and stores propositional information about the feeding habits of animals named aardvarks. The episodic system integrates, registers, temporally dates, and spatially localizes the rememberer's experience of the experience of being present and witnessing the sentence appearing on and disappearing from the screen" (Tulving, 1999, p. 20).

Objections to Memory Systems

Dissociations often found equally between two different tasks that are supposed to involve the same memory system

Blaxton (1989) dissociated
    Two tasks thought to involve episodic retrieval
- Semantic cued recall
- Graphemic cued recall

    Two tasks thought to involve semantic memory
- Word fragment completion
- Answering general-knowledge questions

What is Gained or Lost by Identifying Memory Systems?

Differentiate types of memory phenomena—phenomena to be explained
- Valuable insofar as it helps us avoid trying to offer a common explanation for different phenomena

But in itself it does nothing to help explain the various memory phenomena
- That requires decomposing the phenomena in component processes and their operation

Emphasizing memory system may actually inhibit the search for these processes by obscuring commonalities of processes

Components of Processing Alternative

Emphasize different information processing operations that figure differentially in different tasks
Comparable to processing steps in a computer program
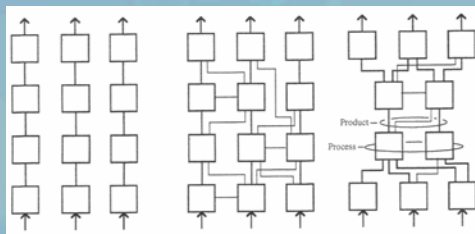
Components recruited in different word stem completion tasks

Different processing areas are recruited in different tasks

| Word-stem completion | Primed word-stem completion | Stem-cued recall |
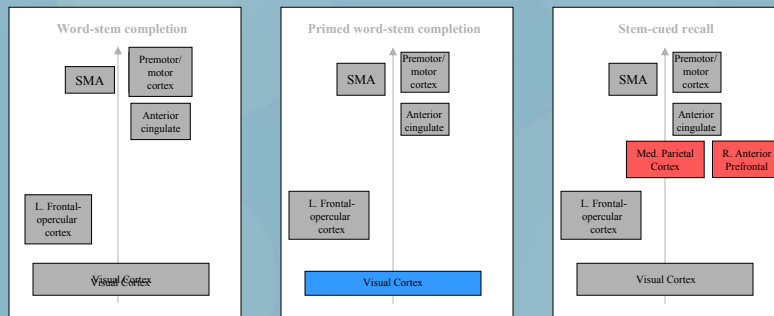
Roediger, Buckner, and McDermott (1999)

May also Artificially Divorce Memory from Other Cognitive Operations

Memory may not be an independent faculty
    May figure in other cognitive processes

John Gabrieli: same areas activated in lexical processing and encoding of semantic memory:

In psychological research on cognition, it is common for different researchers to focus on language, on working memory, on episodic memory, or on implicit memory. The brain and mind, however, need not be organized in the same way that researchers divide cognitive domains. Indeed, one promise of functional neuroimaging is to reveal the natural organization of the brain and mind. Although there is a great deal yet to be understood about the mental operations mediated by the left prefrontal cortex, including how many distinct but adjacent operations occur in that region, it seems already that those operations may be the same whether they are considered in the context of language, working memory, episodic memory, or implicit memory. The left prefrontal cortex thus serves as a crossroads between meaning in language and memory. (Gabrieli et al., 1998)