ASHI 712

The Neuroscience of Human Memory

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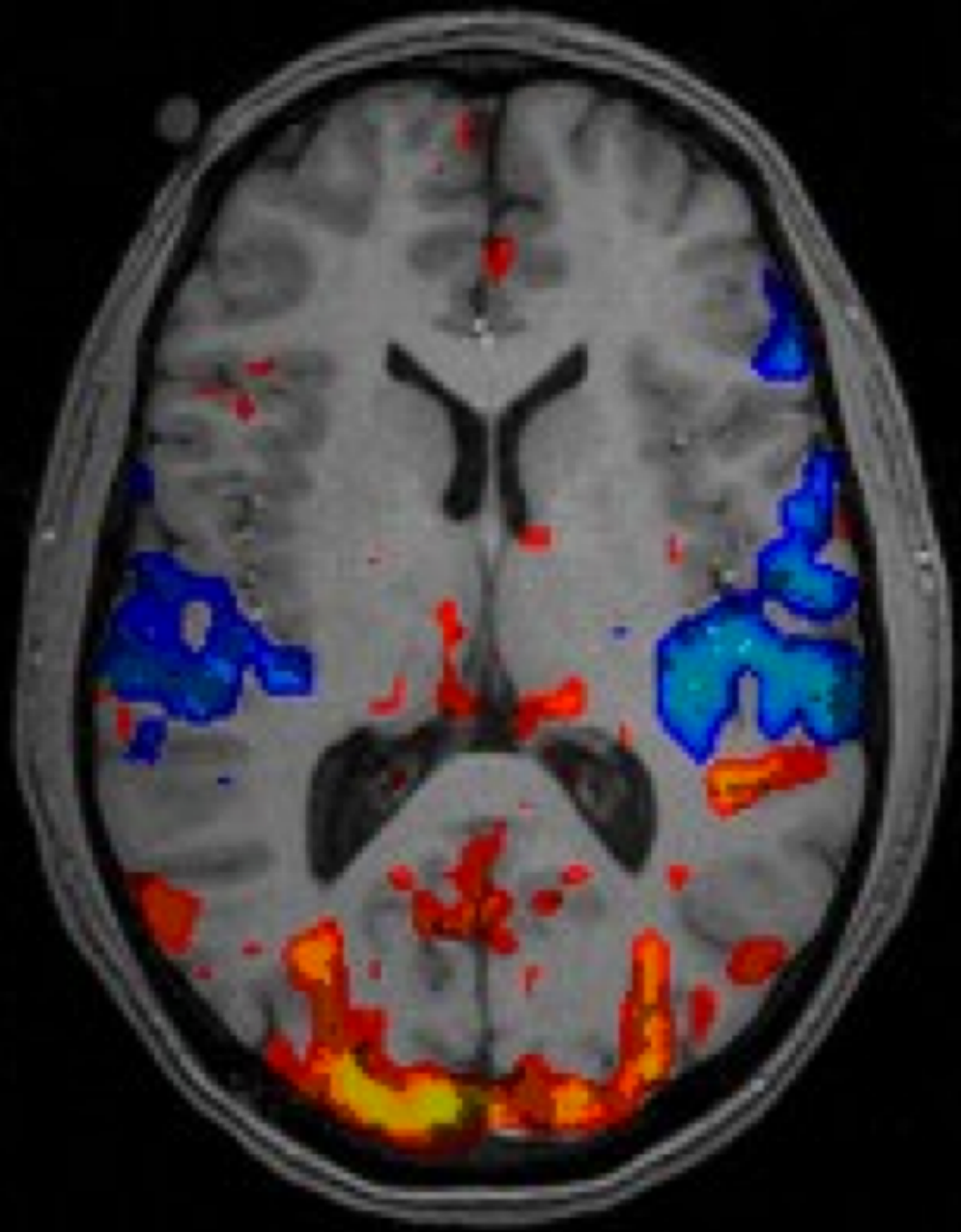
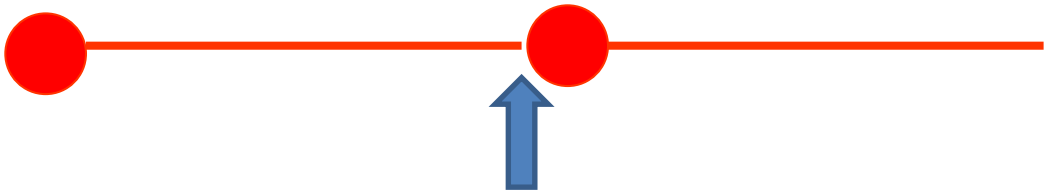
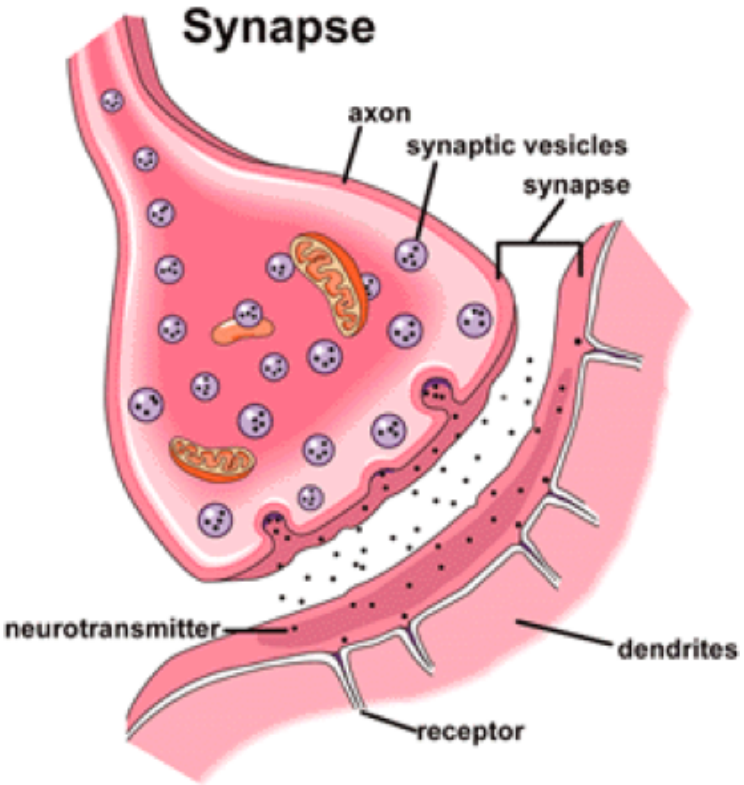
LECTURE 3:
Long Term Memory and False Memories



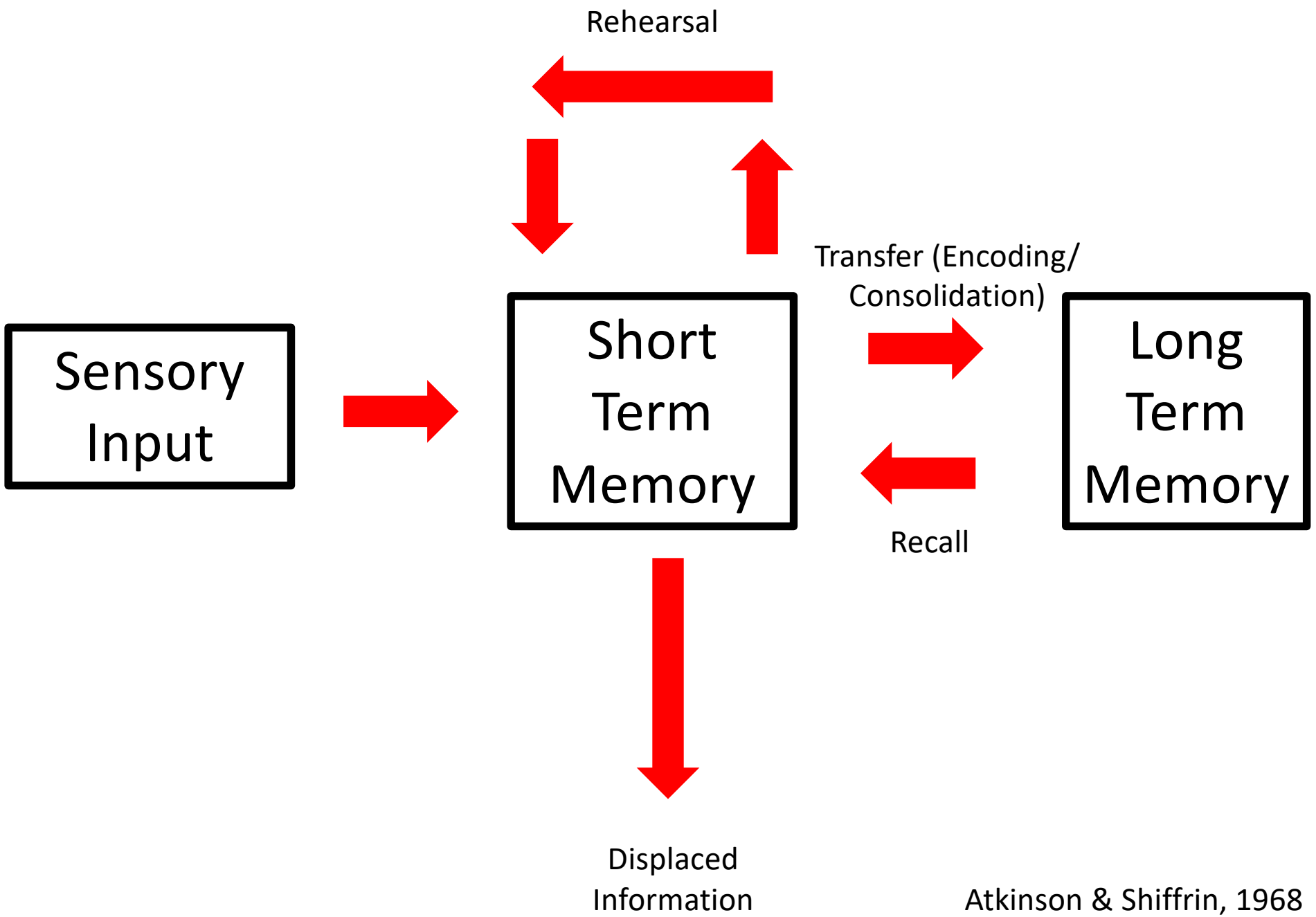


strengthen

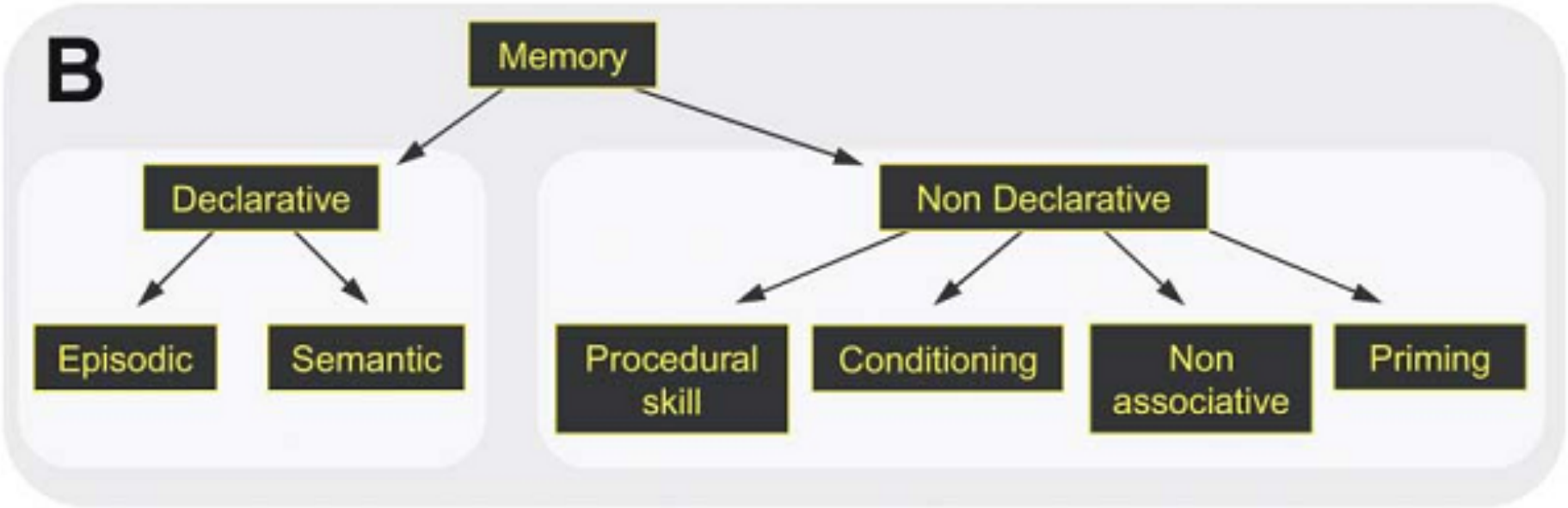


HOW?

Increased neurotransmitter release
Increase receptors
Structural changes



Atkinson & Shiffrin, 1968


B
Memory
Declarative
Non Declarative
Episodic
Semantic
Procedural skill
Conditioning
Non associative
Priming

Episodic Memories

- “I remember”
- Tagged with spatial and temporal context
- Learned in a single exposure

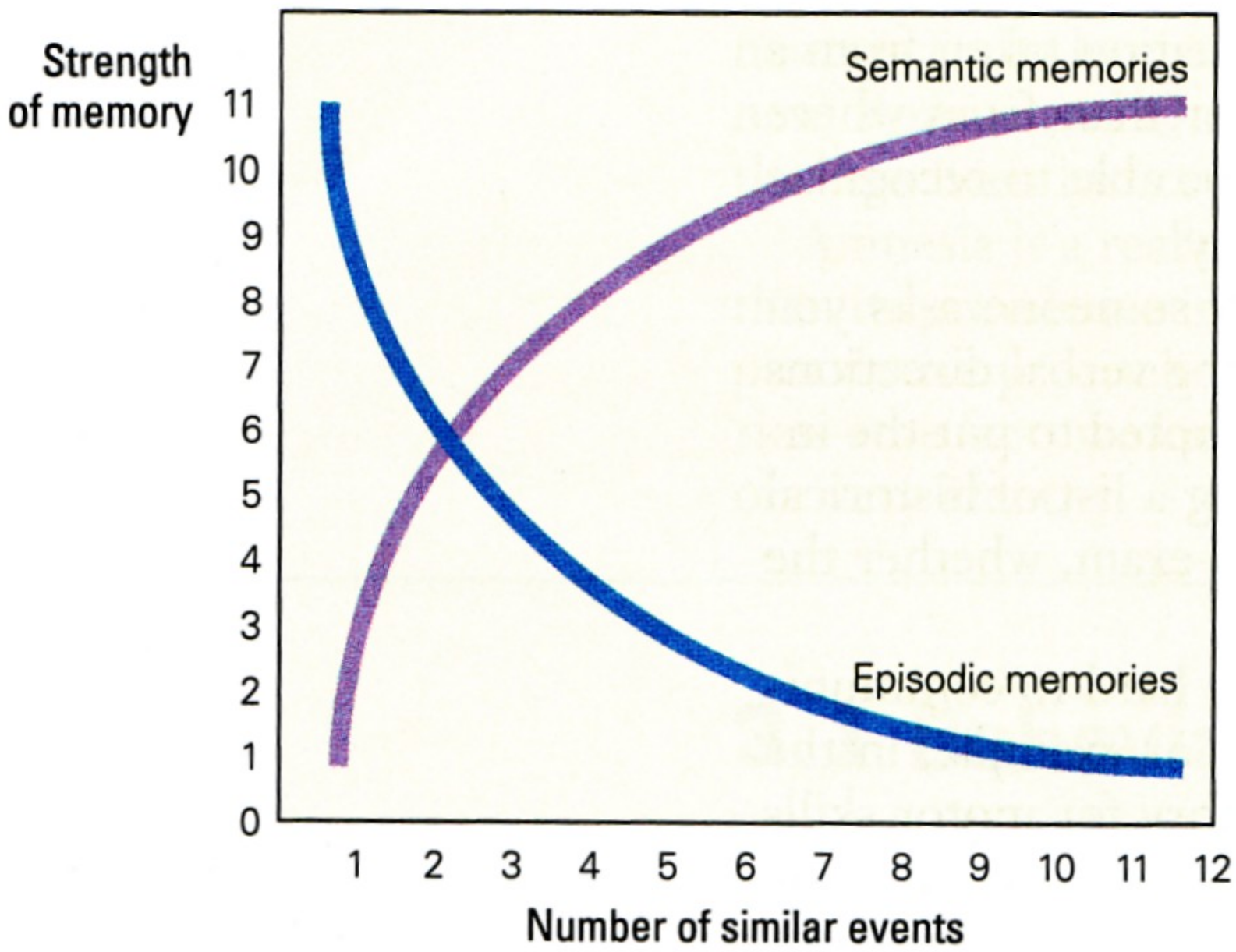
Semantic Memories

- “I know”
- Does not have to have spatial and temporal context
- Learned in a single exposure, but strengthened with repetition

Episodic and Semantic Memories

- Can be communicated flexibly in a format other than they were acquired

- Consciously accessible


Strength of memory
11
10
9
8
7
6
5
4
3
2
1
0
Semantic memories
Episodic memories
1
2
3
4
5
6
7
8
9
10
11
12
Number of similar events

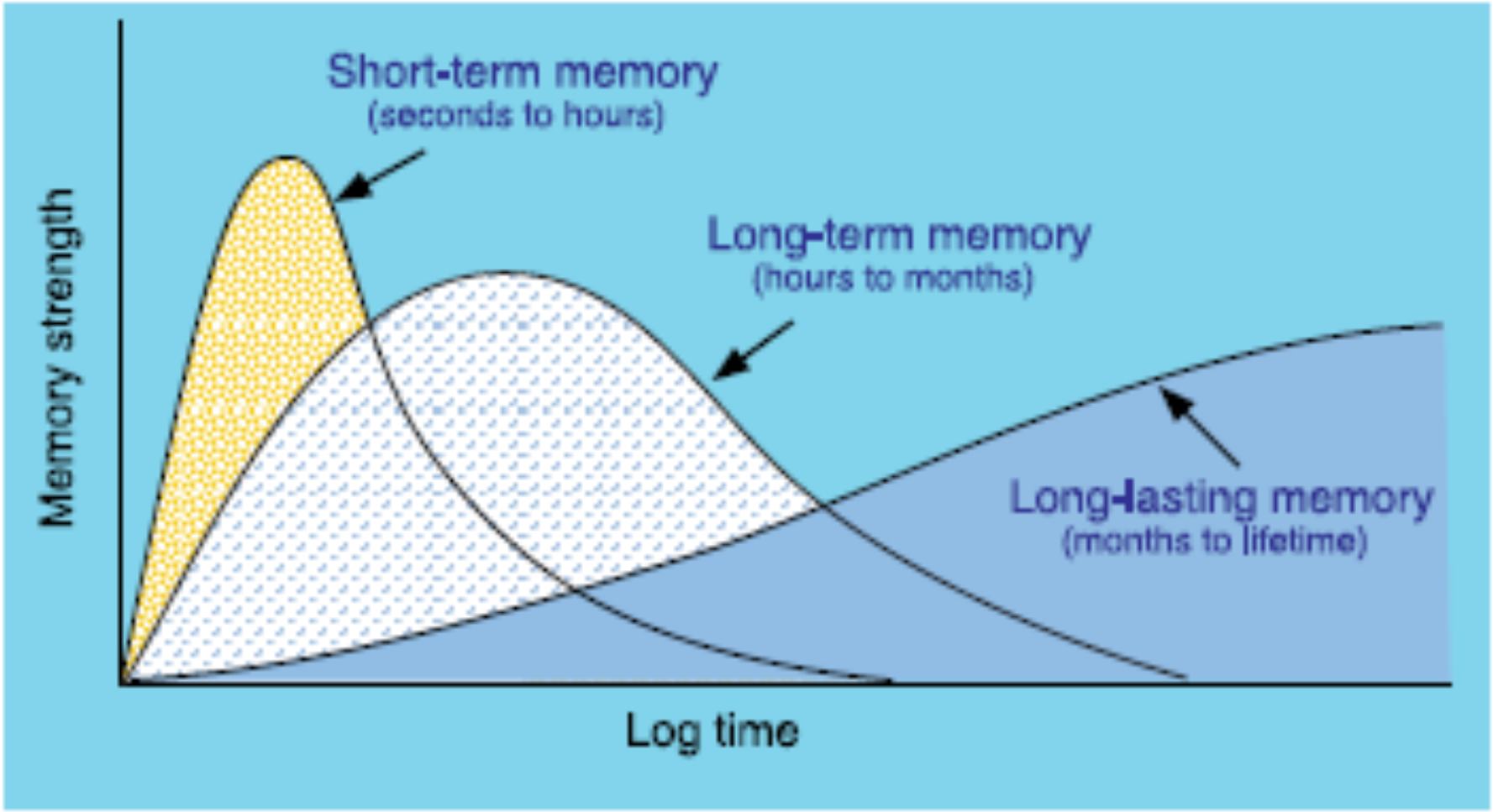
Trace Levels

Sensory Trace (< 1 s)

Short Term Trace (develops within seconds or minutes and last for hours)

Long Term Trace

Long Lasting Trace


Short-term memory
(seconds to hours)
Long-term memory
(hours to months)
Long-lasting memory
(months to lifetime)
Memory strength
Log time

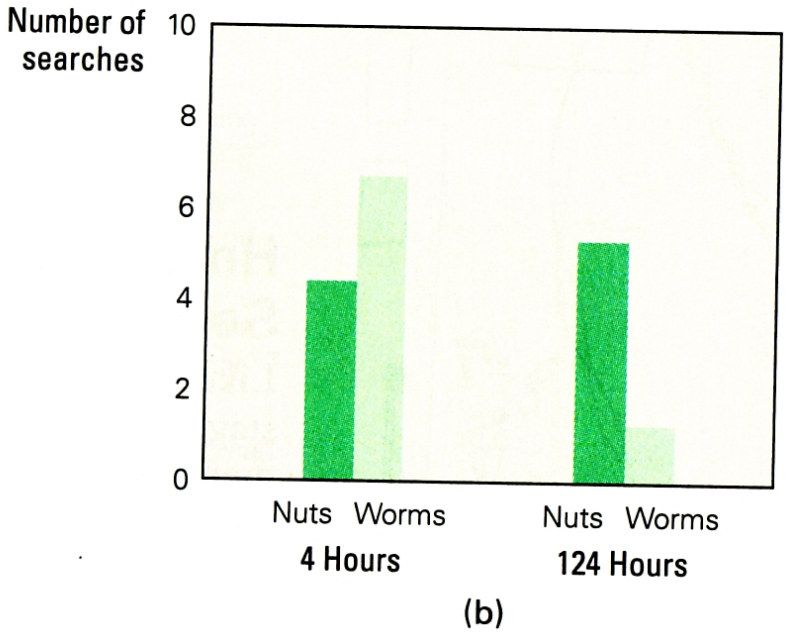
Stages of Memory Formation

1. Encoding
2. Consolidation
3. Retention
4. Retrieval

Do animals have episodic memories?

Figure 3.2 Episodic memory in birds (a) Scrub jays were allowed to cache worms and nuts in the compartments of sand-filled ice-cube trays. (b) Some time later, the birds were allowed to recover food from the trays. If the delay was 4 hours, the birds tended to recover buried worms (their favorite food). But if the delay was 124 hours, during which time the worms would have rotted, the birds tended to recover the nuts instead. This suggests that the birds remembered what they had buried where, and how long ago—an "episodic-like" memory. (a) Adapted from Griffiths et al., 1999; (b) adapted from Roberts, 2002.

(a)



(b)

Episodic-like memory in a gorilla: A review and new findings ☆

Bennett L. Schwartz [a,*], Megan L. Hoffman [b], Siân Evans [c]

[a] *Florida International University, USA*
[b] *Georgia State University, USA*
[c] *DuMond Conservancy for Primates and Tropical Forests, USA*

Received 28 February 2005

We describe two new studies with King, an adult male western lowland gorilla. We show that King can remember the order of past events (Experiment 1) and that King can remember where events occurred (Experiment 2). We conclude by discussing alternate explanations of our findings and speculate on future directions.

Table 1
King's percent correct (Schwartz et al., 2002)

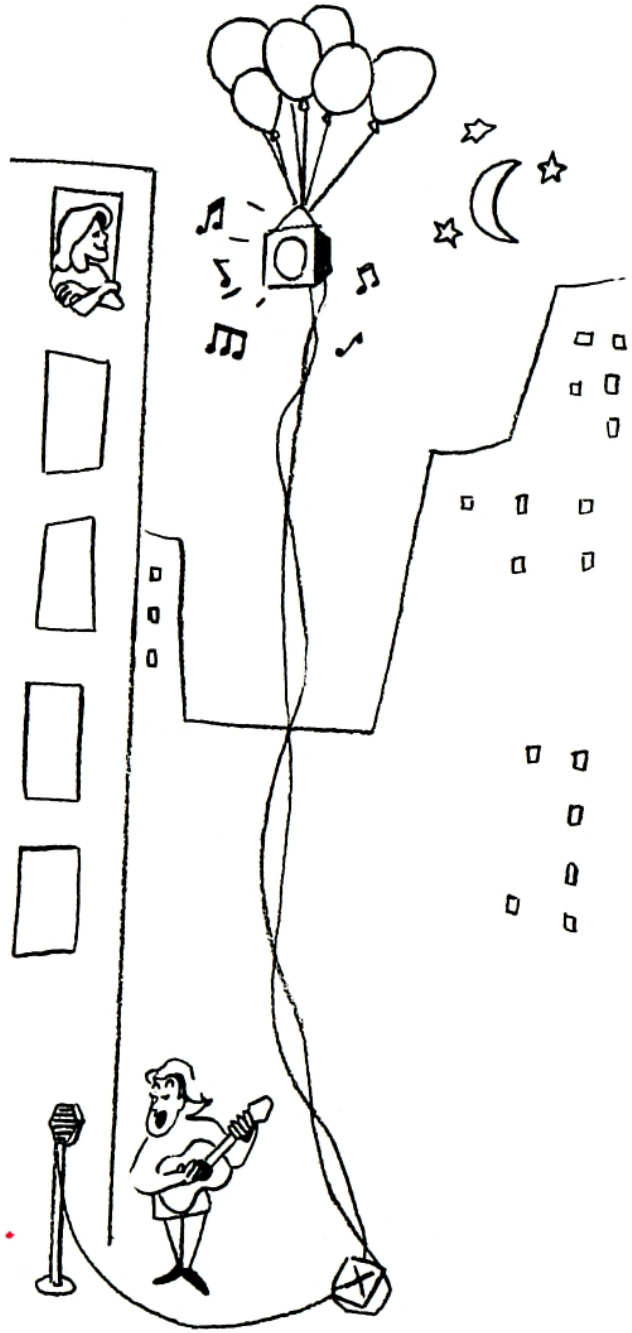
	Percent correct			
	5-min RI		24-h RI	
	"What"	"Who"	"What"	"Who"
Experiment 1	70%		82%	
Experiment 2	55%	82%	73%	87%

20% is chance baseline for "what" questions; 50% is chance baseline for "who" questions.

Factors which influence semantic and episodic memory formation

Context

If the balloons popped, the sound wouldn't be able to carry, since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying, since most buildings tend to be well-insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face-to-face contact, the least number of things could go wrong.



(b)

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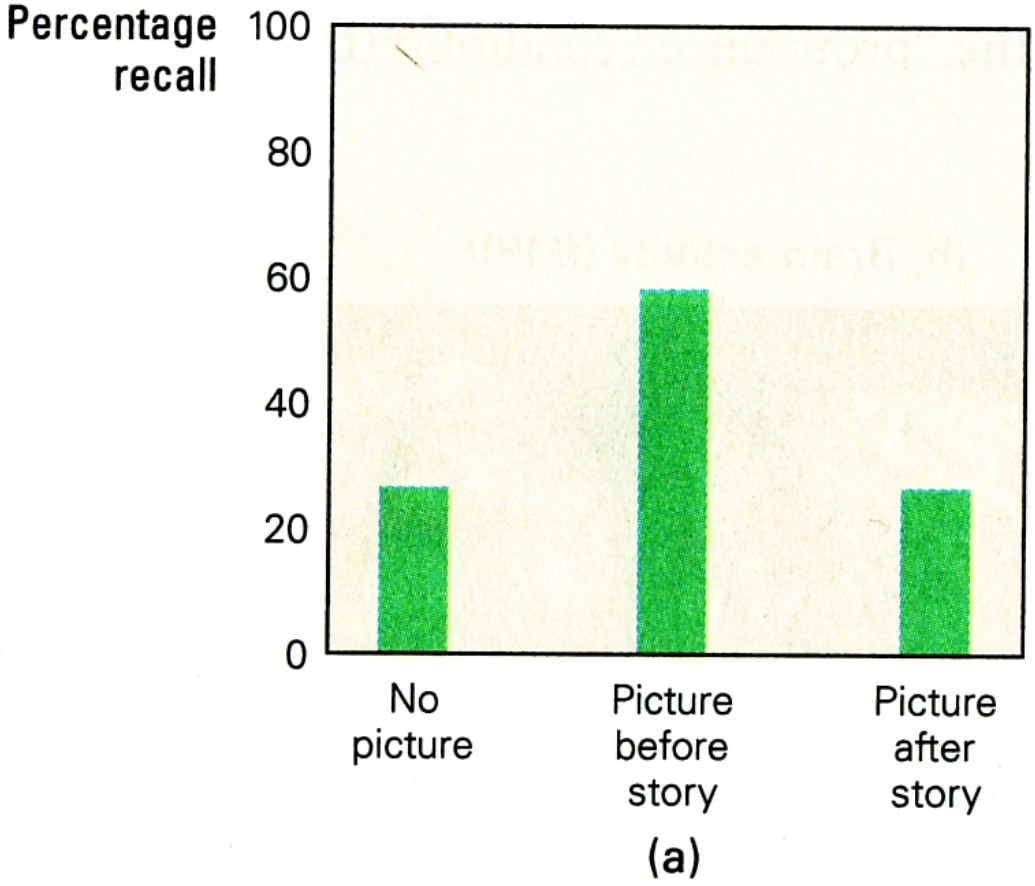
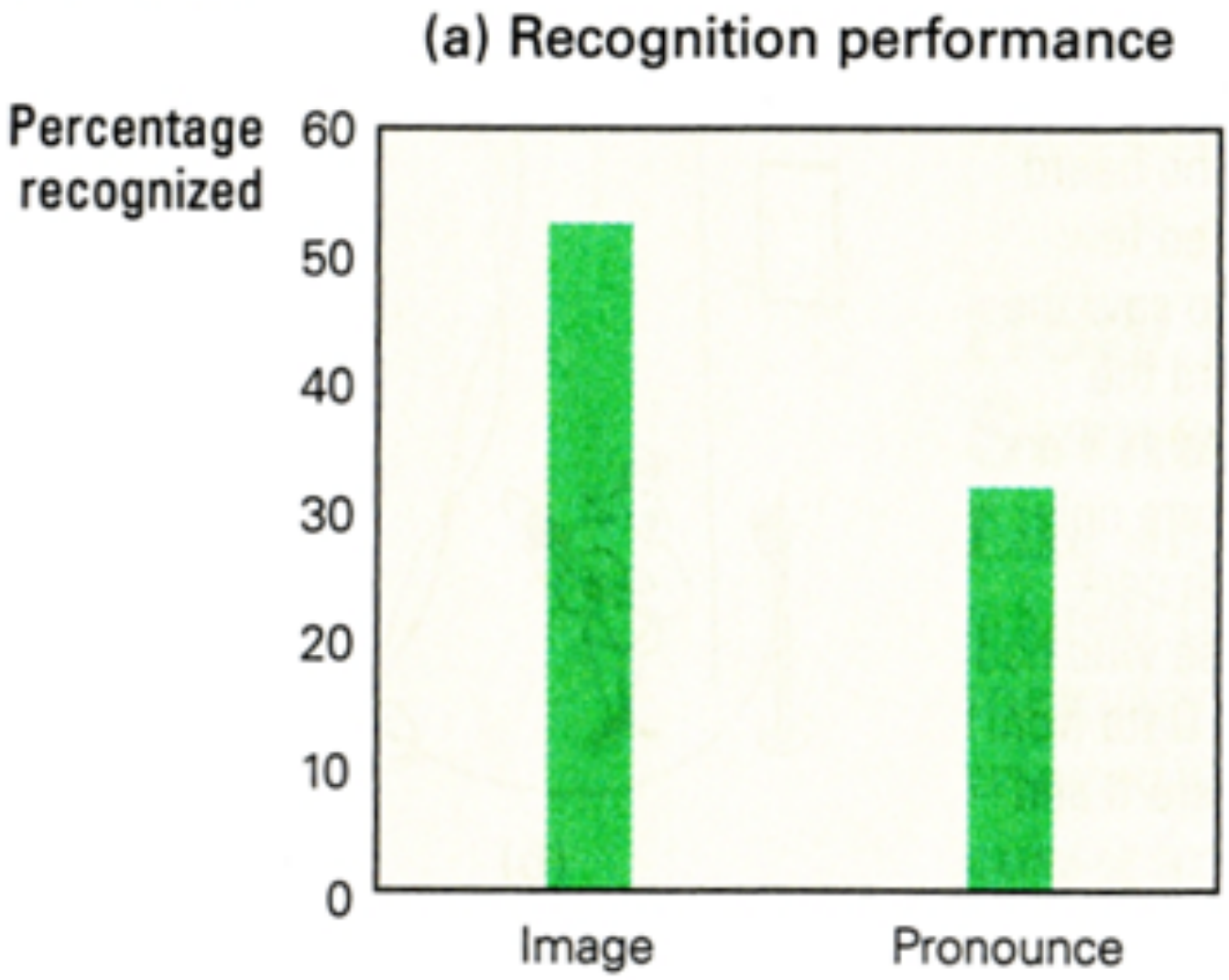


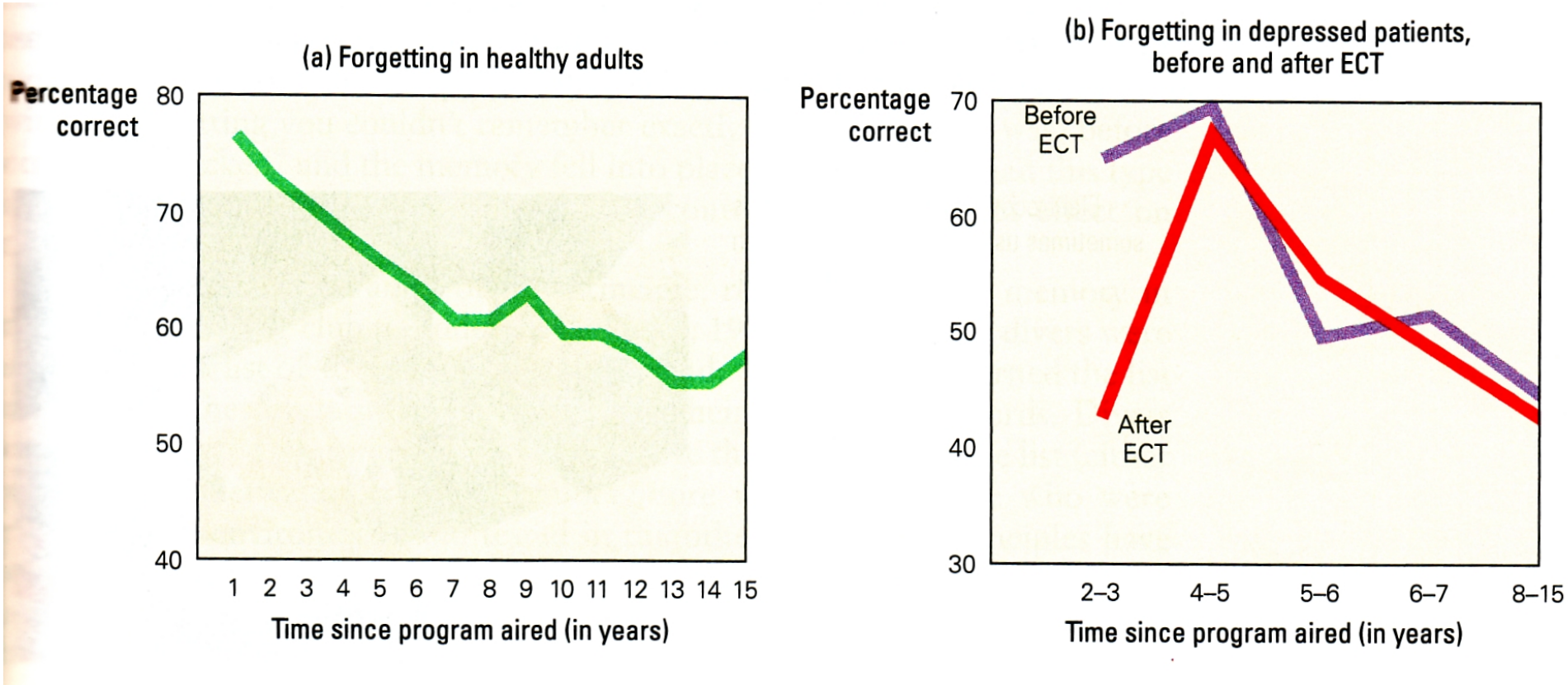
Figure 3.3 The effects of organization on memory An experimenter read aloud to participants a paragraph describing a scene. (a) Participants who heard the paragraph alone recalled few items; but participants who saw the picture in (b) and then heard the paragraph recalled more items. Participants who saw the picture only after hearing the paragraph performed no better than those who had never seen the picture. (a) Data from and (b) adapted from Bransford and Johnson, 1972.

Depth of Processing

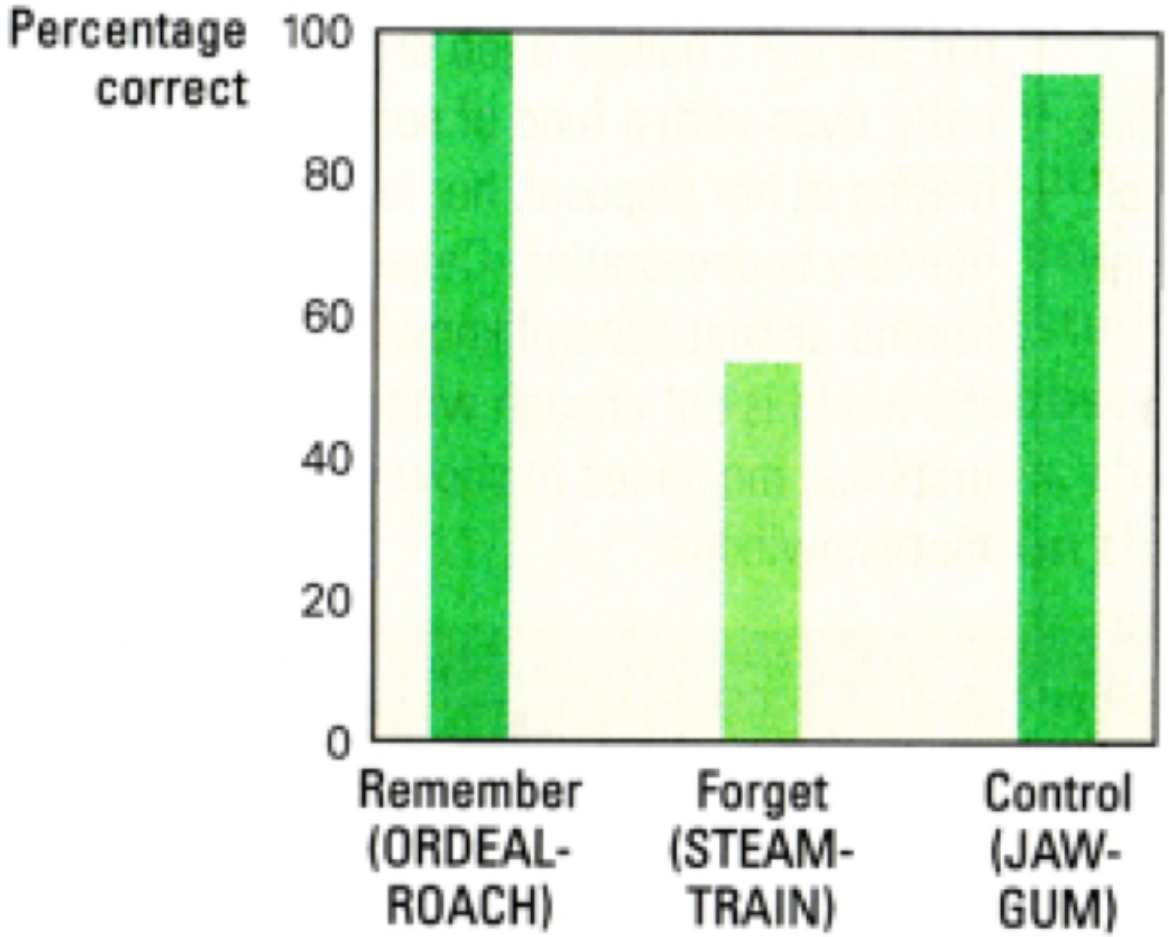


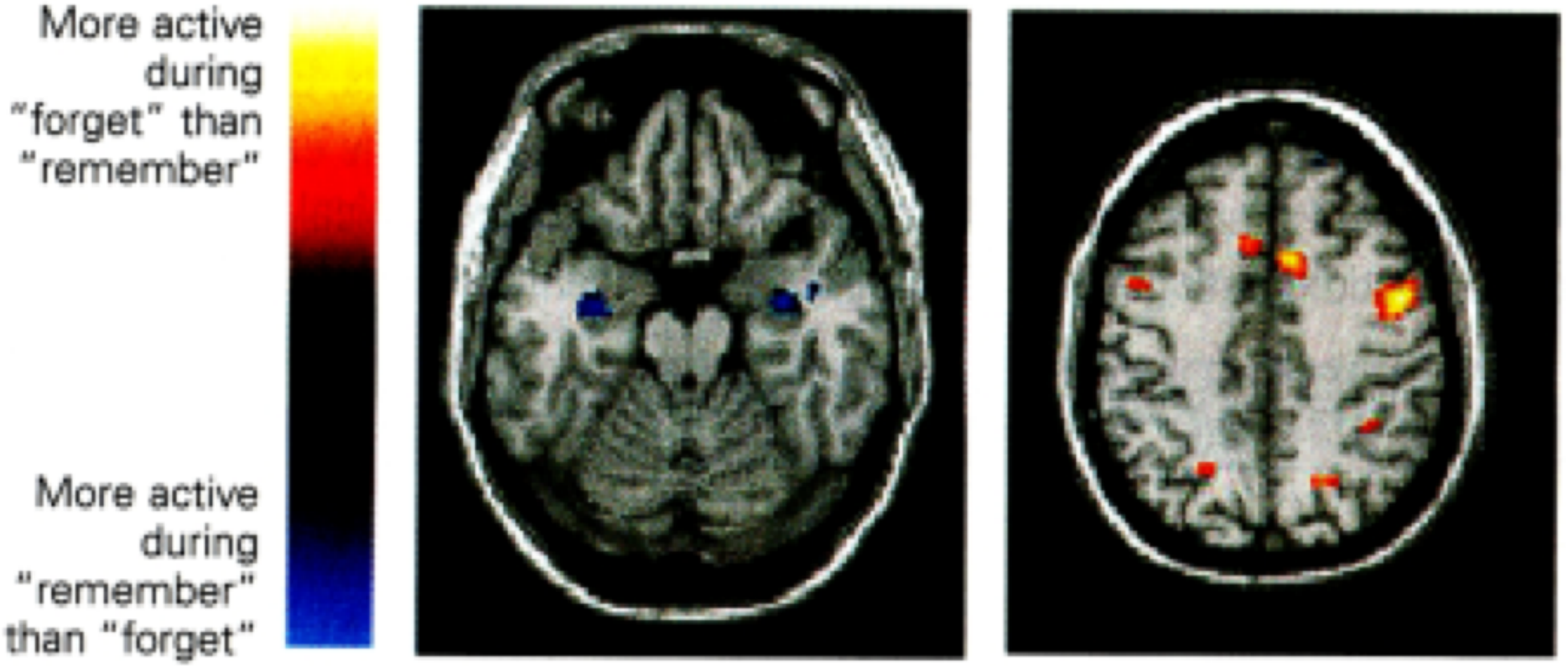
Depth of processing facilitates encoding

Interference during consolidation disrupts memory encoding


(a) Forgetting in healthy adults
Percentage correct
80
70
60
50
40
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Time since program aired (in years)
(b) Forgetting in depressed patients, before and after ECT
Percentage correct
70
60
50
40
30
Before ECT
After ECT
2–3
4–5
5–6
6–7
8–15
Time since program aired (in years)

Memory Loss and Deficits


Percentage correct
100
80
60
40
20
0
Remember (ORDEAL-ROACH)
Forget (STEAM-TRAIN)
Control (JAW-GUM)


More active during "forget" than "remember"
More active during "remember" than "forget"

Interference

Proactive

Previously acquired information interferes with new learning

Retroactive

Acquisition of new information disrupts old memories

Amnesia

Anterograde

- Inability to form new memories

Retrograde

- Loss of old memories

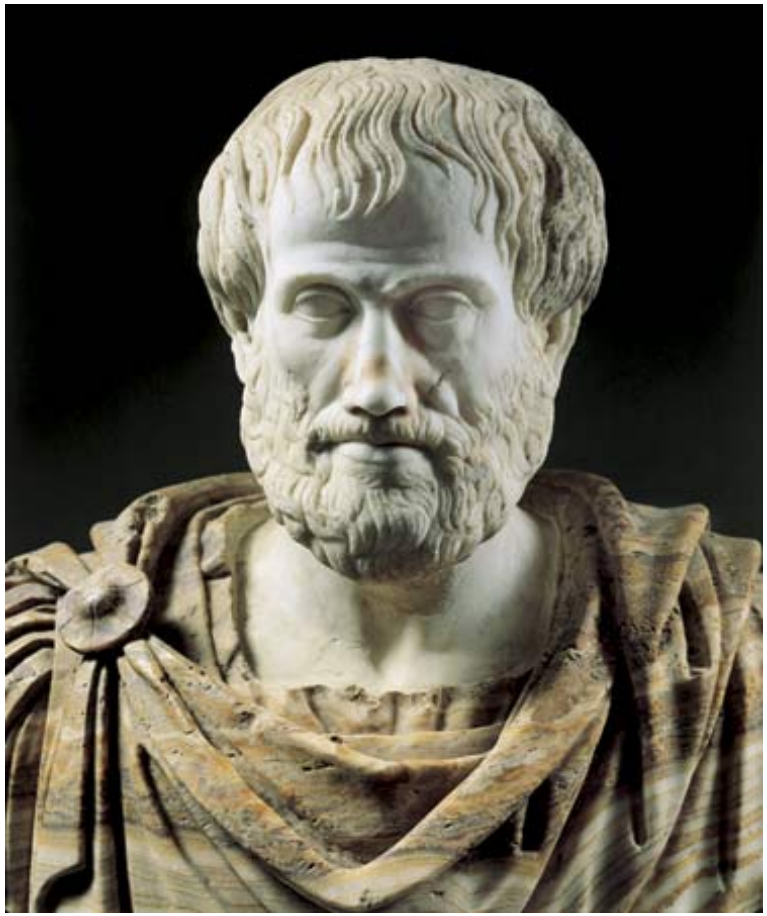
Source Amnesia

- Remembering the photograph, not the event

Cryptomnesia – the plagiarists excuse

- thinking your current thoughts and ideas are original

Models for episodic and semantic memory



Aristotle

Associationism

- Linkages between events or ideas

Three Principles

- Contiguity
- Frequency
- Similarity

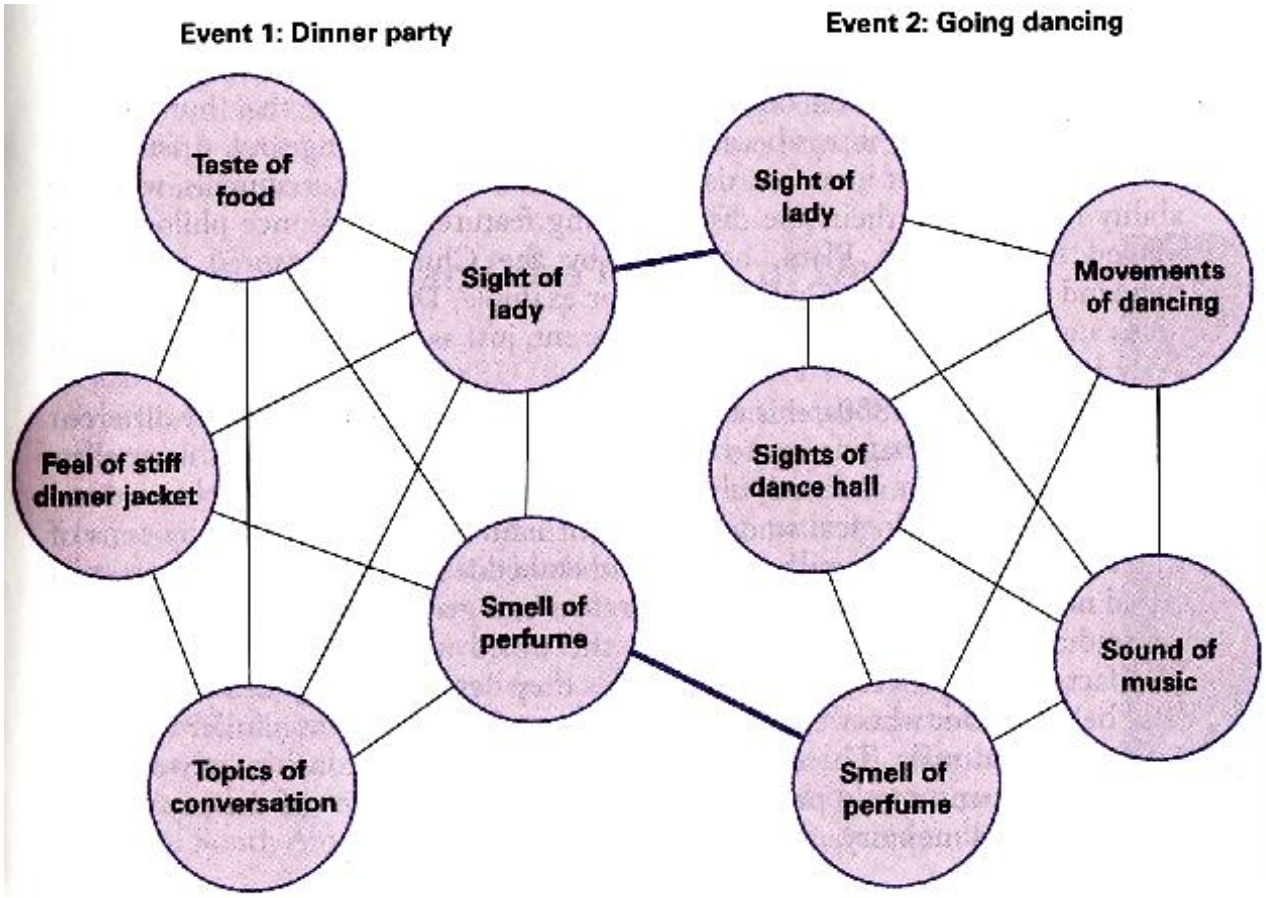


Figure 1.2 William James's memory model
Memory of an event, such as a dinner party, has multiple components, such as the taste of the food, the topics of conversation, and the smell of perfume, all linked together. Another event, such as going dancing with a lady from the dinner party, also has component parts linked together. An association between the two events in turn consists of multiple connections between the underlying components.

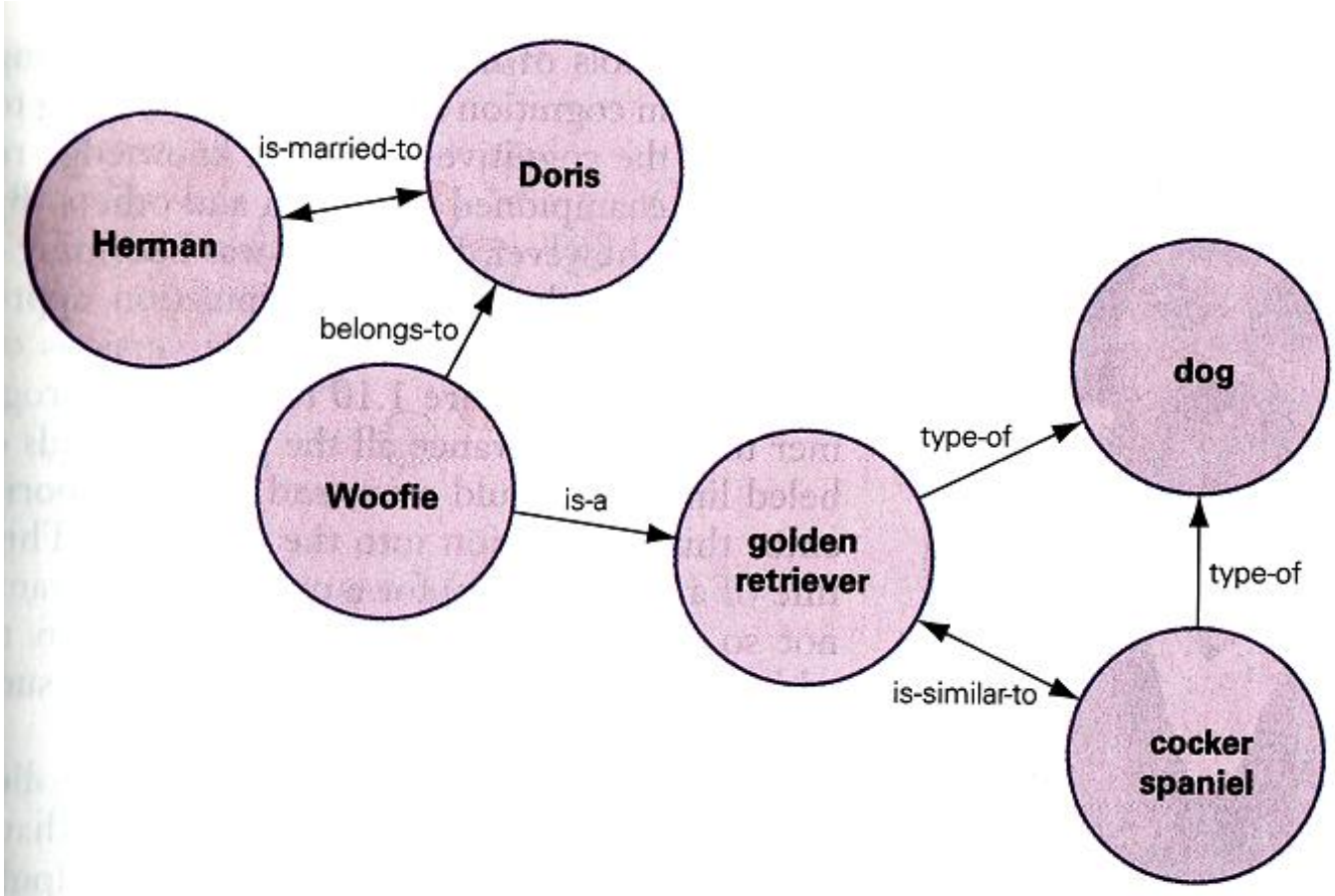
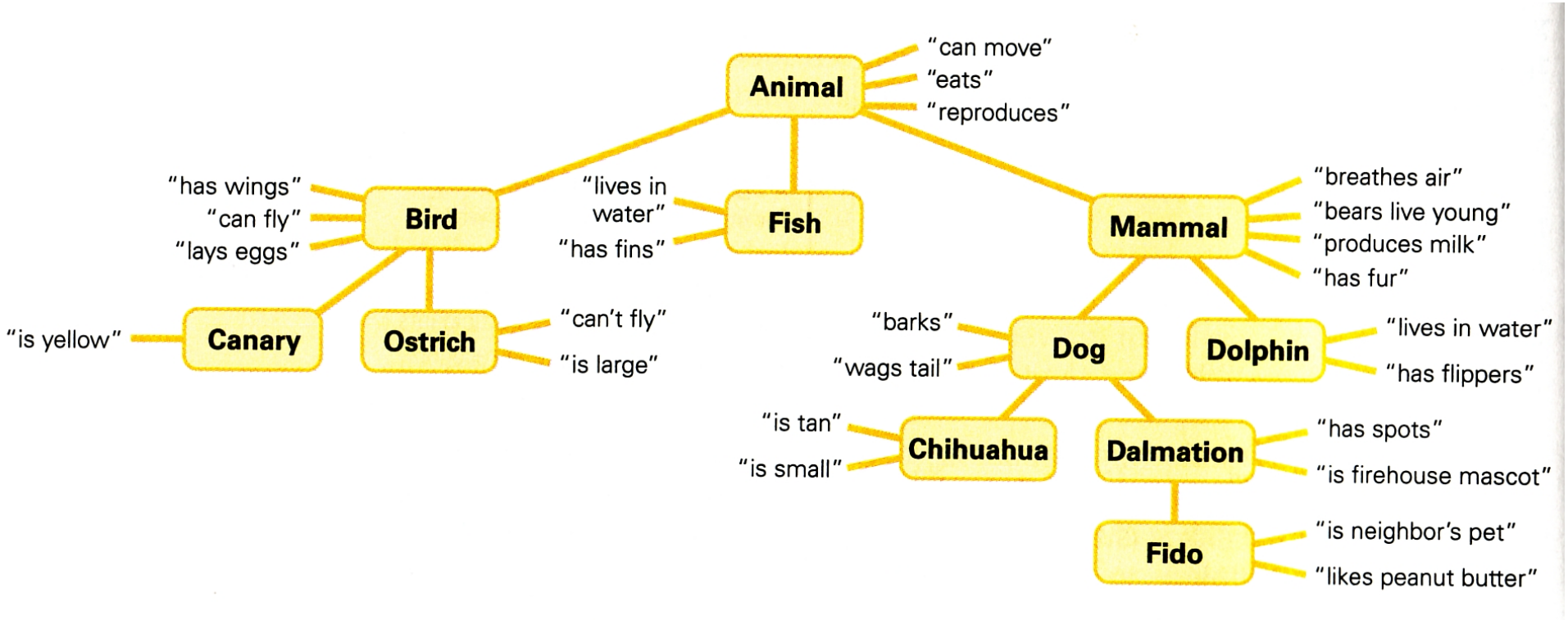


Figure 1.10 A symbol-manipulation model of memory Symbols, shown here as circles, represent different animals, objects, and people. Associations between symbols are encoded as labeled lines that specify certain relationships, such as "is-a," "is-similar-to," and "belongs-to."


Animal
"can move"
"eats"
"reproduces"
Bird
"has wings"
"can fly"
"lays eggs"
Fish
"lives in water"
"has fins"
Mammal
"breathes air"
"bears live young"
"produces milk"
"has fur"
Canary
"is yellow"
Ostrich
"can't fly"
"is large"
Dog
"barks"
"wags tail"
Dolphin
"lives in water"
"has flippers"
Chihuahua
"is tan"
"is small"
Dalmation
"has spots"
"is firehouse mascot"
Fido
"is neighbor's pet"
"likes peanut butter"

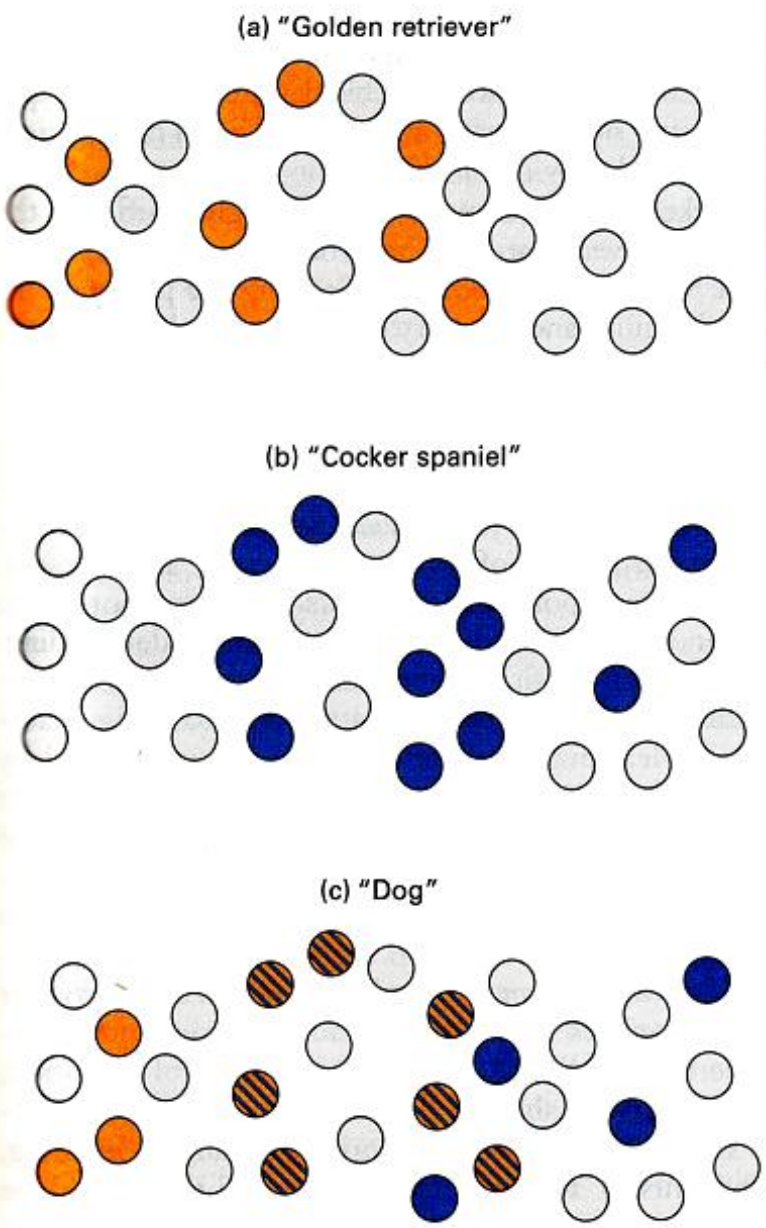
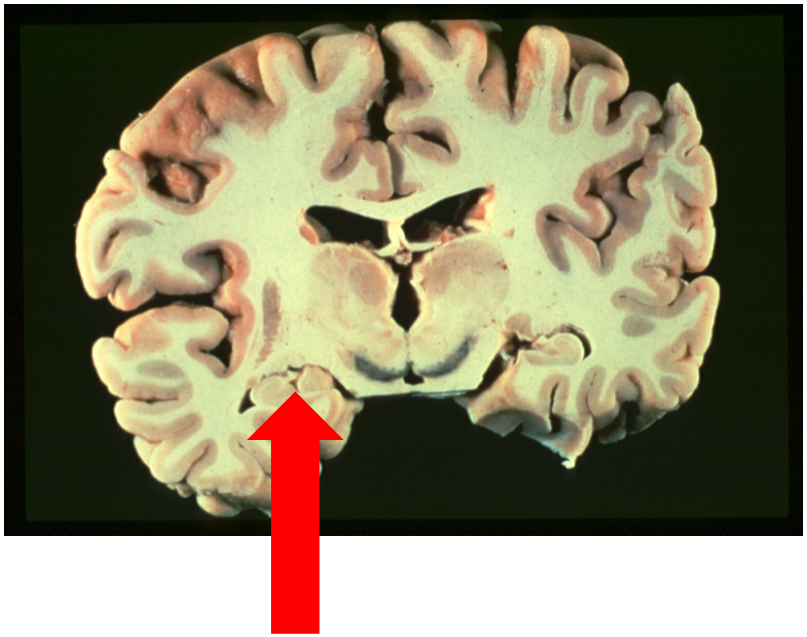
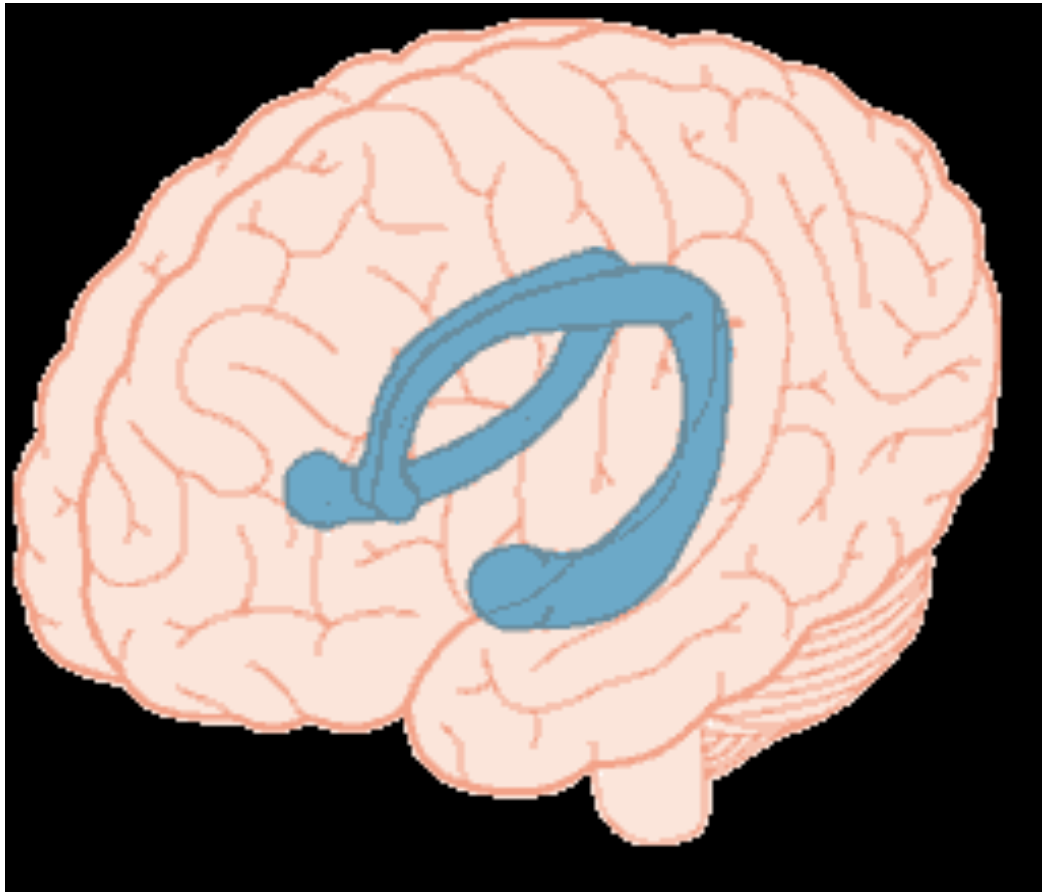
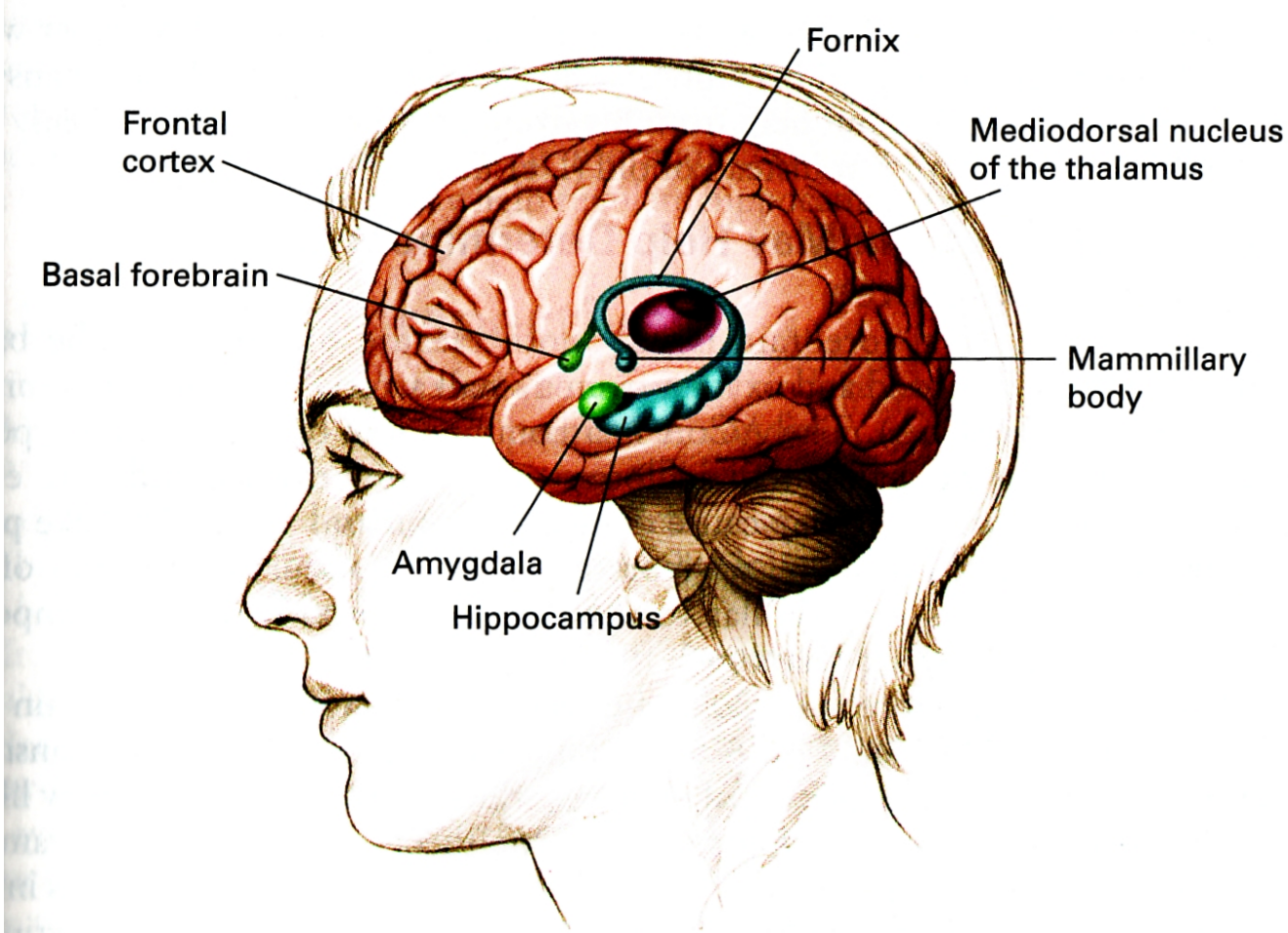


Figure 1.11 Distributed representations (a) The representation of "golden retriever" activates one subset of nodes, shown in yellow. (b) "Cocker spaniel" activates a different subset, shown in blue. (c) The similarity between them—both are dogs—emerges naturally as a function of the overlap between representations, shown by the yellow-and-blue nodes.

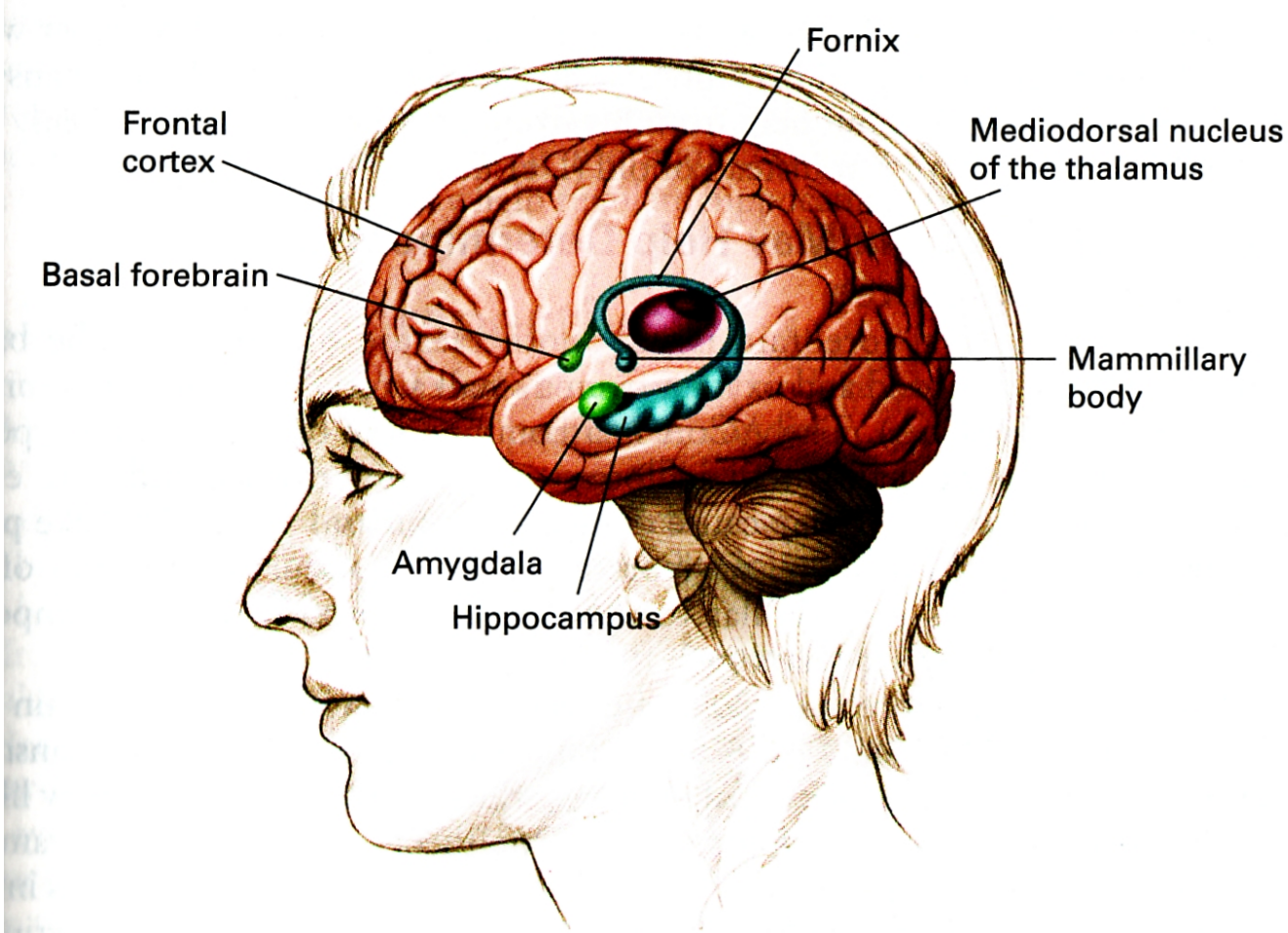
Neuroanatomy of Semantic and Episodic Memories



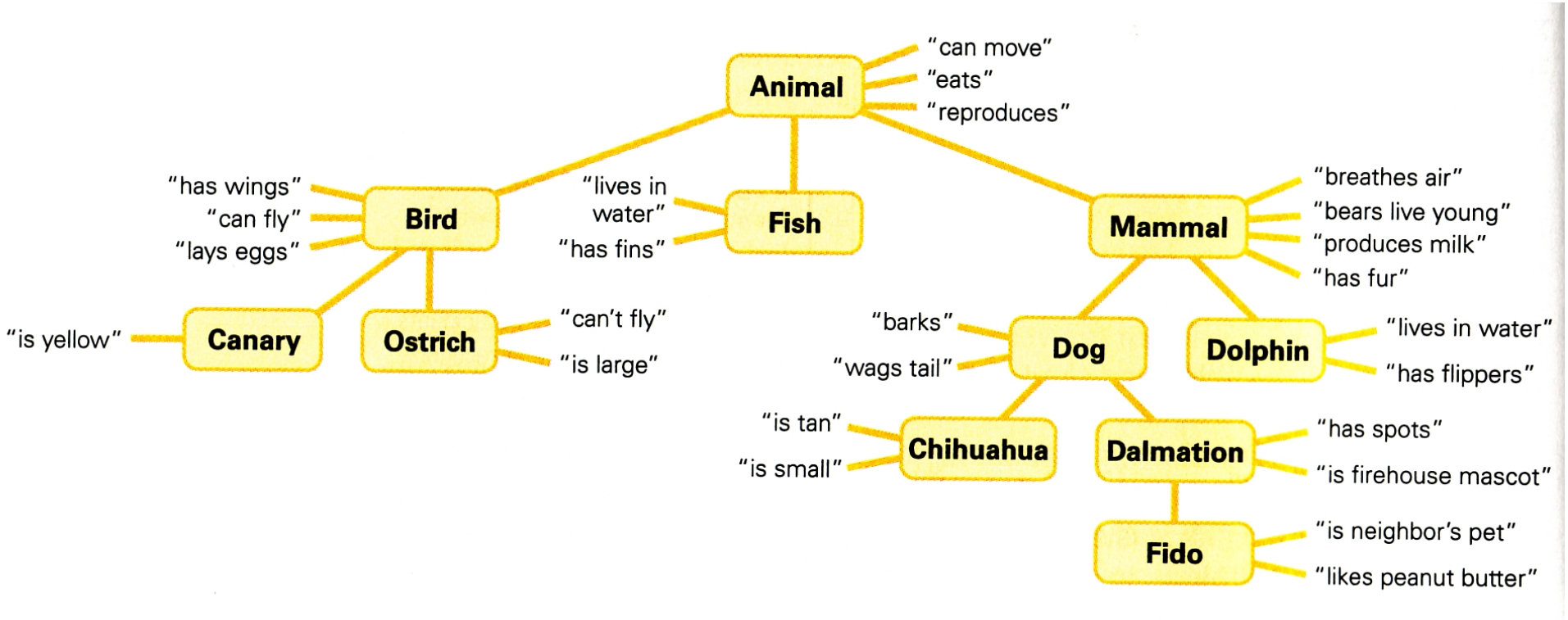




Basal Forebrain: signals that new information needs to be encoded



Hippocampus helps make links between information and encode new information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Mammal
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"produces milk"
"has fur"
Canary
"is yellow"
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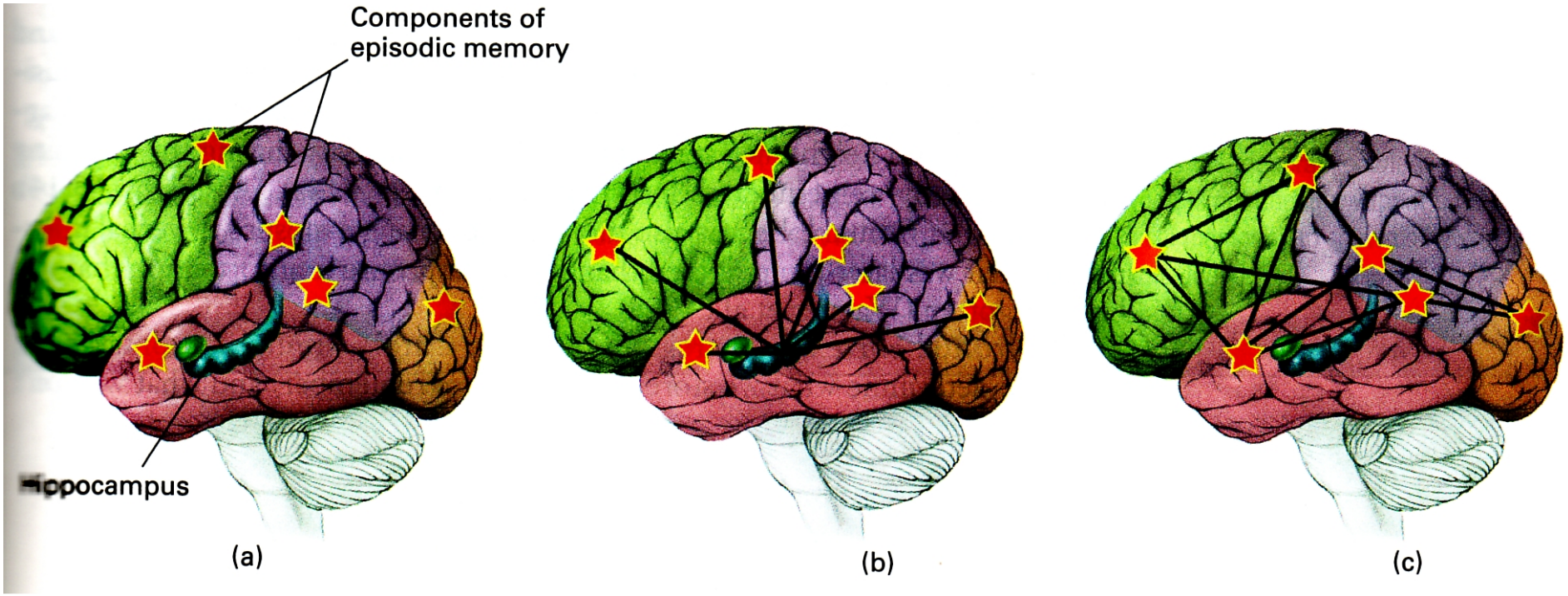
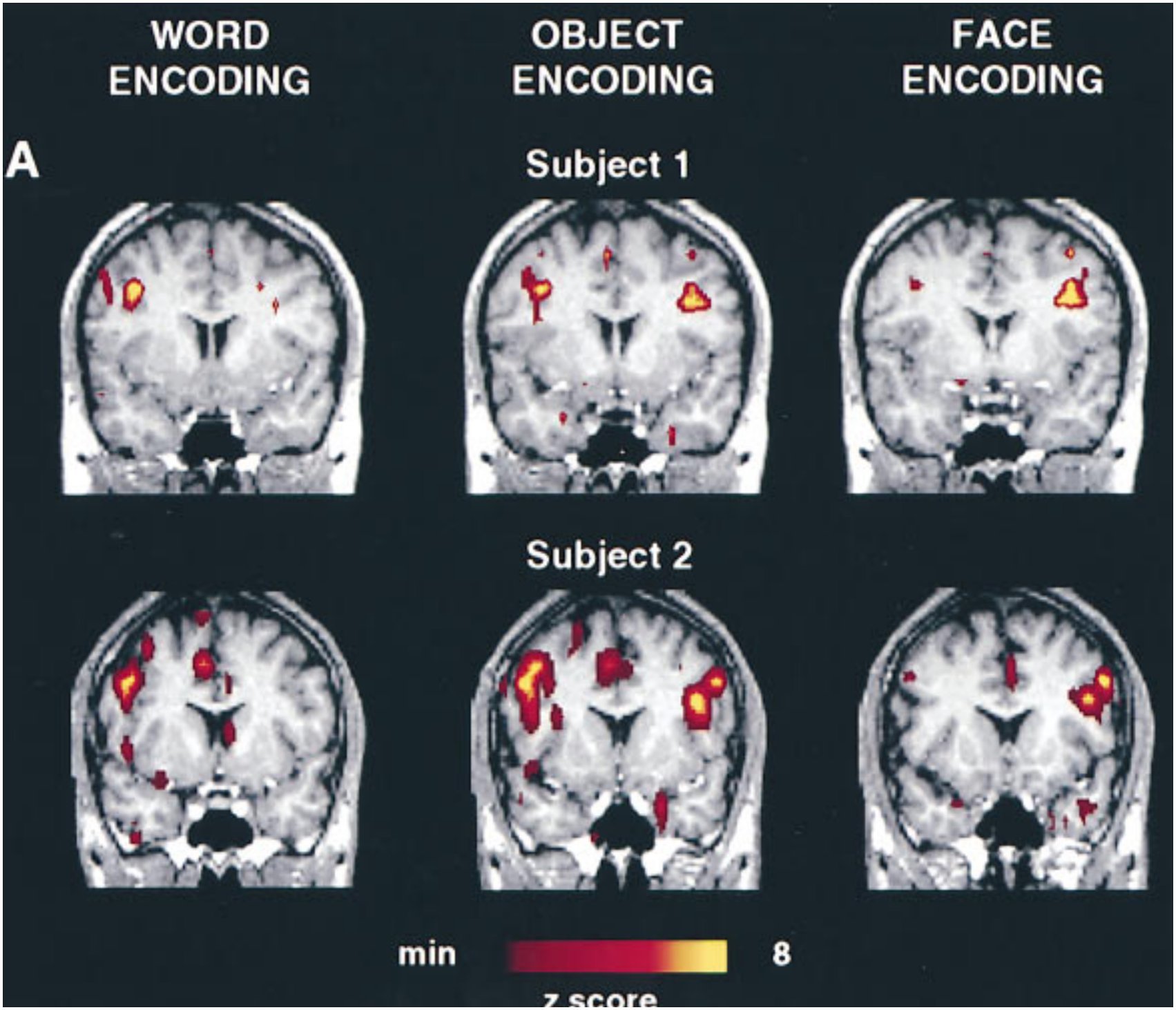
"can't fly"
"is large"
Dog
"barks"
"wags tail"
Dolphin
"lives in water"
"has flippers"
Chihuahua
"is tan"
"is small"
Dalmation
"has spots"
"is firehouse mascot"
Fido
"is neighbor's pet"
"likes peanut butter"

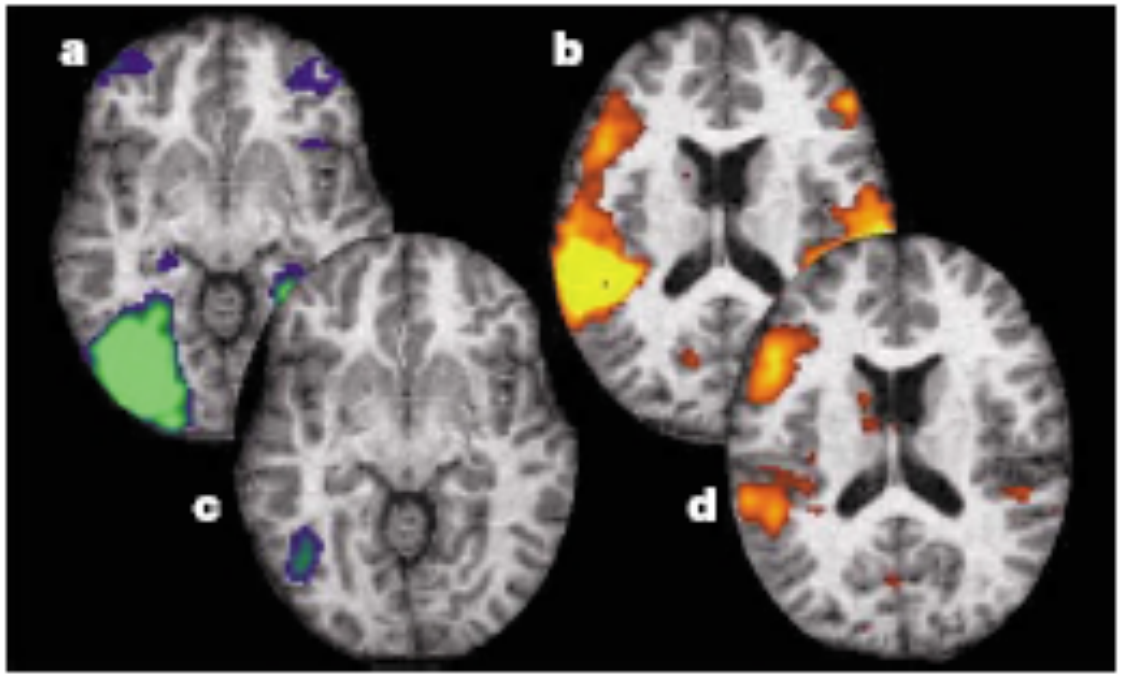

Components of
episodic memory
Hippocampus
(a)
(b)
(c)

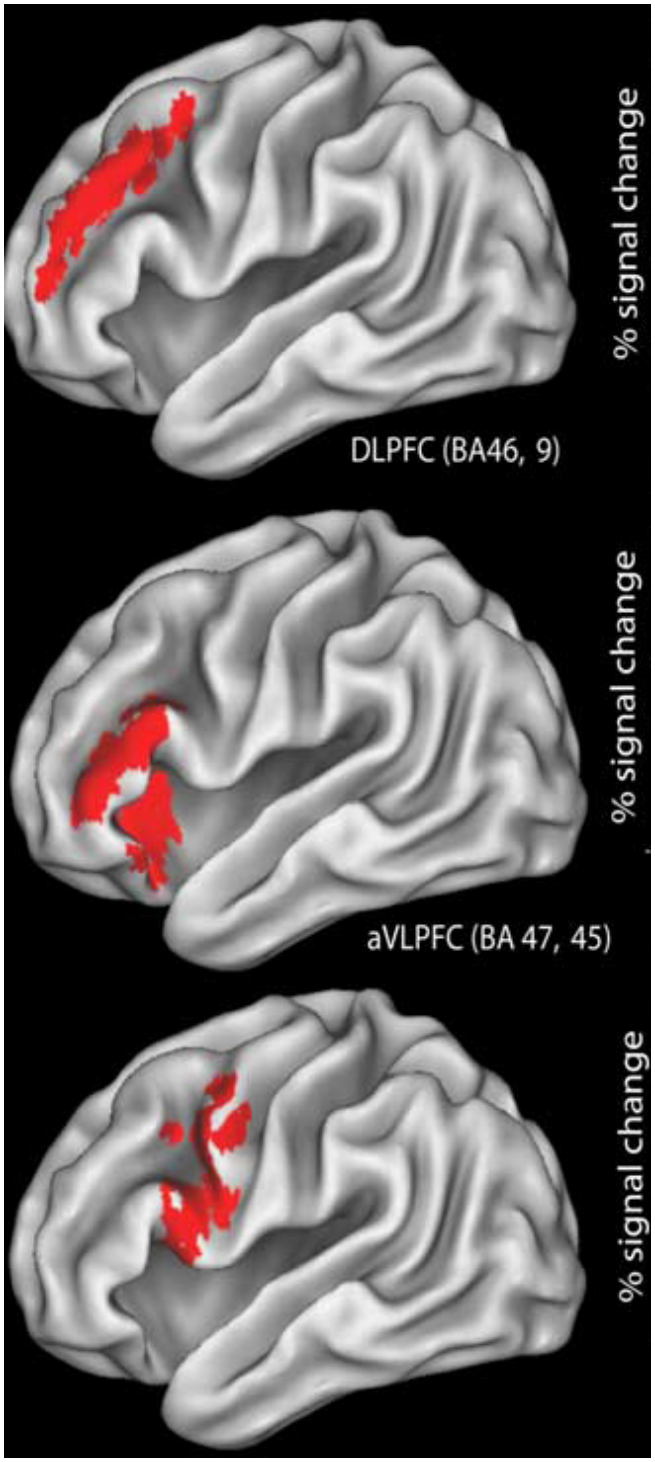

WORD ENCODING
OBJECT ENCODING
FACE ENCODING
A
Subject 1
Subject 2
min
8
z score

Pictures Sounds

Perception

Recall





Relationships btw Episodic Memory Items

Encoding of Individual Items

Problems with traditional memory theory...

Representations

Categorization

Representation

A physical state that stands for an object, event, or concept

Representations

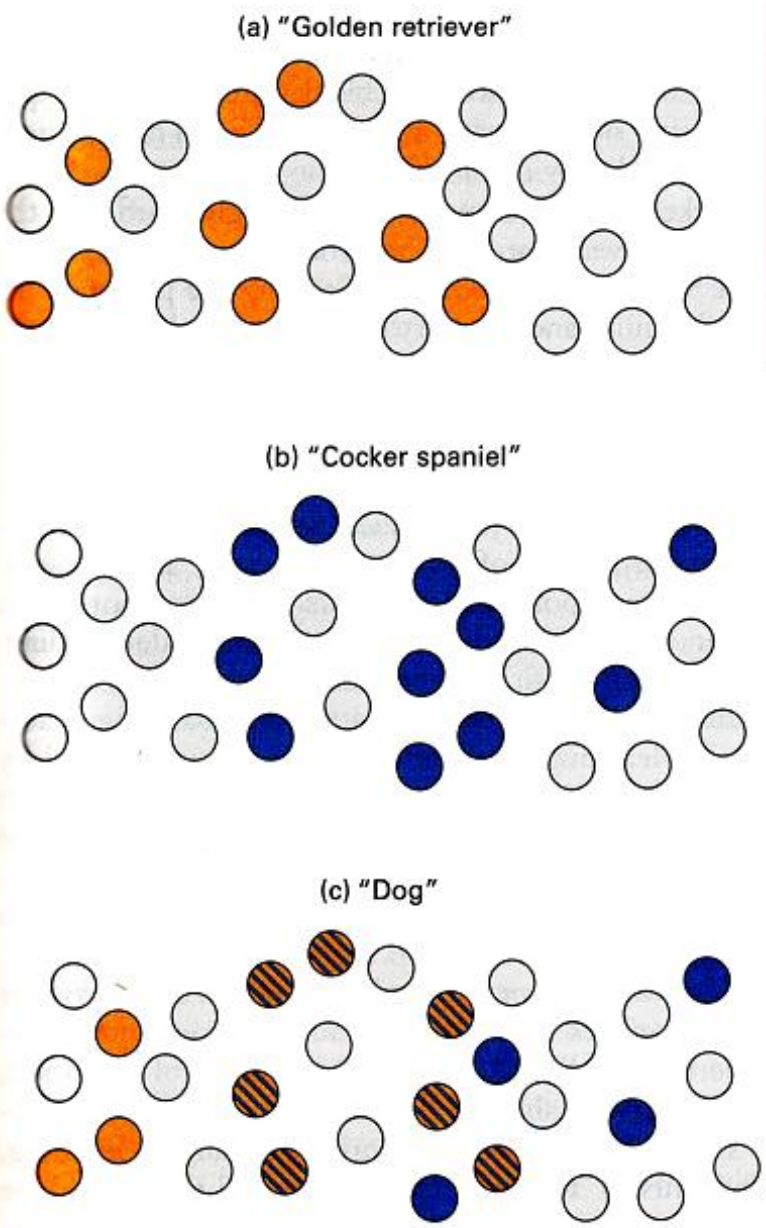
The intentionality criterion

The representation must be constructed intentionally to stand for something else

(even when not done intentionally)

The information carrying criterion

The representation must carry information about what it stands for



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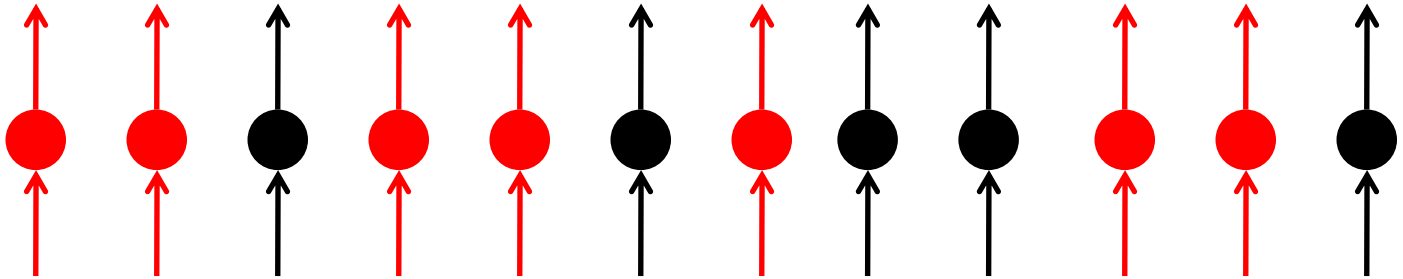
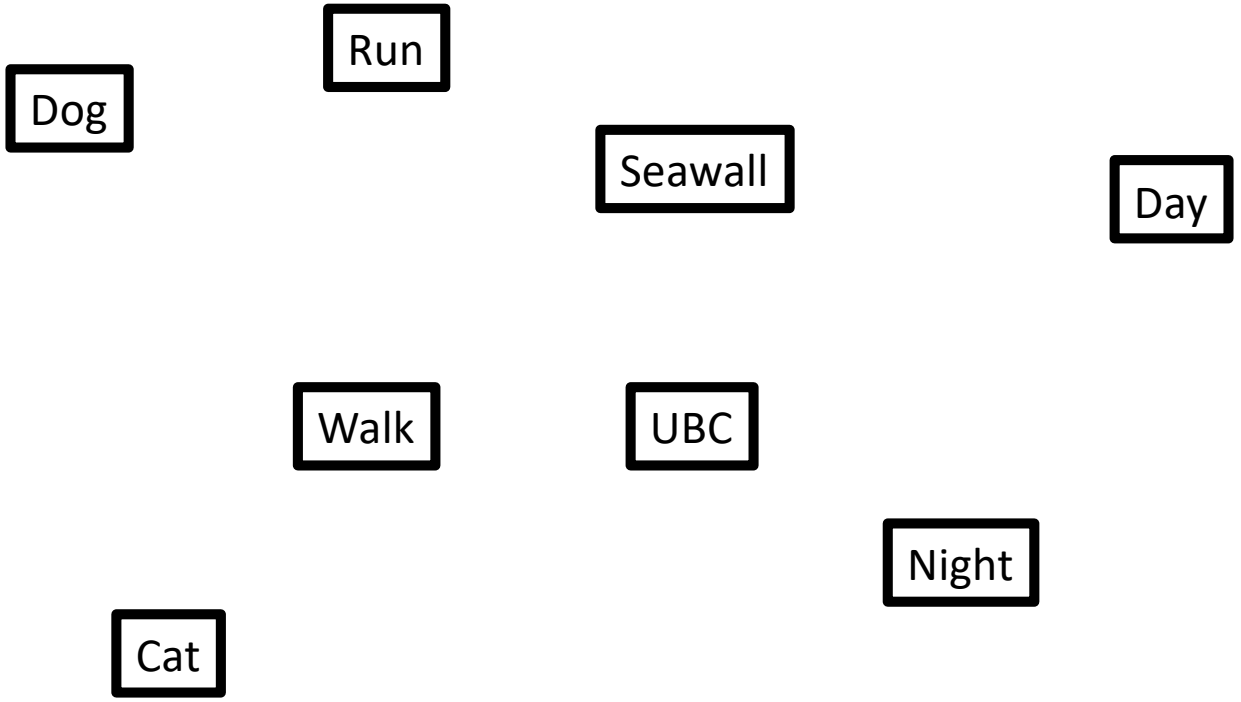
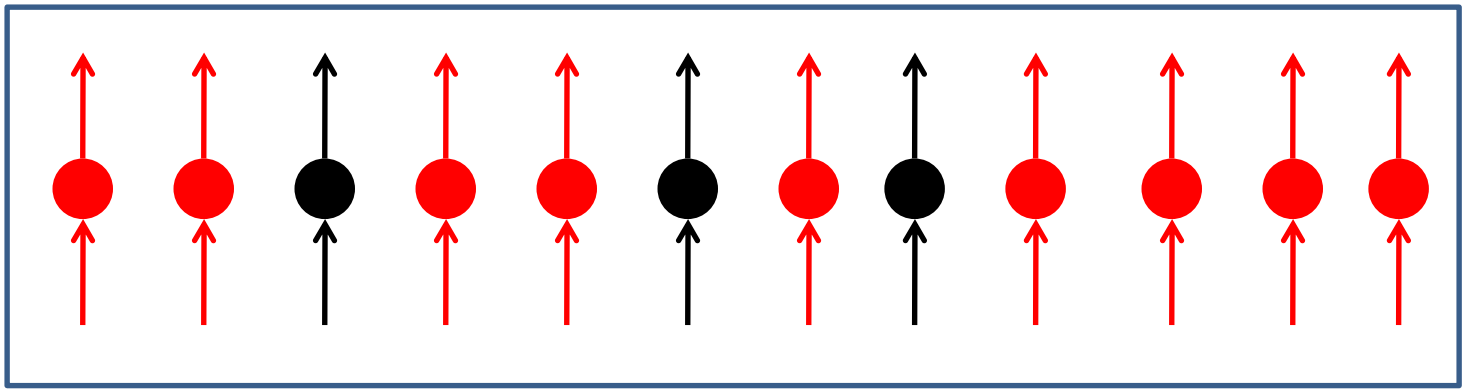


Representations and Episodic Memories





Dog

Run

Seawall

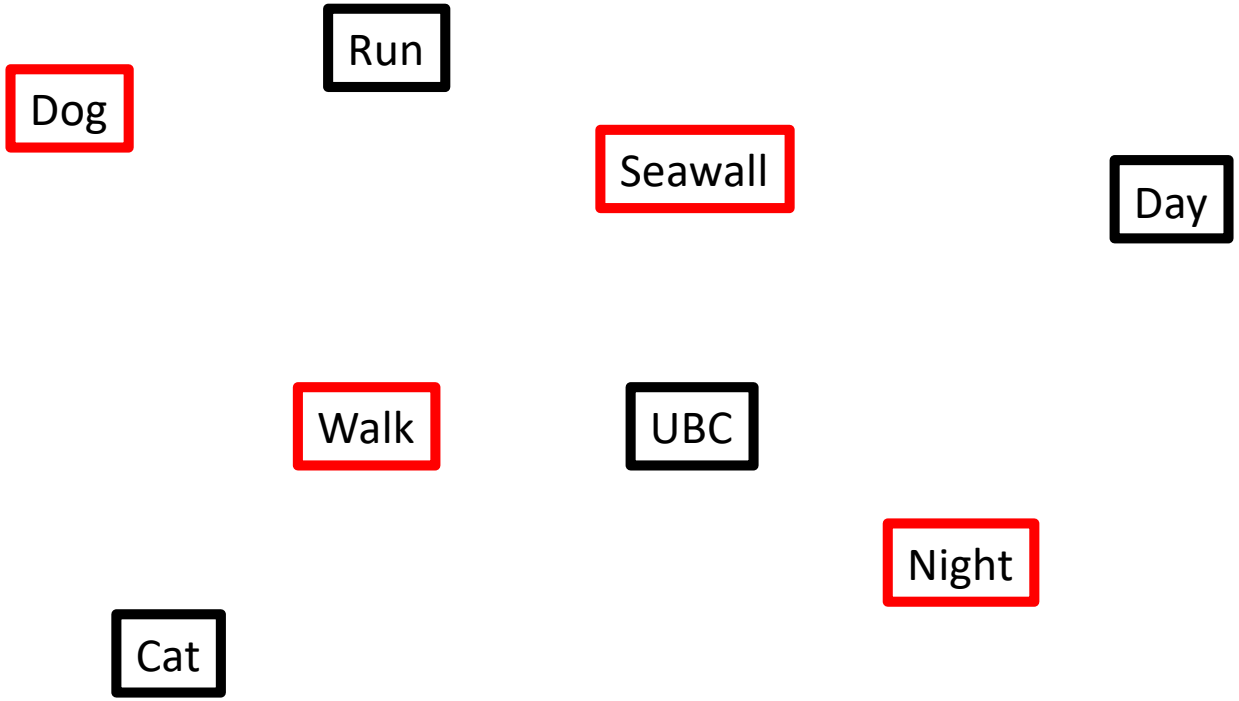
Day

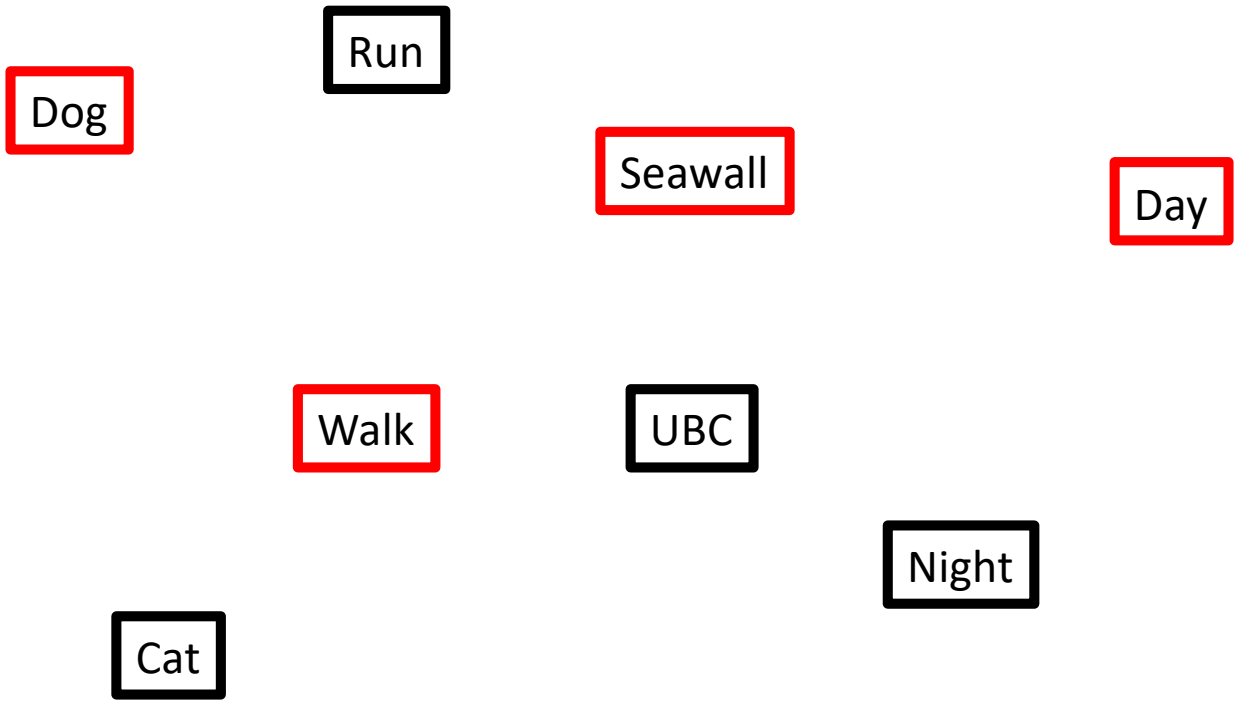
Walk

UBC

Night

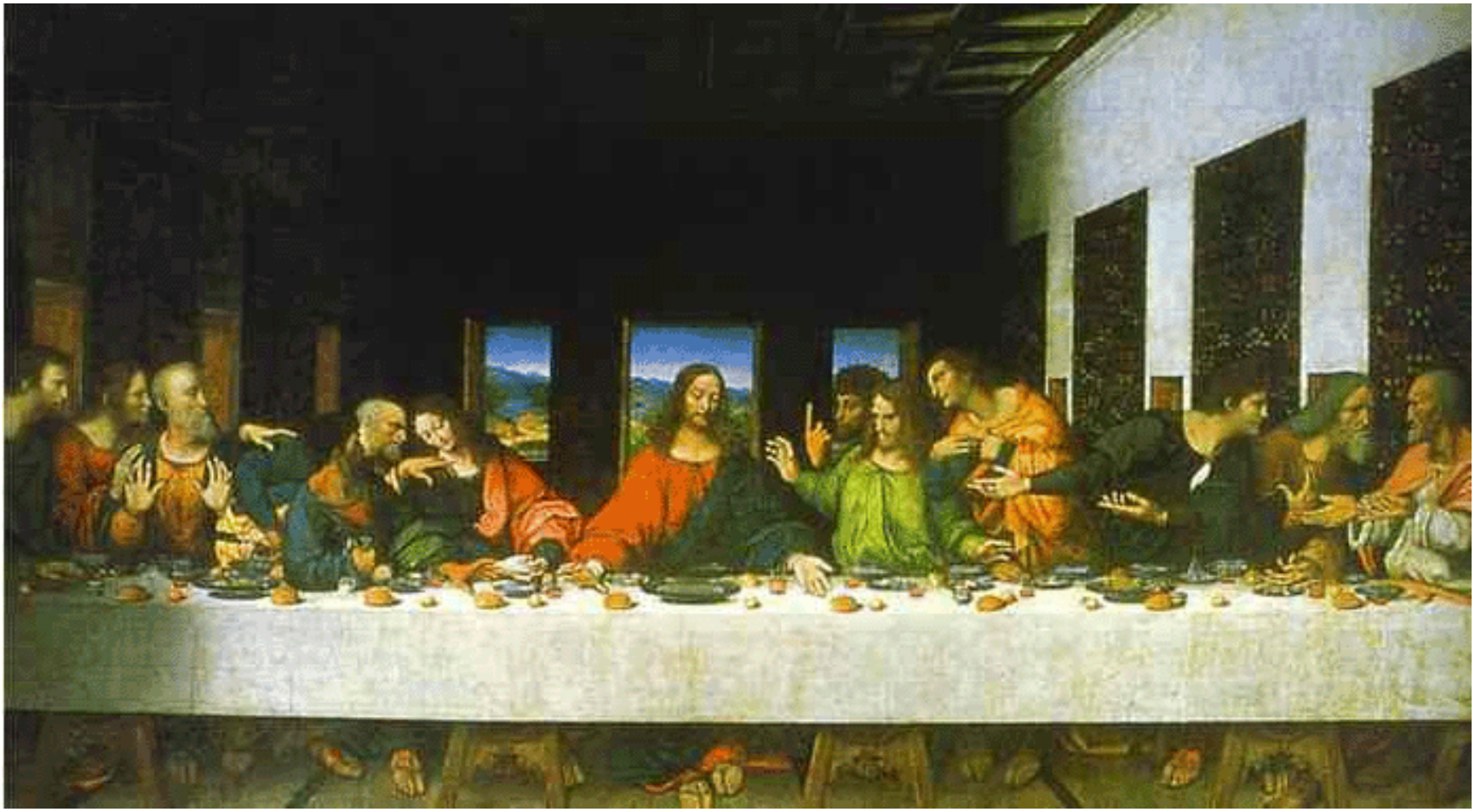
Cat


Run
Dog
Seawall
Day
Walk
UBC
Night
Cat

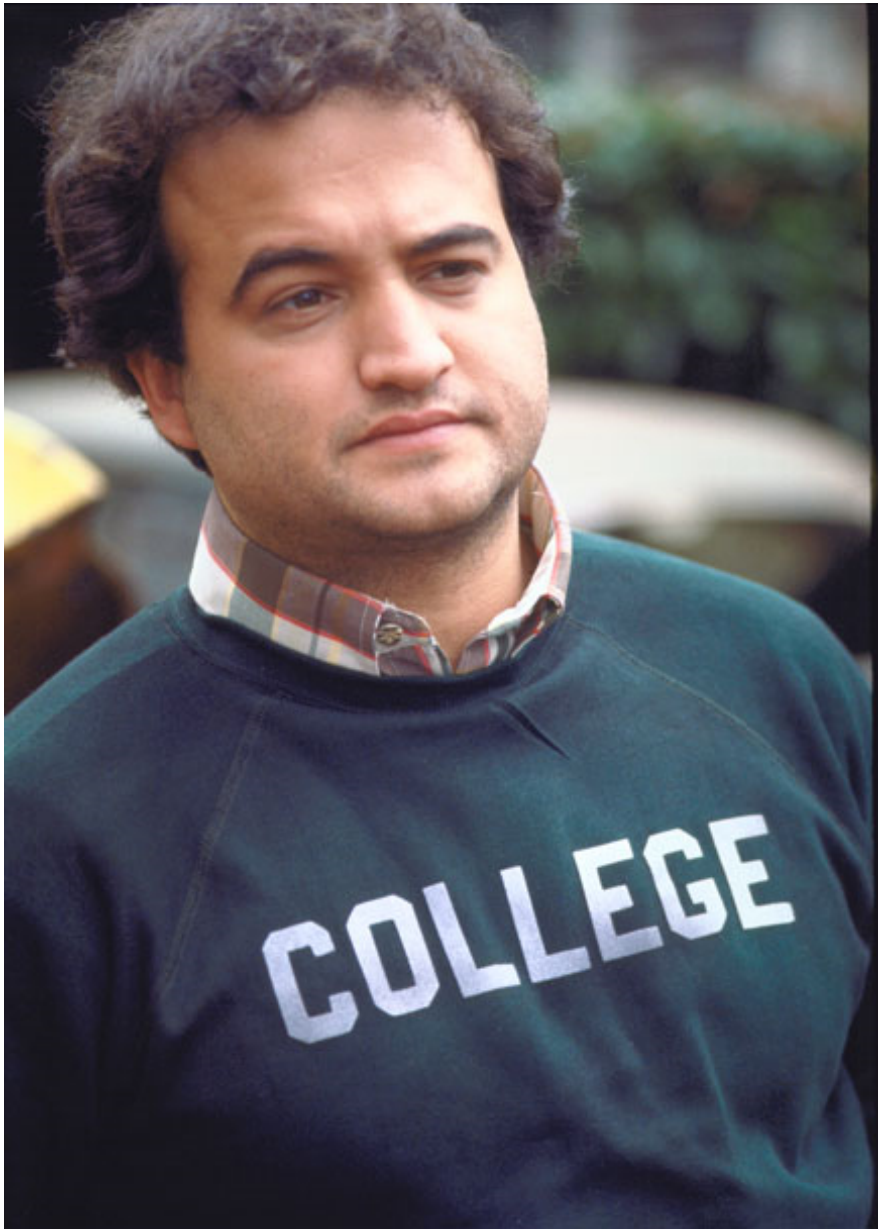

Run
Dog
Seawall
Day
Walk
UBC
Night
Cat

Emotional Memories

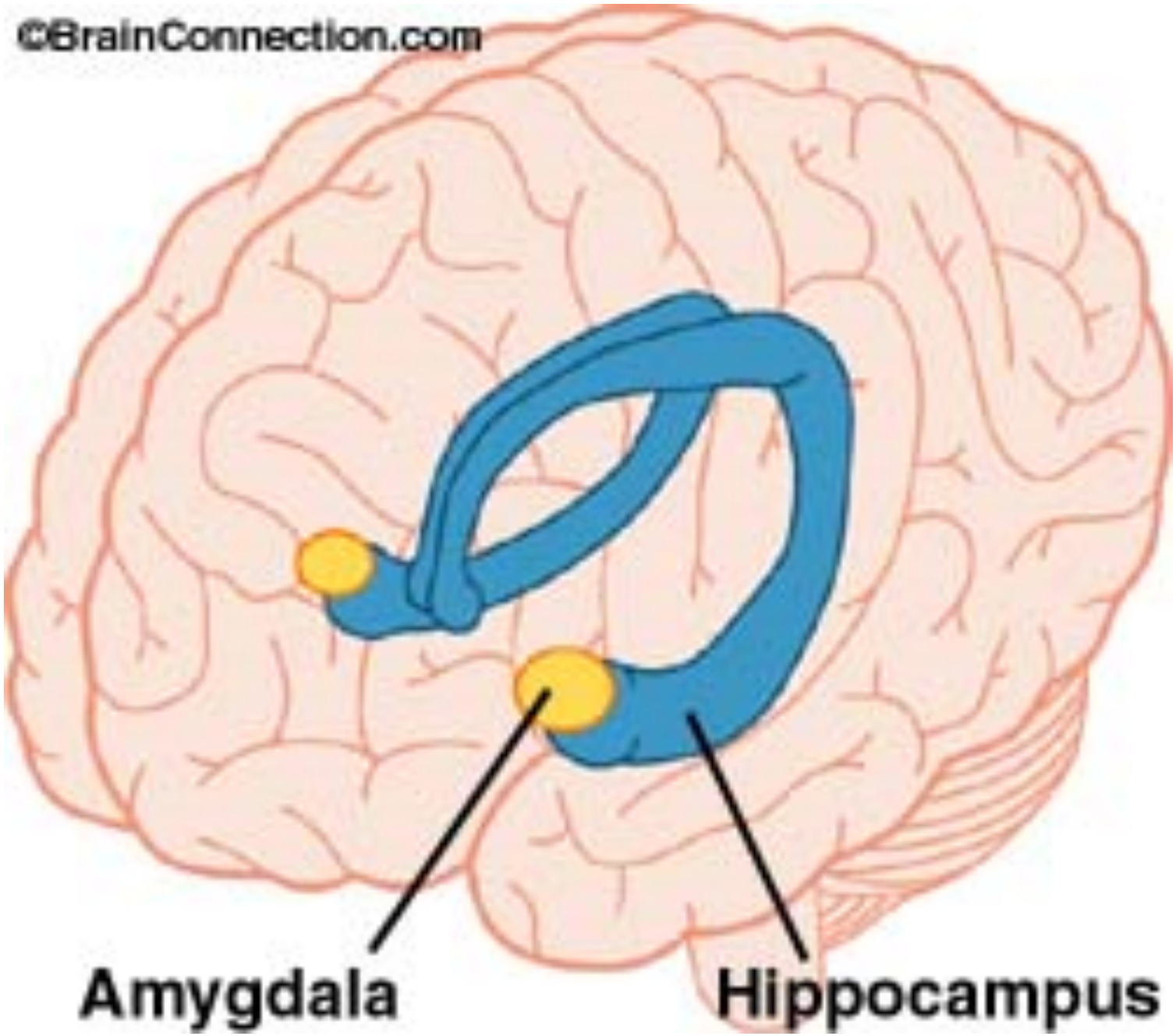
What is emotion?

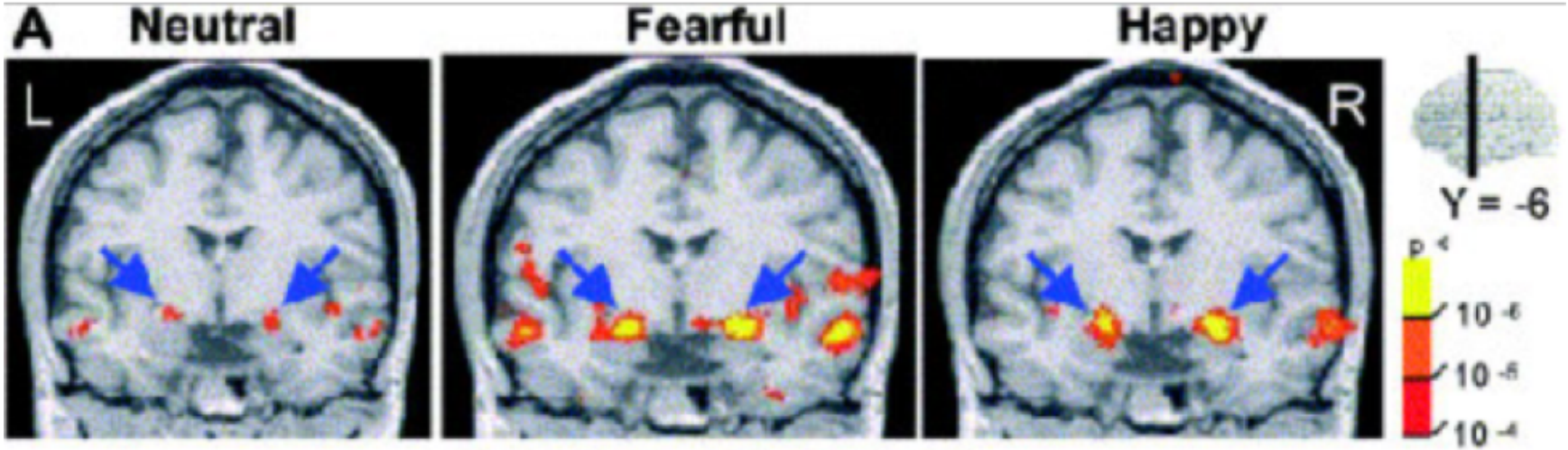


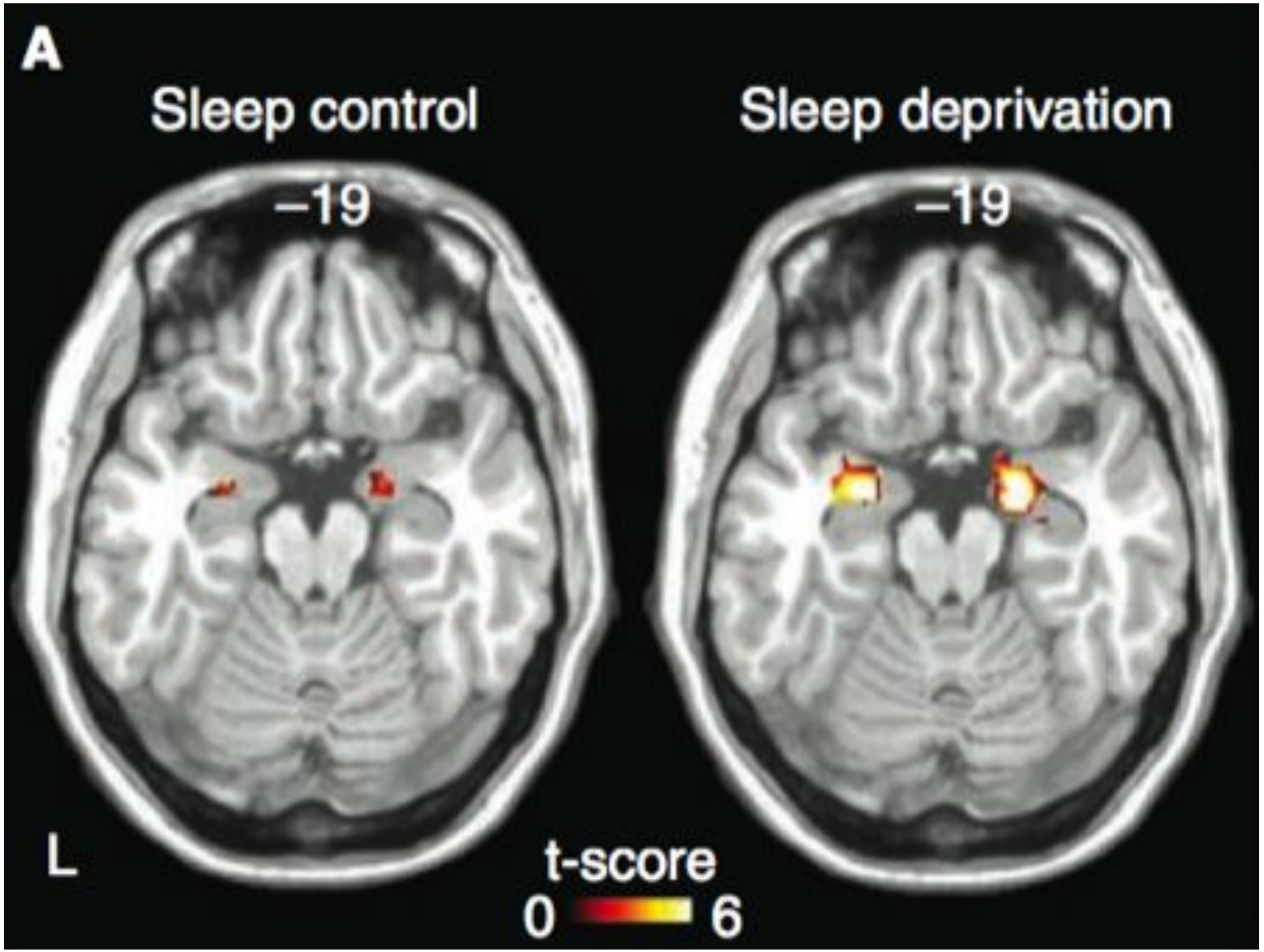

TO ME, YOU
PERFECT


COLLEGE


Little tikes


©BrainConnection.com
Amygdala
Hippocampus


A
Neutral
Fearful
Happy
L
R
Y = -6
p <
10 -6
10 -5
10 -4


A
Sleep control
Sleep deprivation
−19
−19
L
t-score
0
6

What are the five most prominent memories in your life?

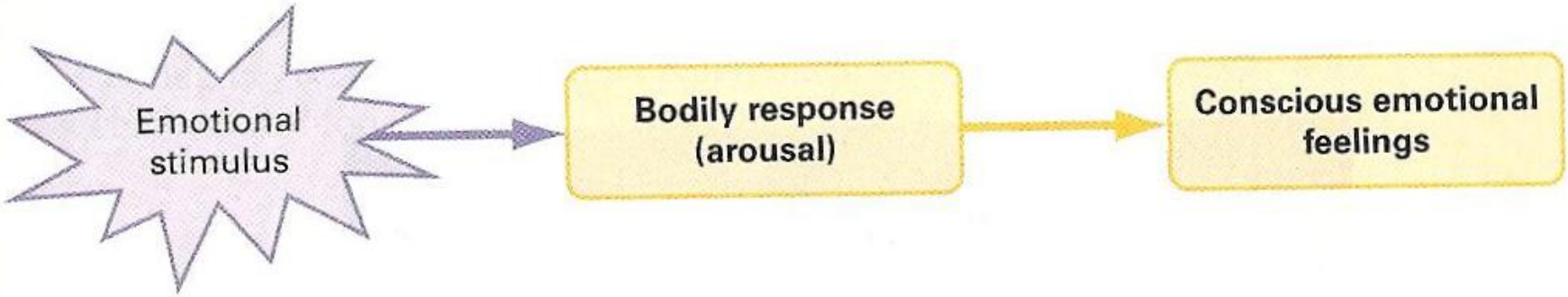
What is an emotion?

Table 10.1

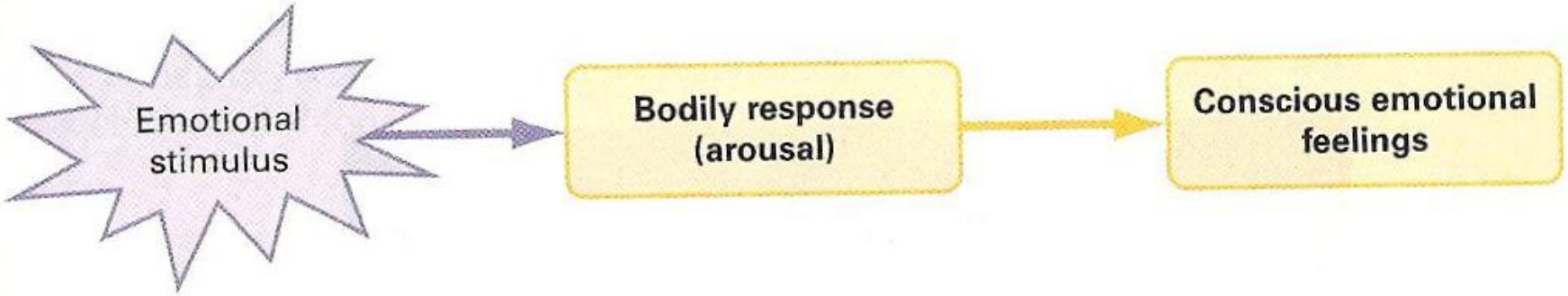
The Fight-or-Flight Response

Increases in:	Energy diverted to:	Energy diverted from:
▪ Respiration ▪ Blood pressure and heart rate ▪ Blood glucose level ▪ Release of stress hormones	▪ Large muscles in legs and arms ▪ Pain suppression ▪ Reflexes ▪ Perception and awareness (e.g., pupils dilate)	▪ Digestion ▪ Reproduction ▪ Immune system ▪ Sensation (e.g., touch receptors in the skin)

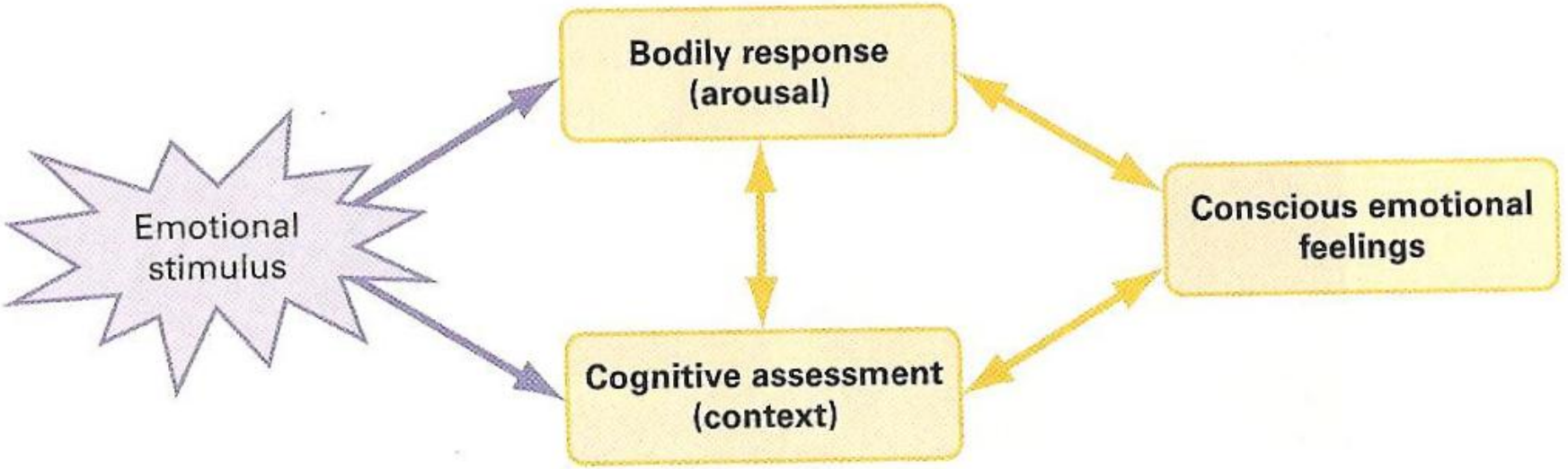
(a) James-Lange theory

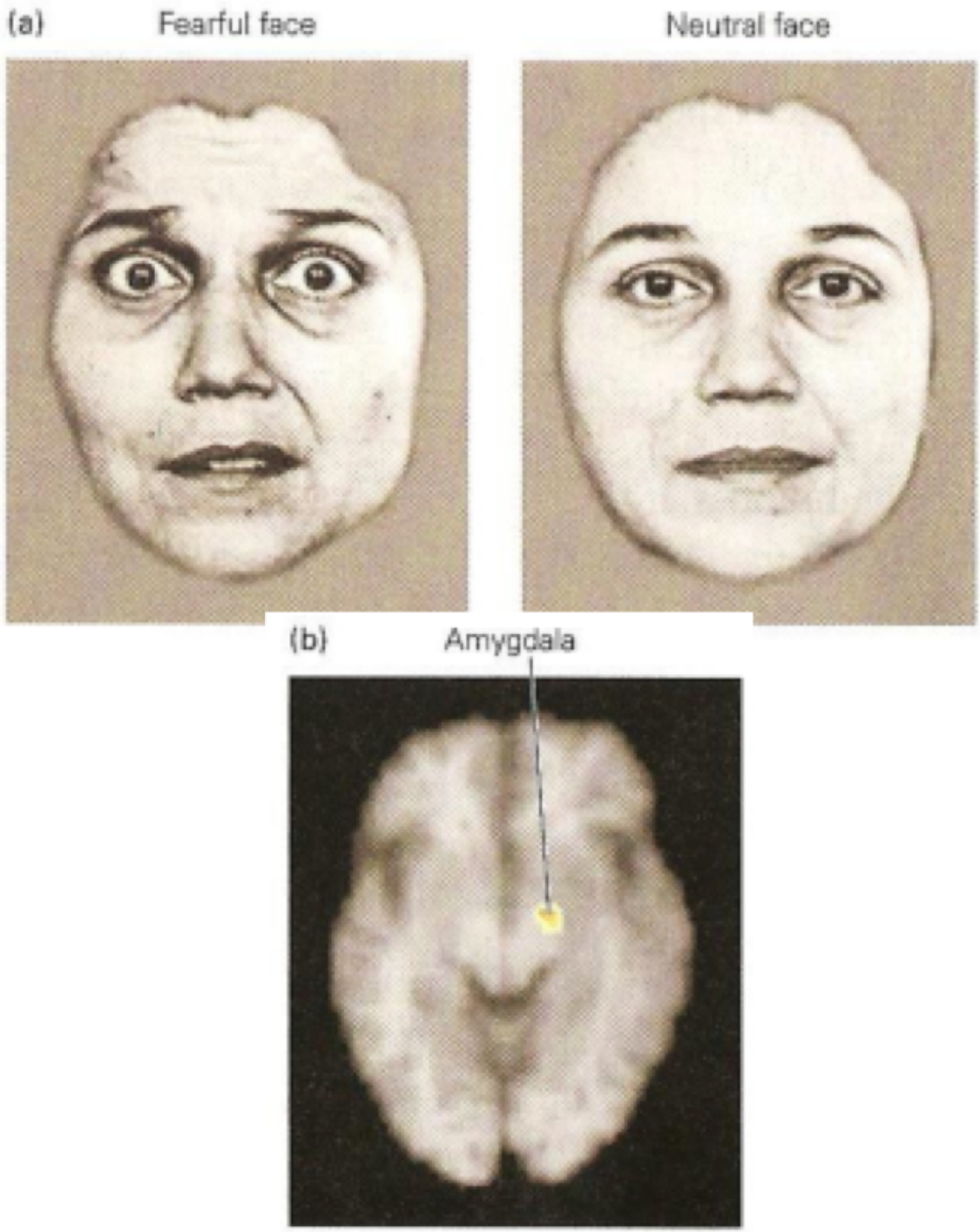


(a) **James-Lange theory**



(b) **Modern emotional theory**




(a)
Fearful face
Neutral face
(b)
Amygdala

1. A mother and her son are leaving home in the morning.

2. She is taking him to visit his father's workplace.

3. The father is the chief laboratory technician at a nearby hospital.

4. They check before crossing a busy road.

5. While crossing the road, the boy is struck by a runaway car, which critically injures him.

5. While walking along, they pass the scene of a minor accident, which the boy finds interesting.

6. At the hospital, the staff prepares the emergency room, to which the boy is rushed.

6. At the hospital, the staff are preparing for a practice disaster drill, which the boy will watch.

7. All morning long, surgeons struggled to save the boy's life.

7. All morning long, surgeons practiced the standard disaster drill procedures.

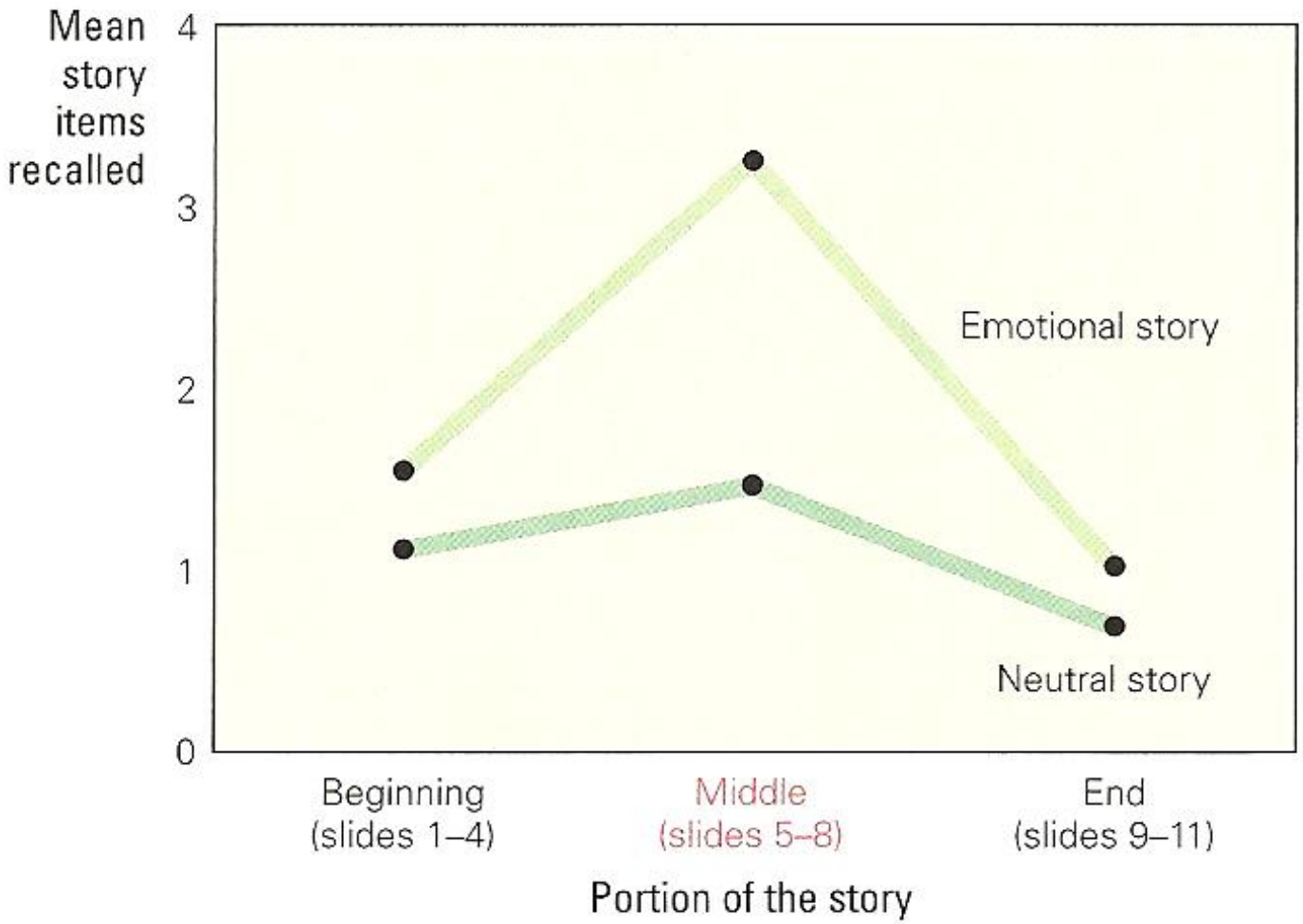
8. Specialized surgeons were able to successfully reattach the boy's severed feet.

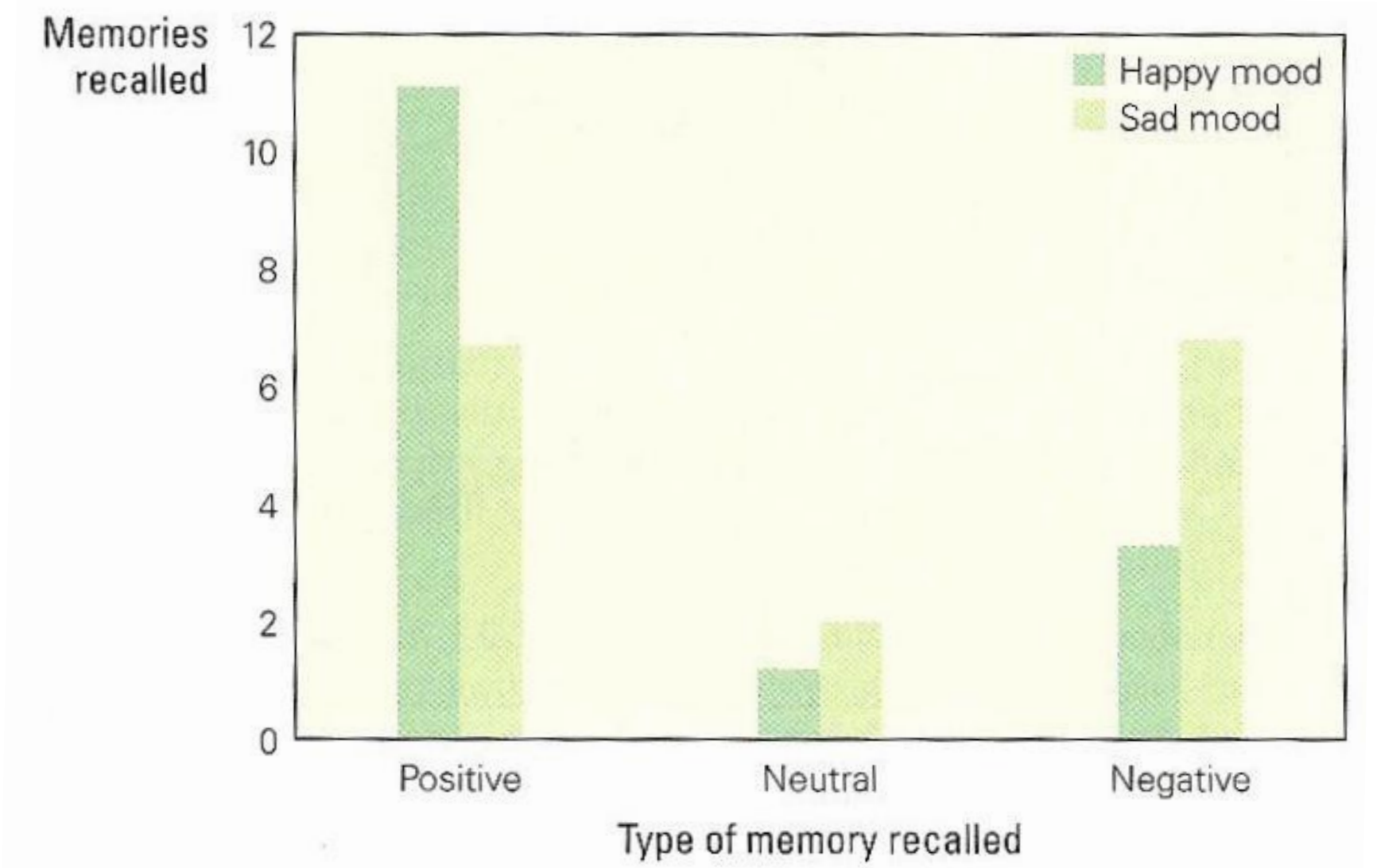
8. Special make-up artists were able to create realistic-looking injuries on actors for the drill.

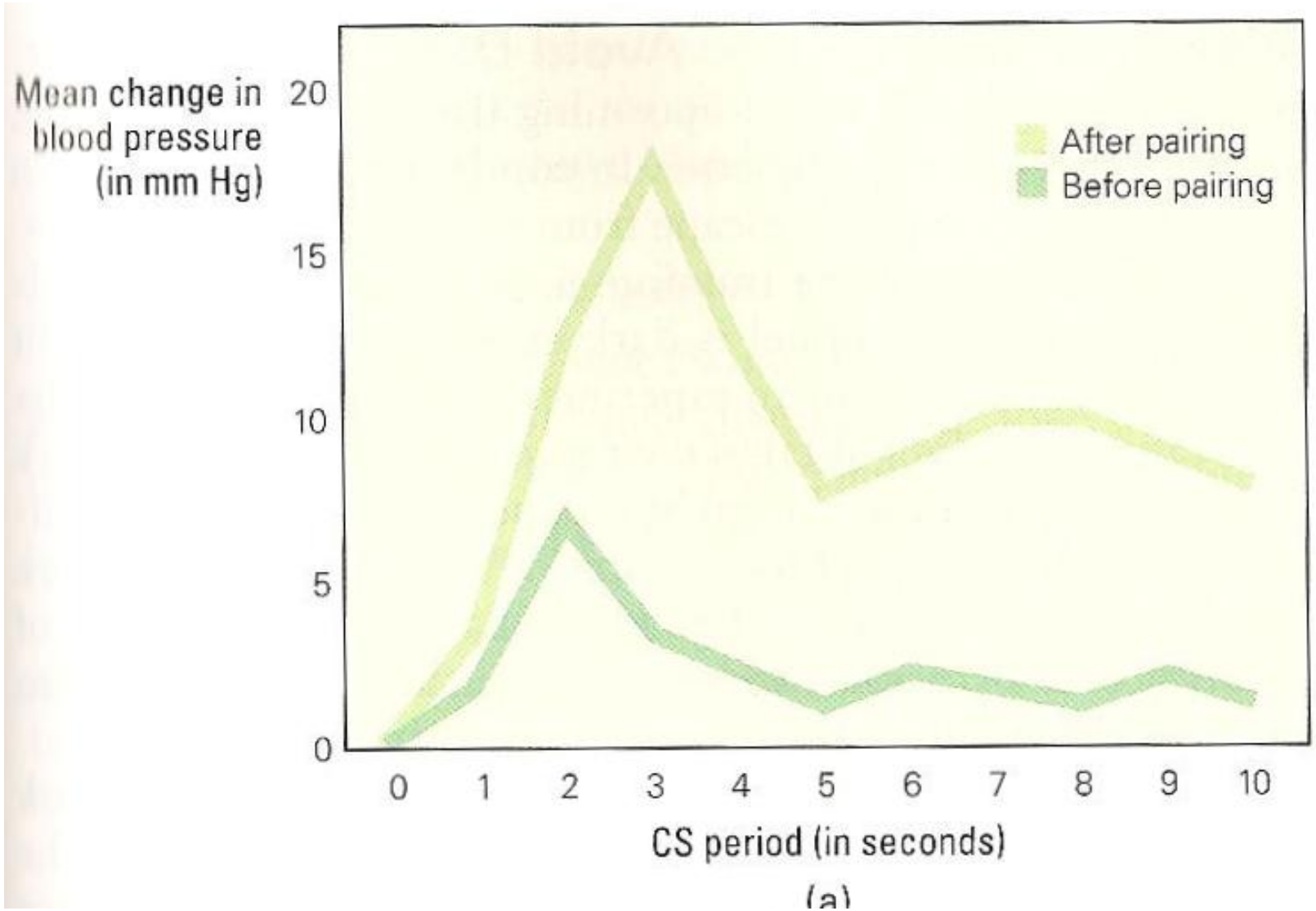
9. Afterward, while the father stayed with the boy, the mother left to phone her other child's preschool.

10. She phones the preschool to tell them she will soon pick up her child.

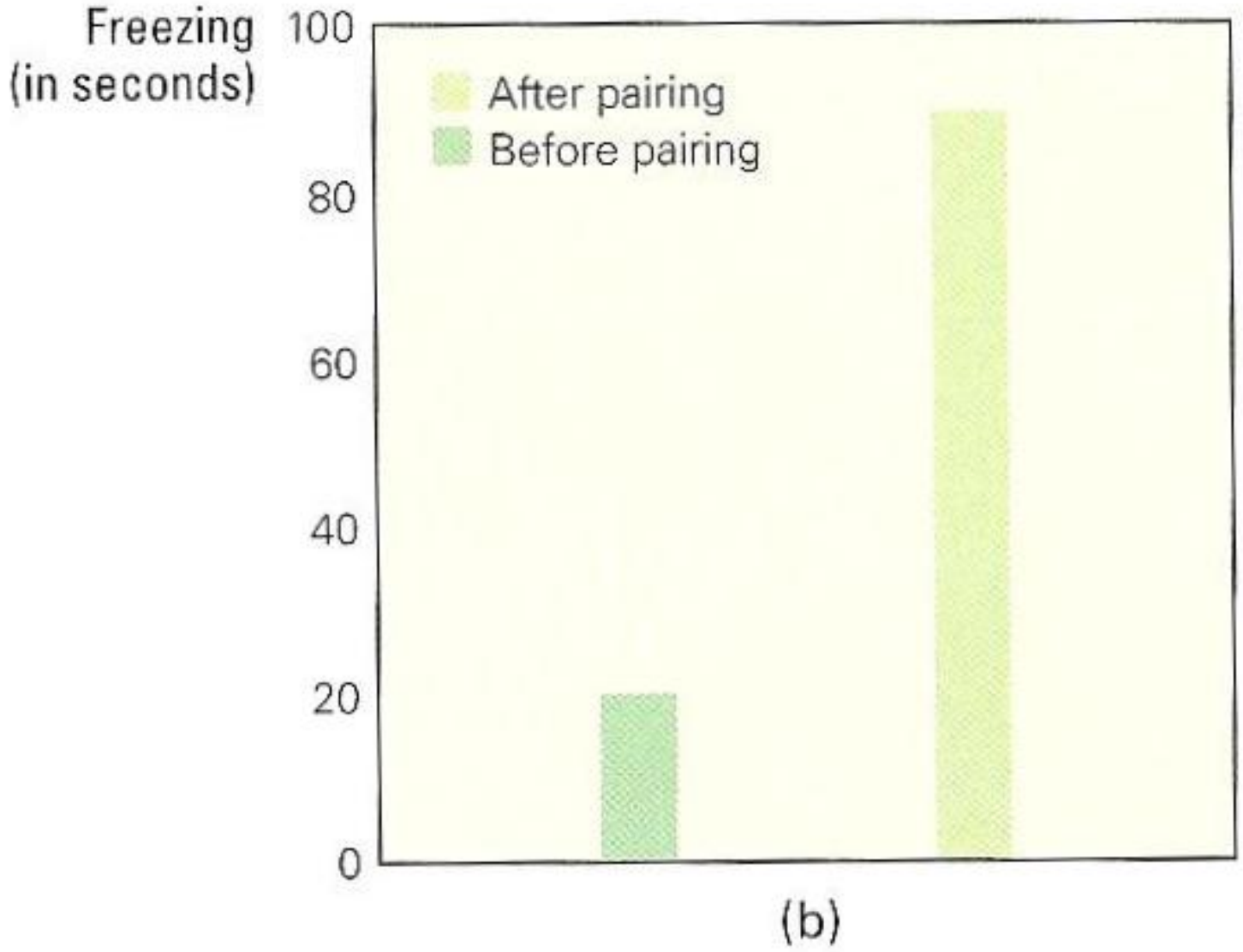
11. Heading to pick up her child, she hails a taxi at the number 9 bus stop.


Mean story items recalled
4
3
2
1
0
Emotional story
Neutral story
Beginning (slides 1–4)
Middle (slides 5–8)
End (slides 9–11)
Portion of the story


Memories recalled
12
10
8
6
4
2
0
Happy mood
Sad mood
Positive
Neutral
Negative
Type of memory recalled

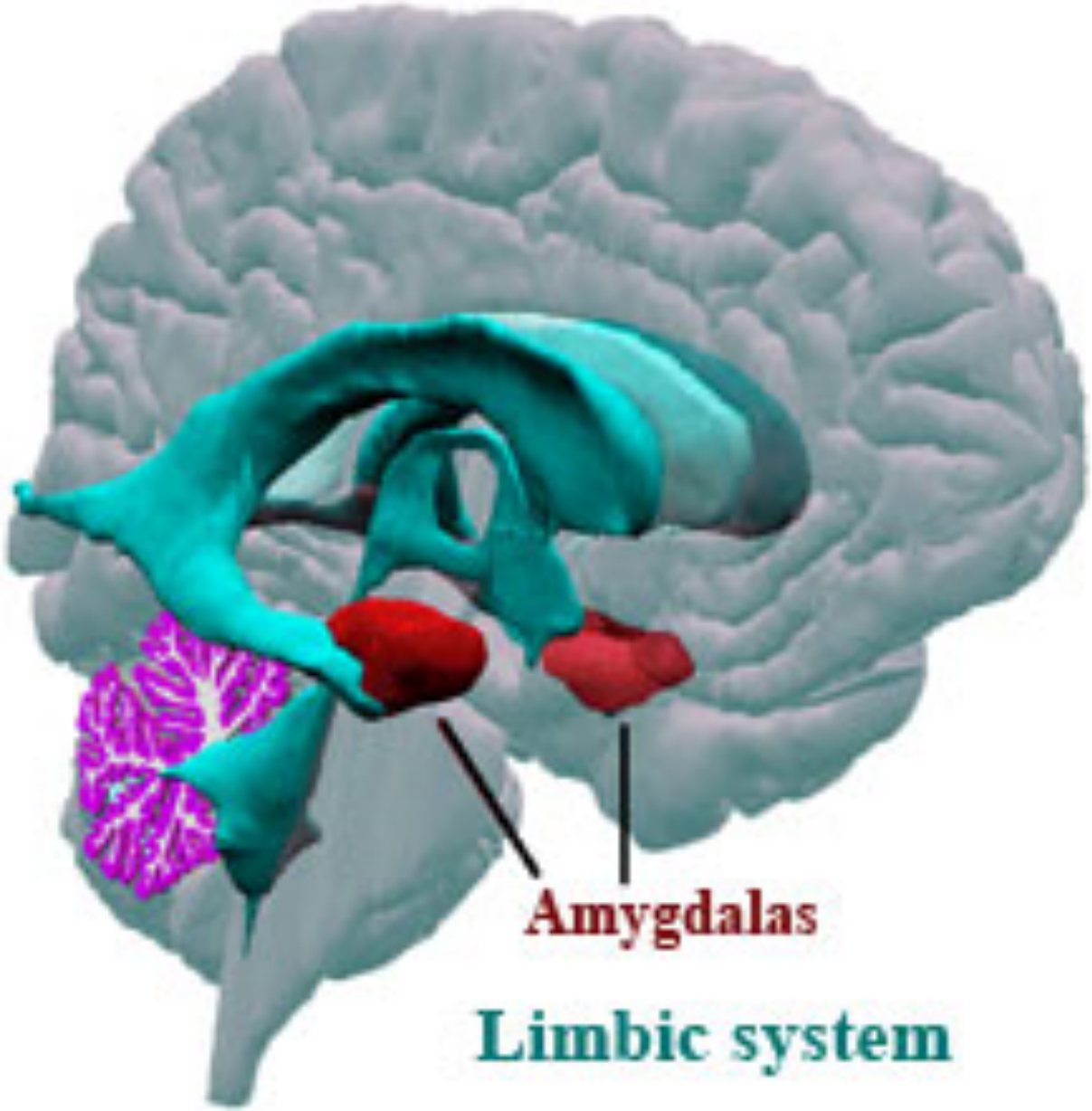


Tone vs Tone Paired with Shock



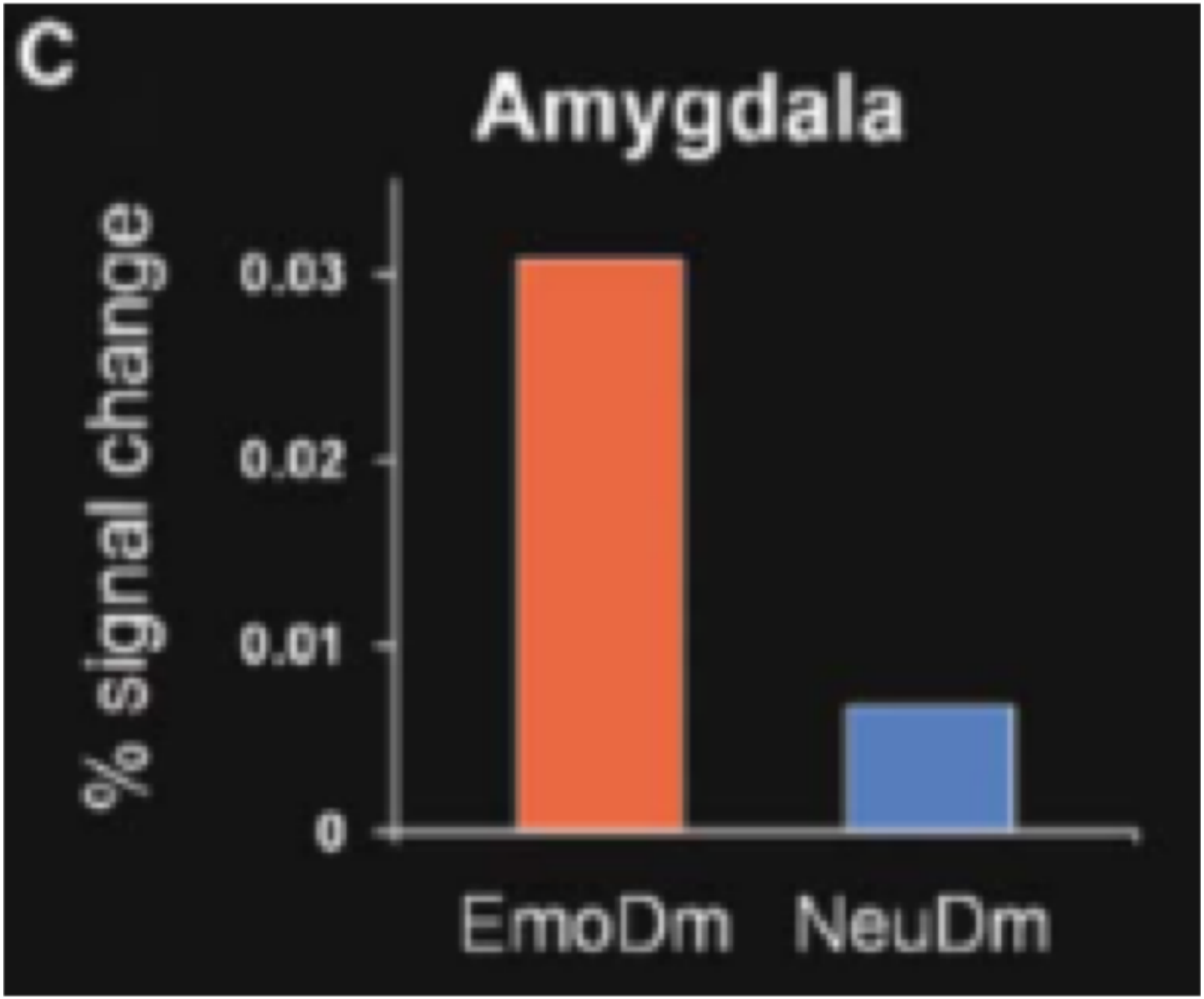
Tone vs Tone Paired with Shock

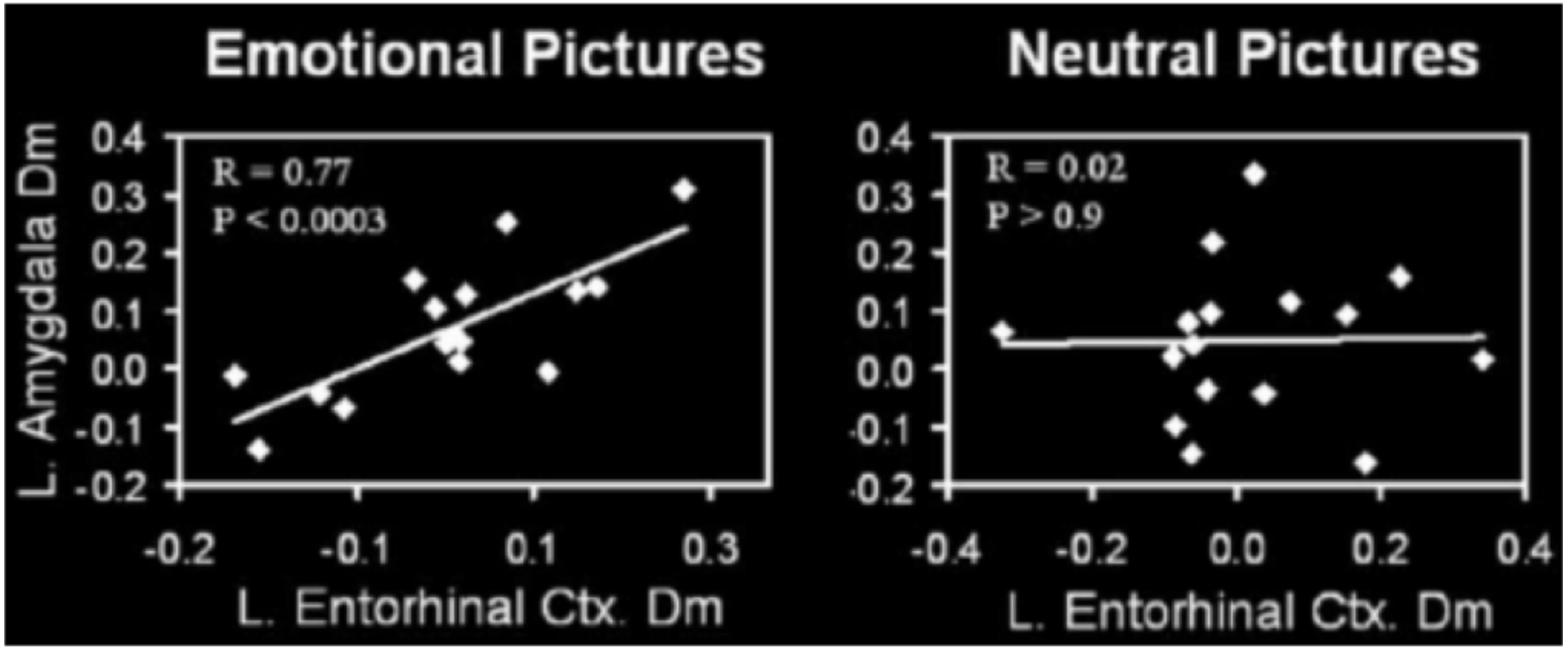
The Amygdala


Amygdalas
Limbic system

Neuron, Vol. 42, 855–863, June 10, 2004,

Interaction between the Amygdala and the Medial Temporal Lobe Memory System Predicts Better Memory for Emotional Events


C
Amygdala
% signal change
0.03
0.02
0.01
0
EmoDm
NeuDm


Emotional Pictures
L. Amygdala Dm
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
R = 0.77
P < 0.0003
-0.2
-0.1
0.1
0.3
L. Entorhinal Ctx. Dm
Neutral Pictures
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
R = 0.02
P > 0.9
-0.4
-0.2
0.0
0.2
0.4
L. Entorhinal Ctx. Dm

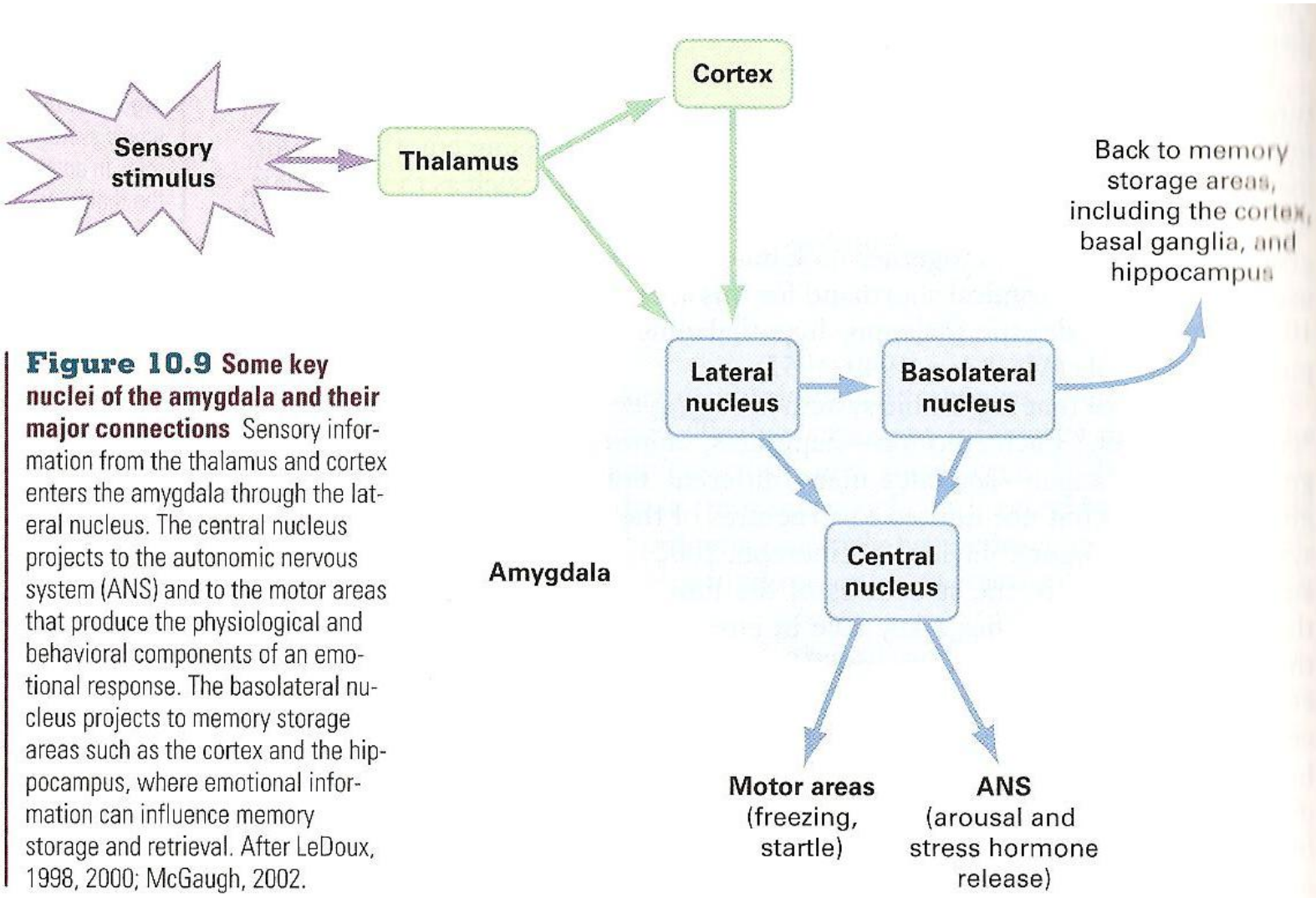
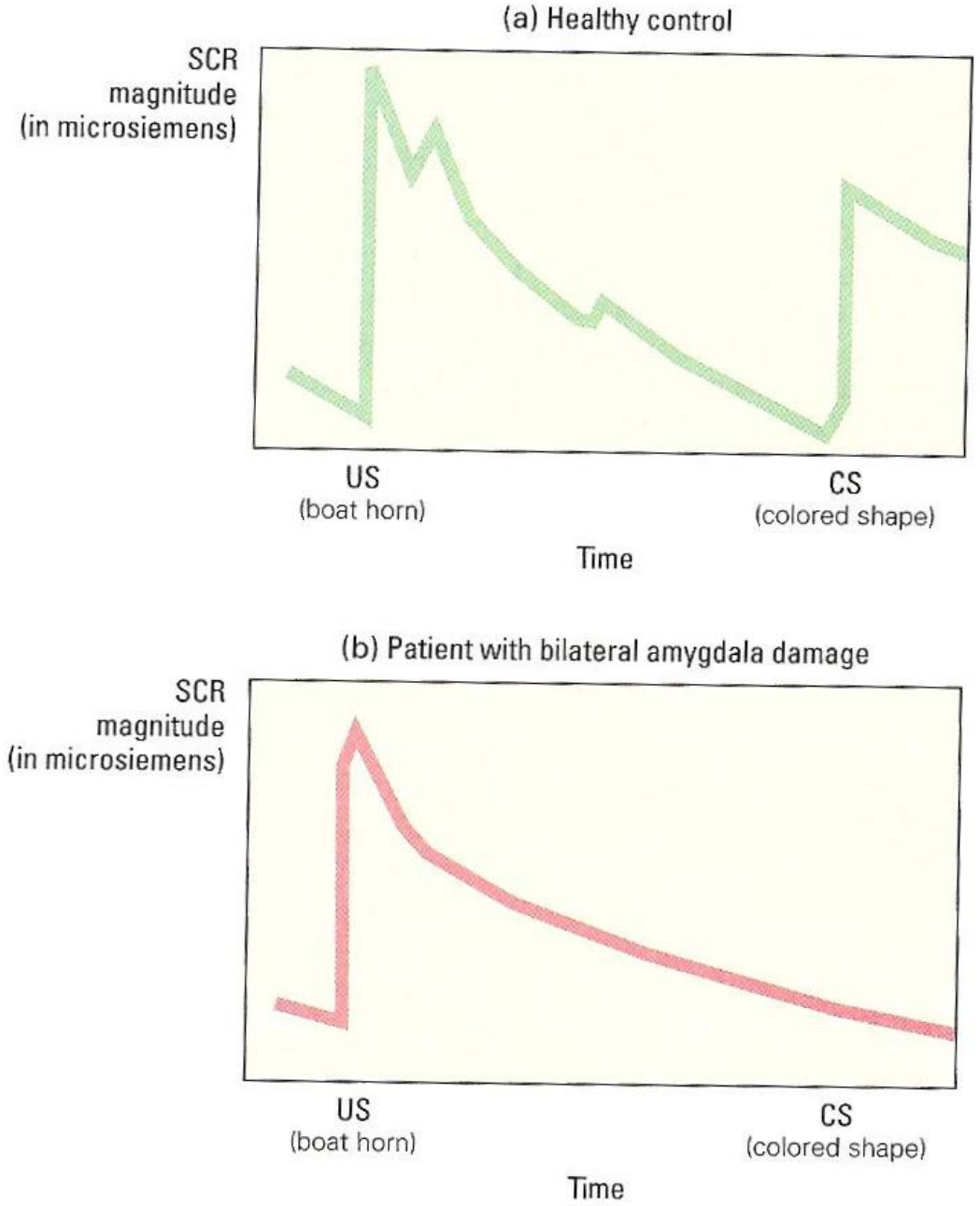
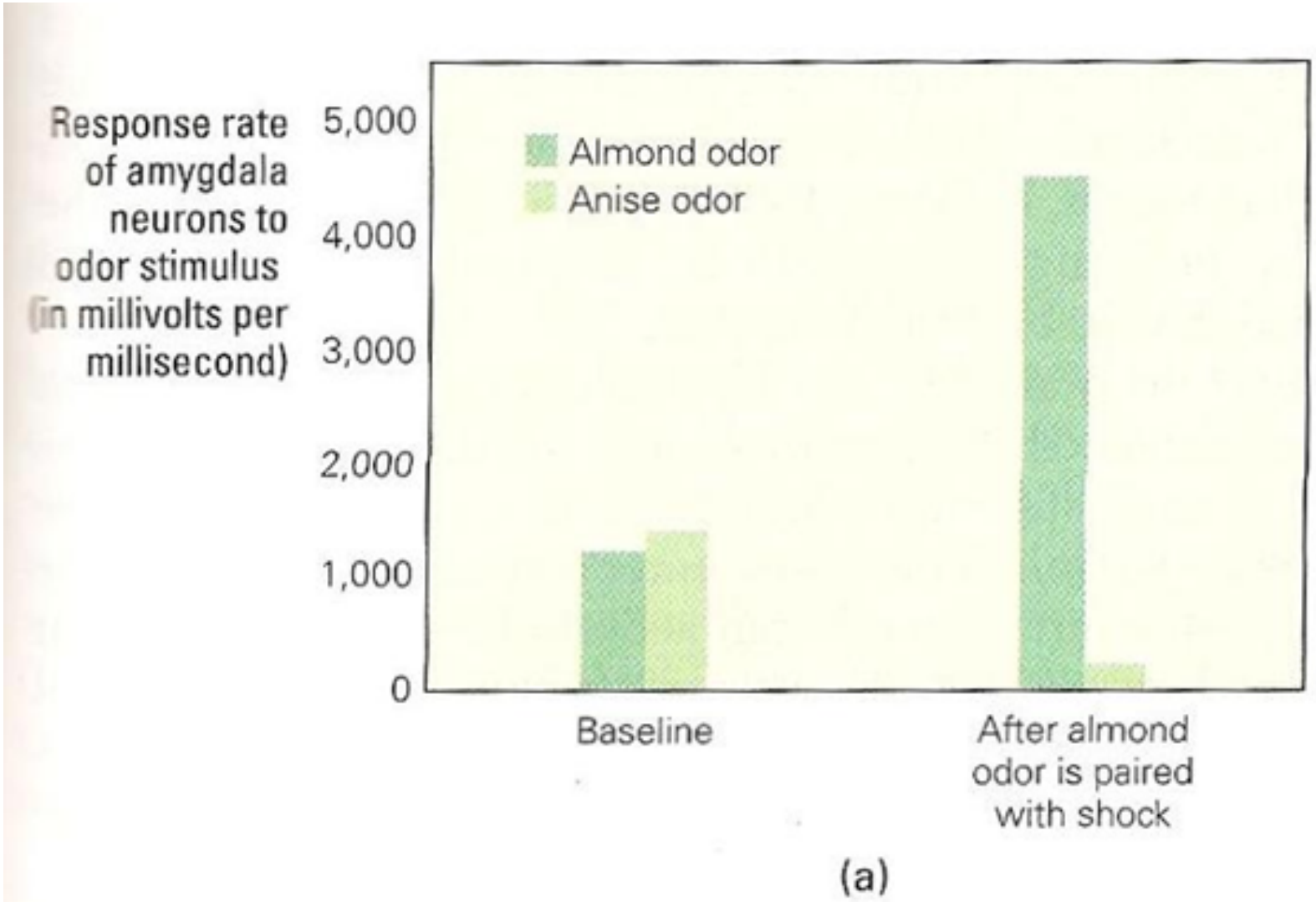
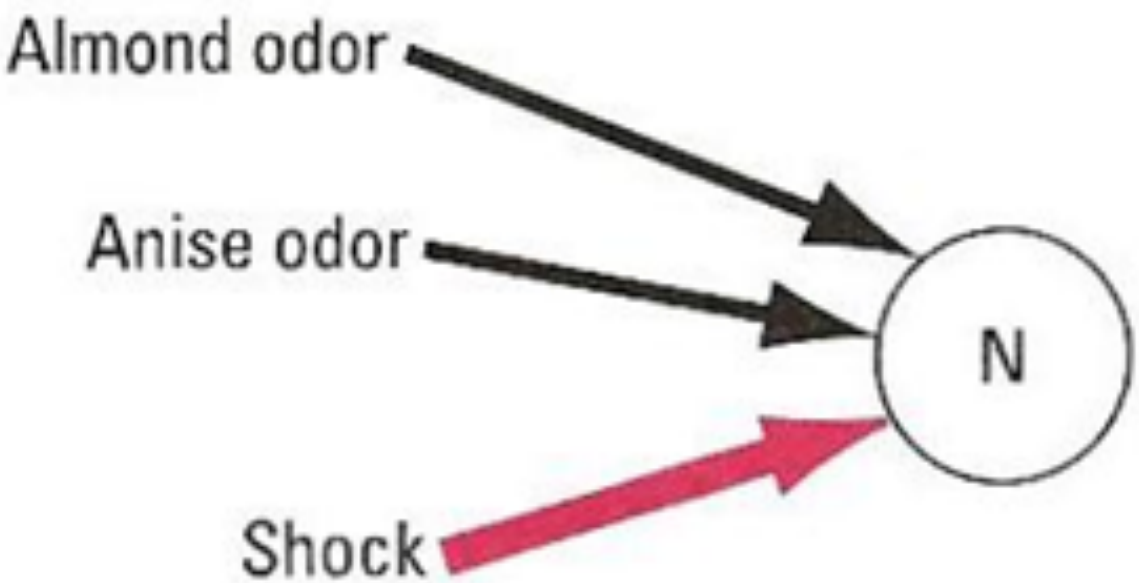


Figure 10.9 Some key nuclei of the amygdala and their major connections Sensory information from the thalamus and cortex enters the amygdala through the lateral nucleus. The central nucleus projects to the autonomic nervous system (ANS) and to the motor areas that produce the physiological and behavioral components of an emotional response. The basolateral nucleus projects to memory storage areas such as the cortex and the hippocampus, where emotional information can influence memory storage and retrieval. After LeDoux, 1998, 2000; McGaugh, 2002.

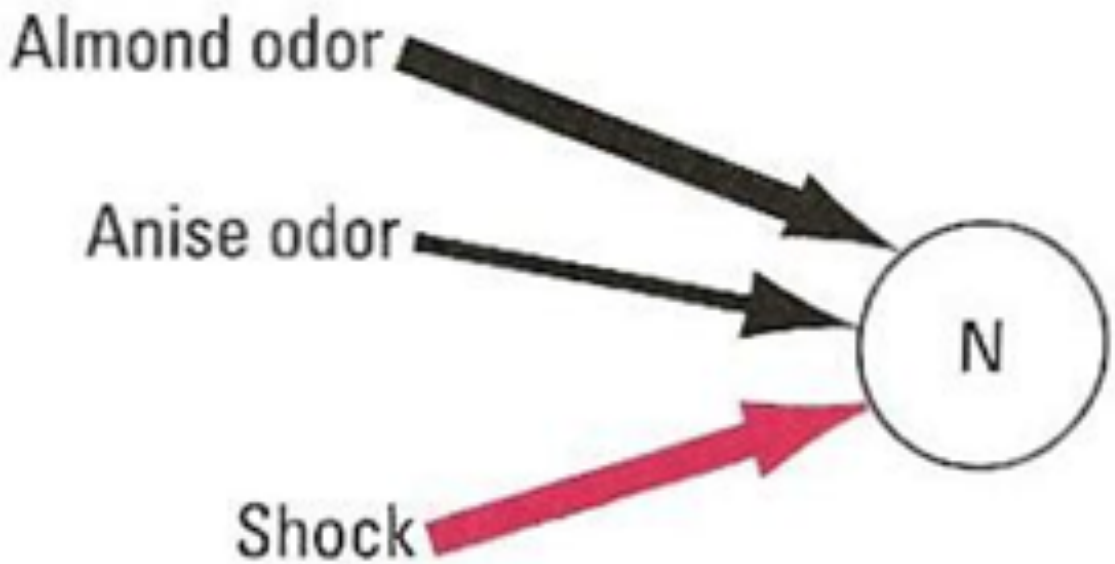

(a) Healthy control
SCR magnitude (in microsiemens)
US (boat horn)
CS (colored shape)
Time
(b) Patient with bilateral amygdala damage
SCR magnitude (in microsiemens)
US (boat horn)
CS (colored shape)
Time


Response rate of amygdala neurons to odor stimulus (in millivolts per millisecond)
5,000
4,000
3,000
2,000
1,000
0
Almond odor
Anise odor
Baseline
After almond odor is paired with shock

(a)



(b)



(c)

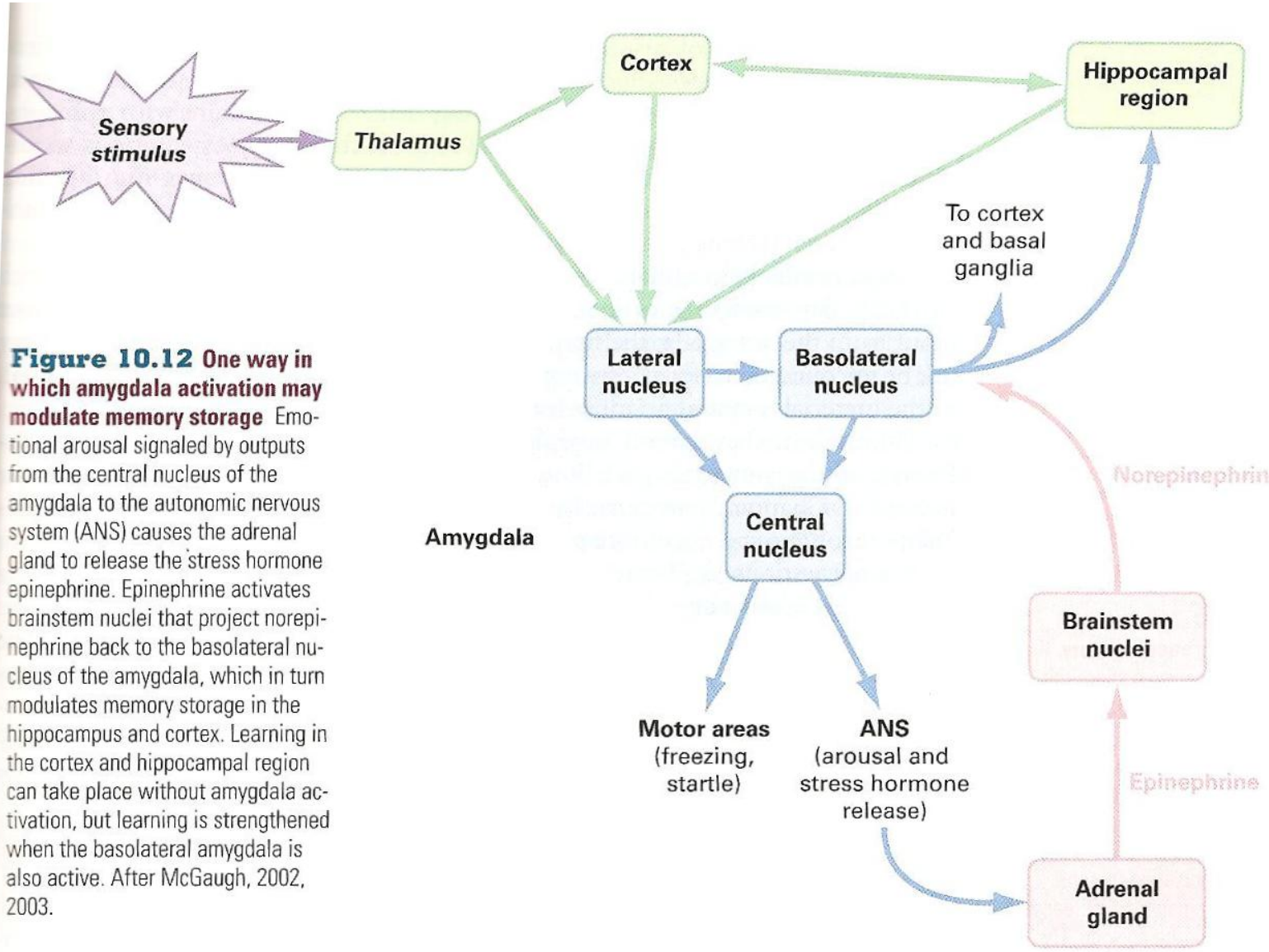
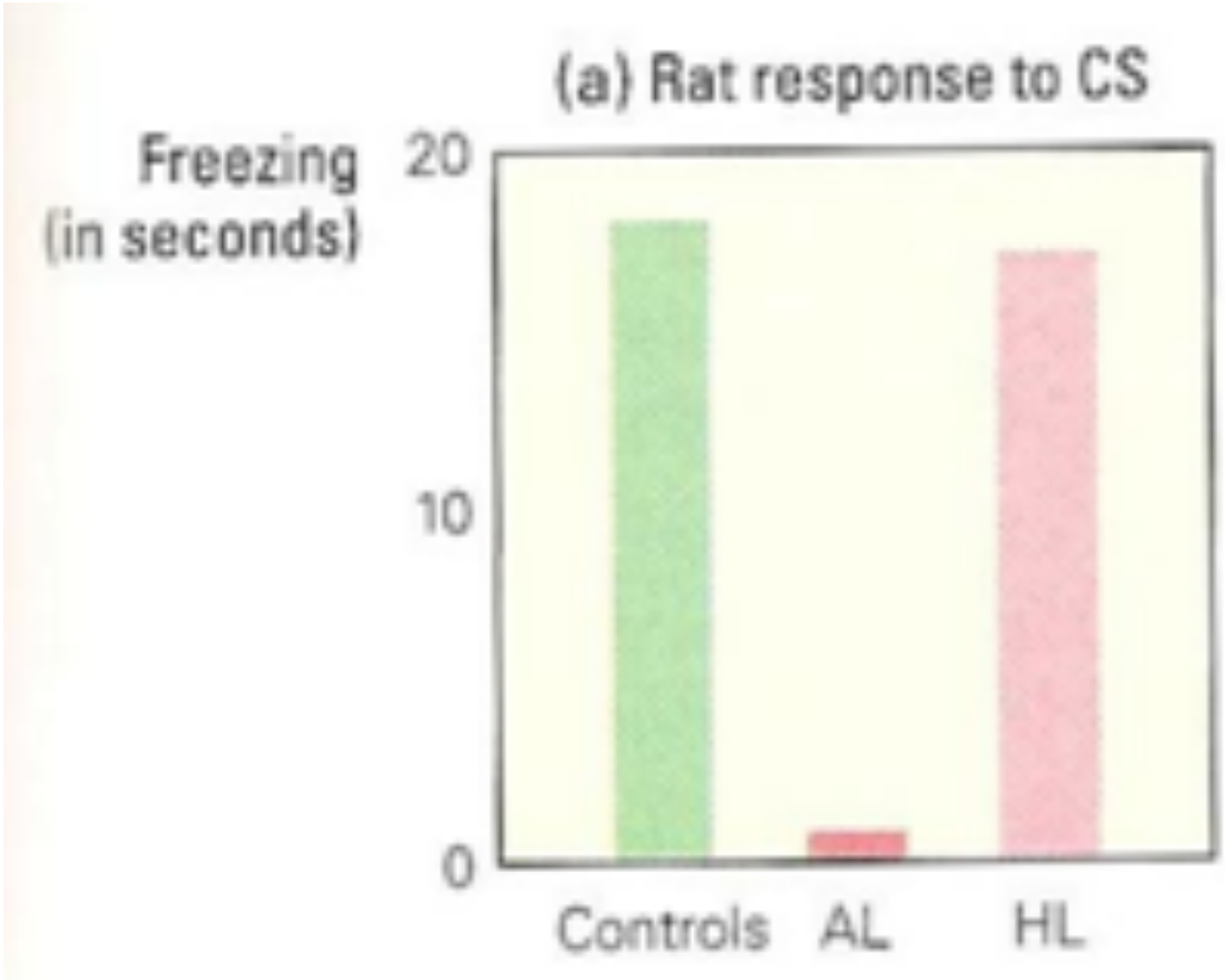
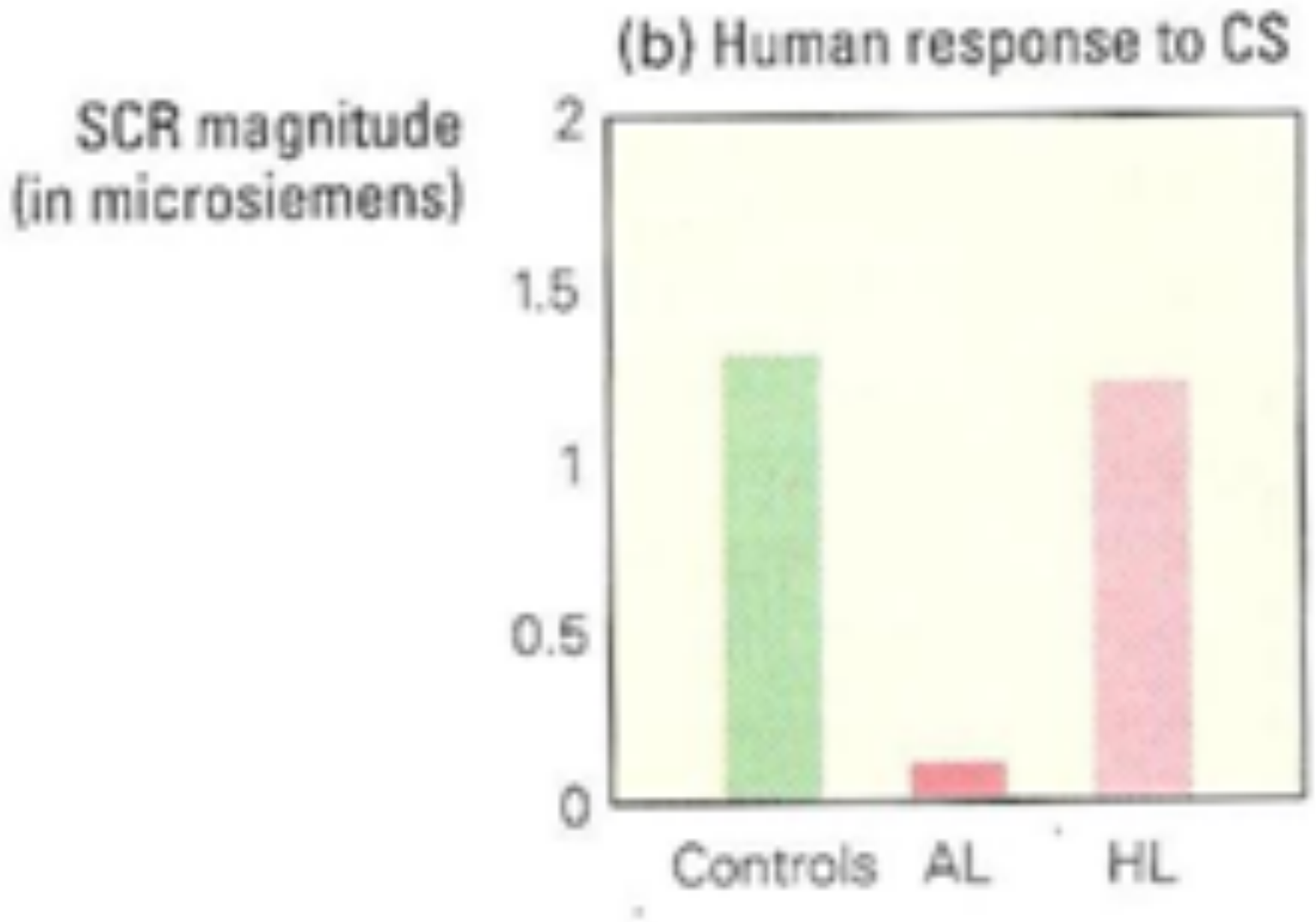
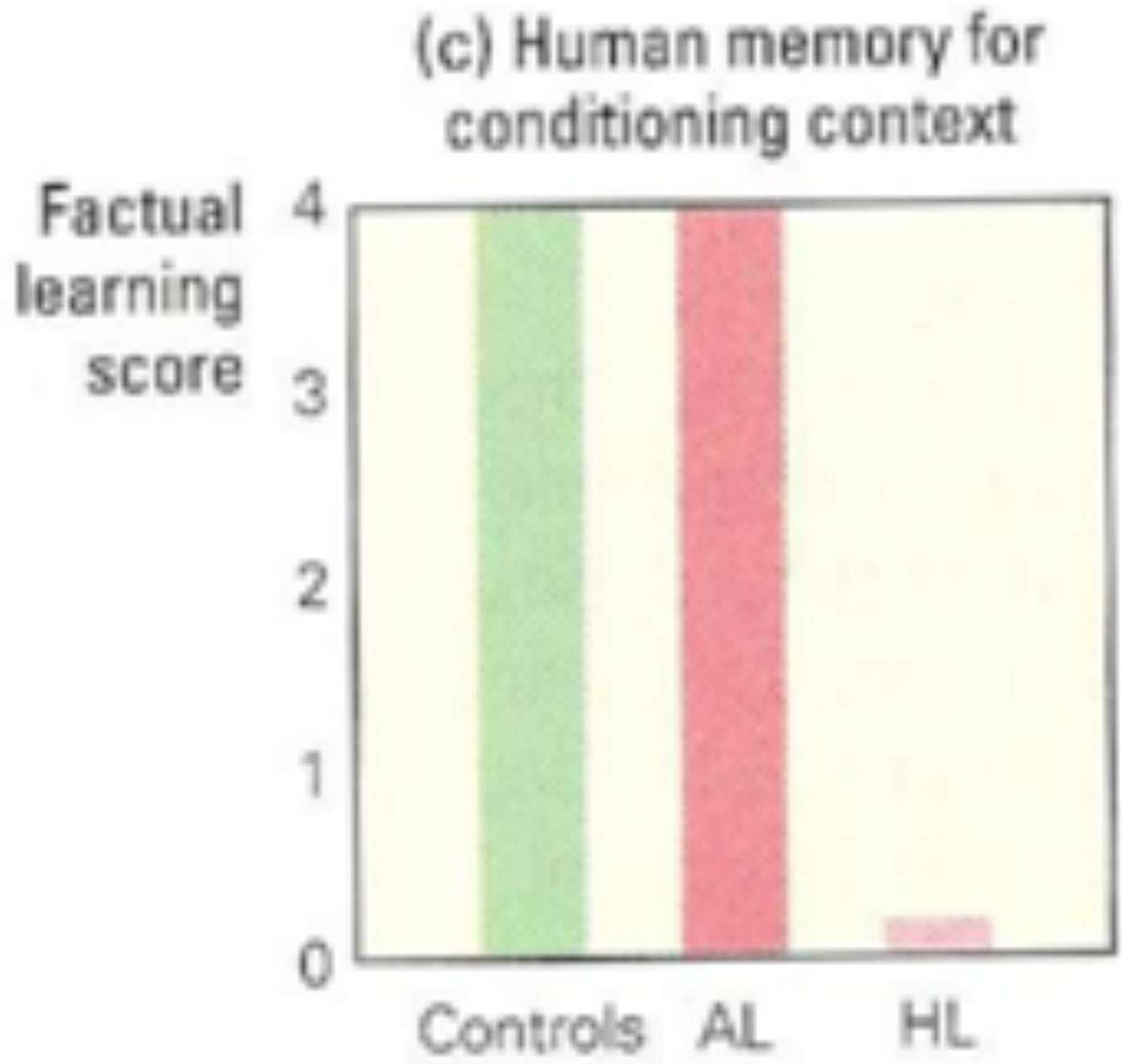


Figure 10.12 One way in which amygdala activation may modulate memory storage Emotional arousal signaled by outputs from the central nucleus of the amygdala to the autonomic nervous system (ANS) causes the adrenal gland to release the stress hormone epinephrine. Epinephrine activates brainstem nuclei that project norepinephrine back to the basolateral nucleus of the amygdala, which in turn modulates memory storage in the hippocampus and cortex. Learning in the cortex and hippocampal region can take place without amygdala activation, but learning is strengthened when the basolateral amygdala is also active. After McGaugh, 2002, 2003.


(a) Rat response to CS
Freezing
(in seconds)
20
10
0
Controls
AL
HL

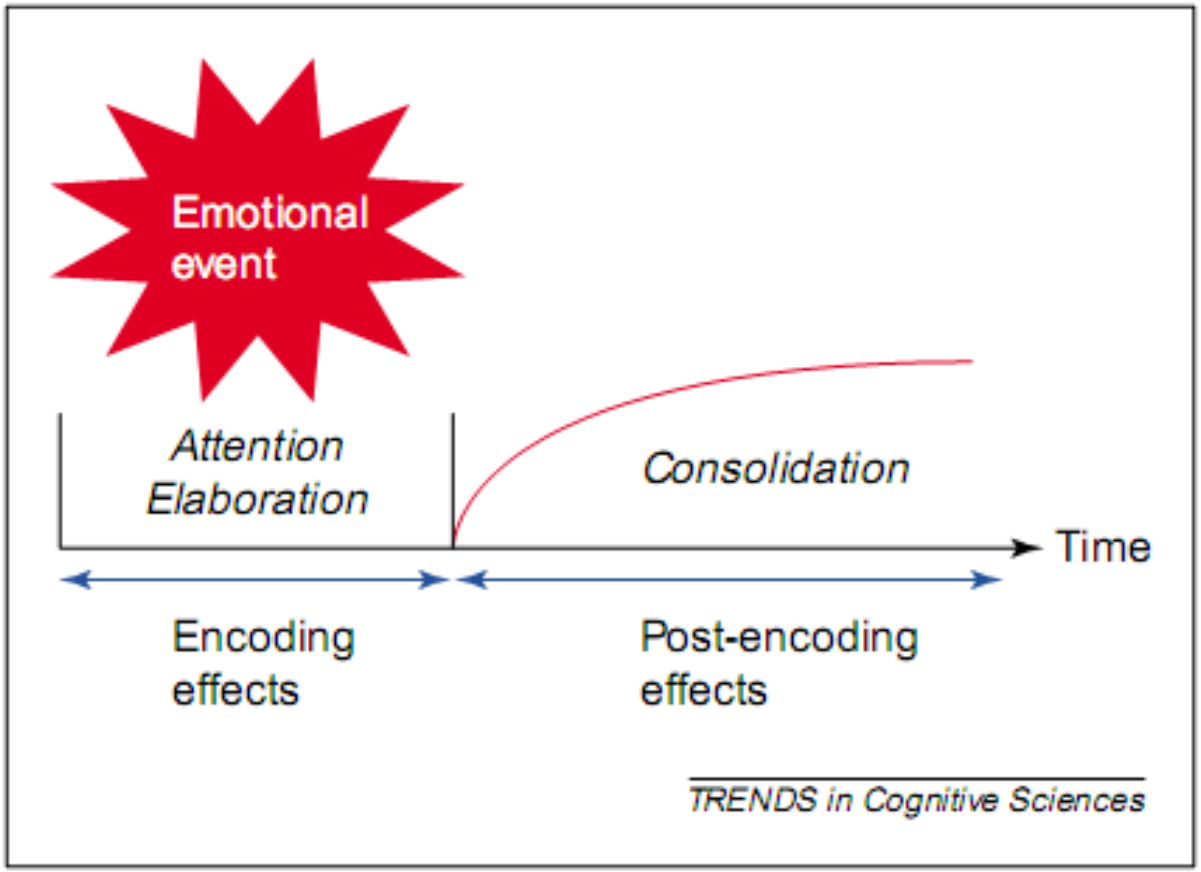

(b) Human response to CS
SCR magnitude
(in microsiemens)
2
1.5
1
0.5
0
Controls
AL
HL


(c) Human memory for conditioning context
Factual learning score
4
3
2
1
0
Controls
AL
HL

Cognitive and neural mechanisms of emotional memory

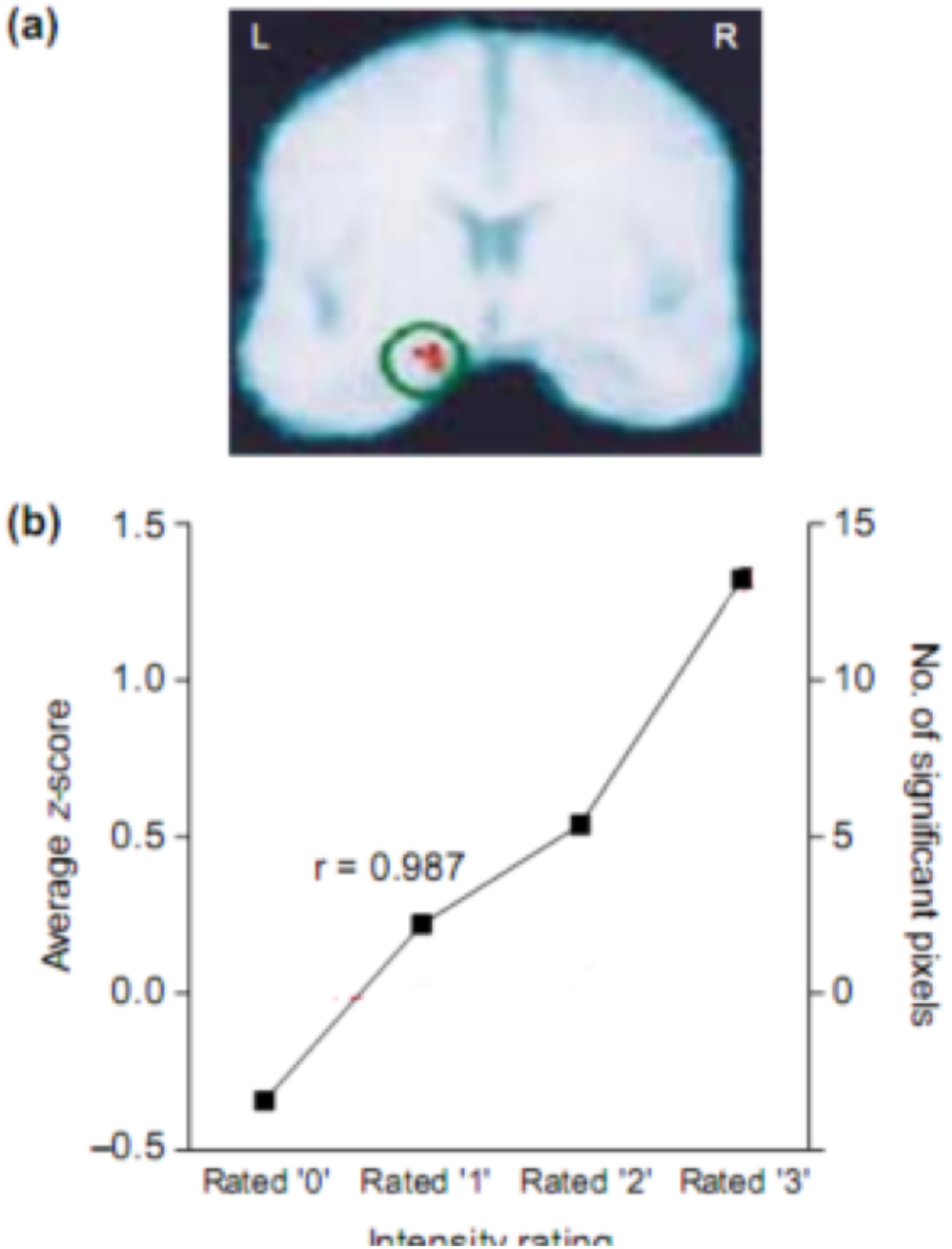
Stephan Hamann

Fig. 1. Encoding and post-encoding effects of emotion. Encoding processes create the initial memory representation. After the event, post-encoding processes, primarily consolidation, continue to influence the memory representation. Consolidation is thought to continue for an extended period; therefore, the observed effects of emotion on memory should increase with time until consolidation is complete.



(1) The amygdala is the primary orchestrator of processes of emotional memory, without which emotional effects on memory cannot occur.

(2) The amygdala can affect explicit memory by modulating or enhancing the activity of other brain regions involved in memory.


(a)
L
R
(b)
1.5
1.0
0.5
0.0
−0.5
Average z-score
15
10
5
0
No. of significant pixels
r = 0.987
Rated '0'
Rated '1'
Rated '2'
Rated '3'
Intensity rating

Implicit Memory


CELTICS
33
VONS

2 + 2 = ?

Perceptual / Motor Skills

Vs

Cognitive Skills

MOTOR PROGRAMS

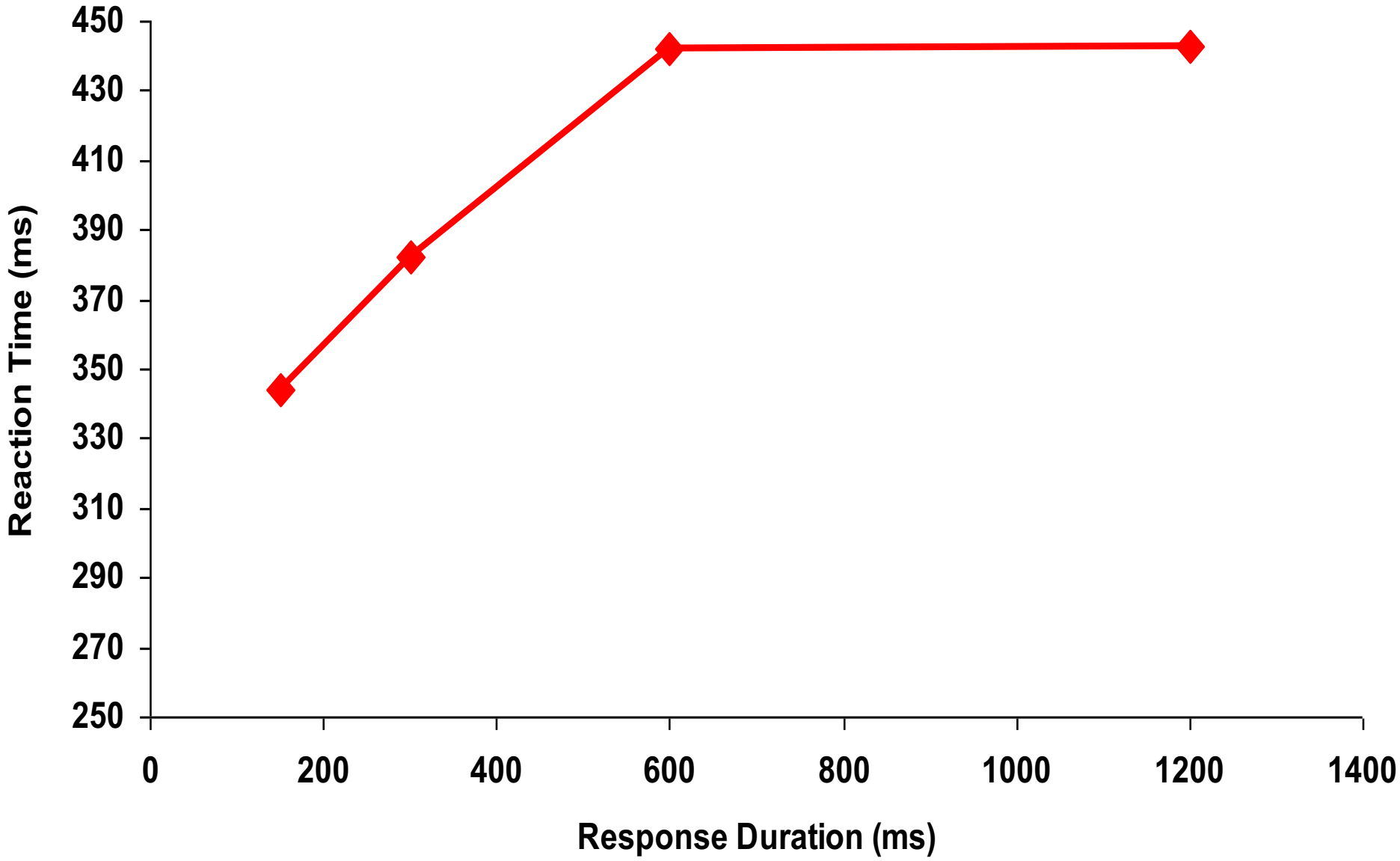
"abstract representation, that, when initiated results in the production of a coordinated movement sequence"

issues commands to muscles (when, how much)

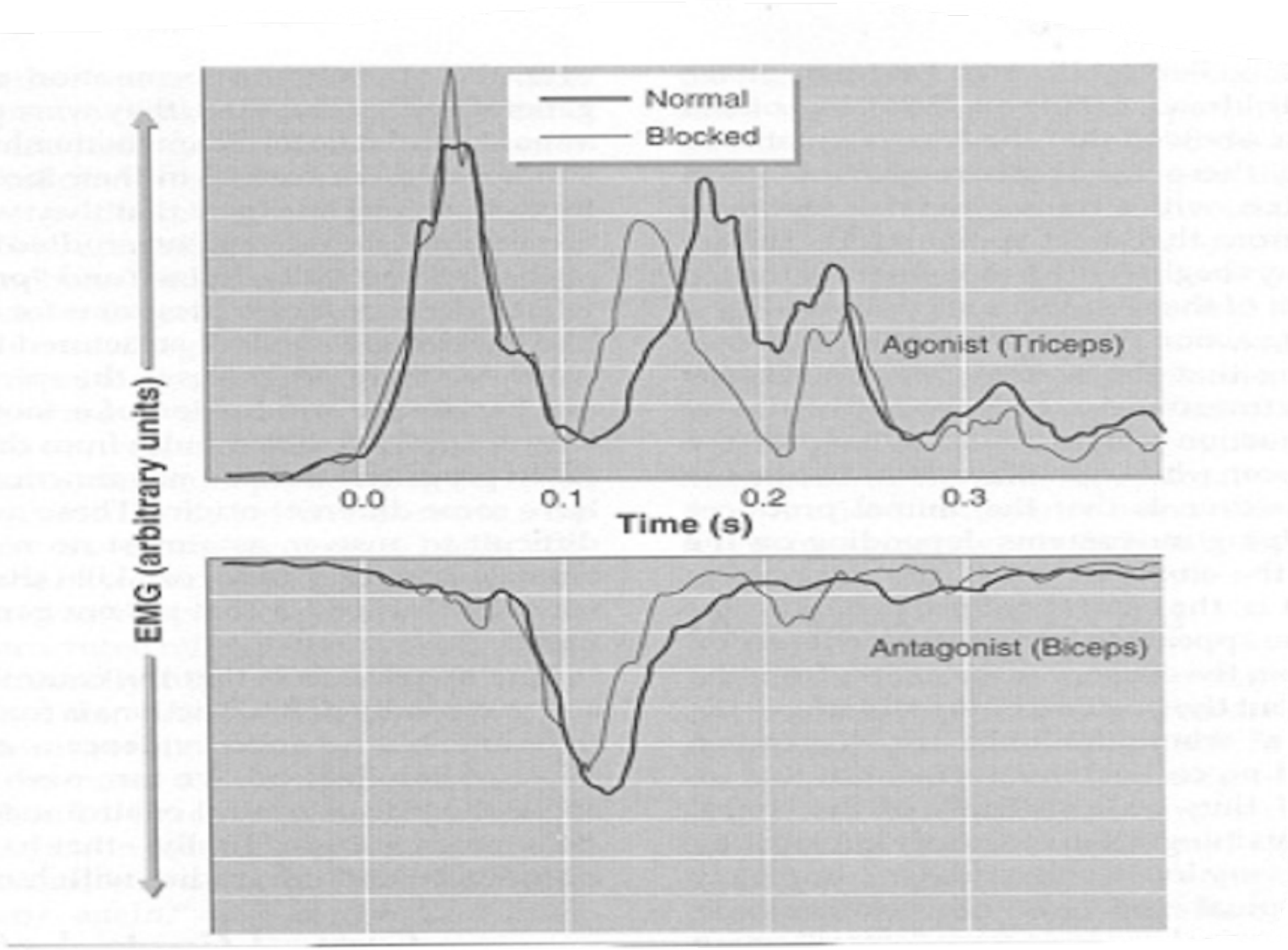
organizes muscles and joints into a single unit

Evidence for Motor Programs

Klapp and Erwin (1976)



Wadman's Results



GENERALIZED MOTOR PROGRAM

A motor program that can be adapted depending on the choice of certain movement or response parameters

GMPs have:

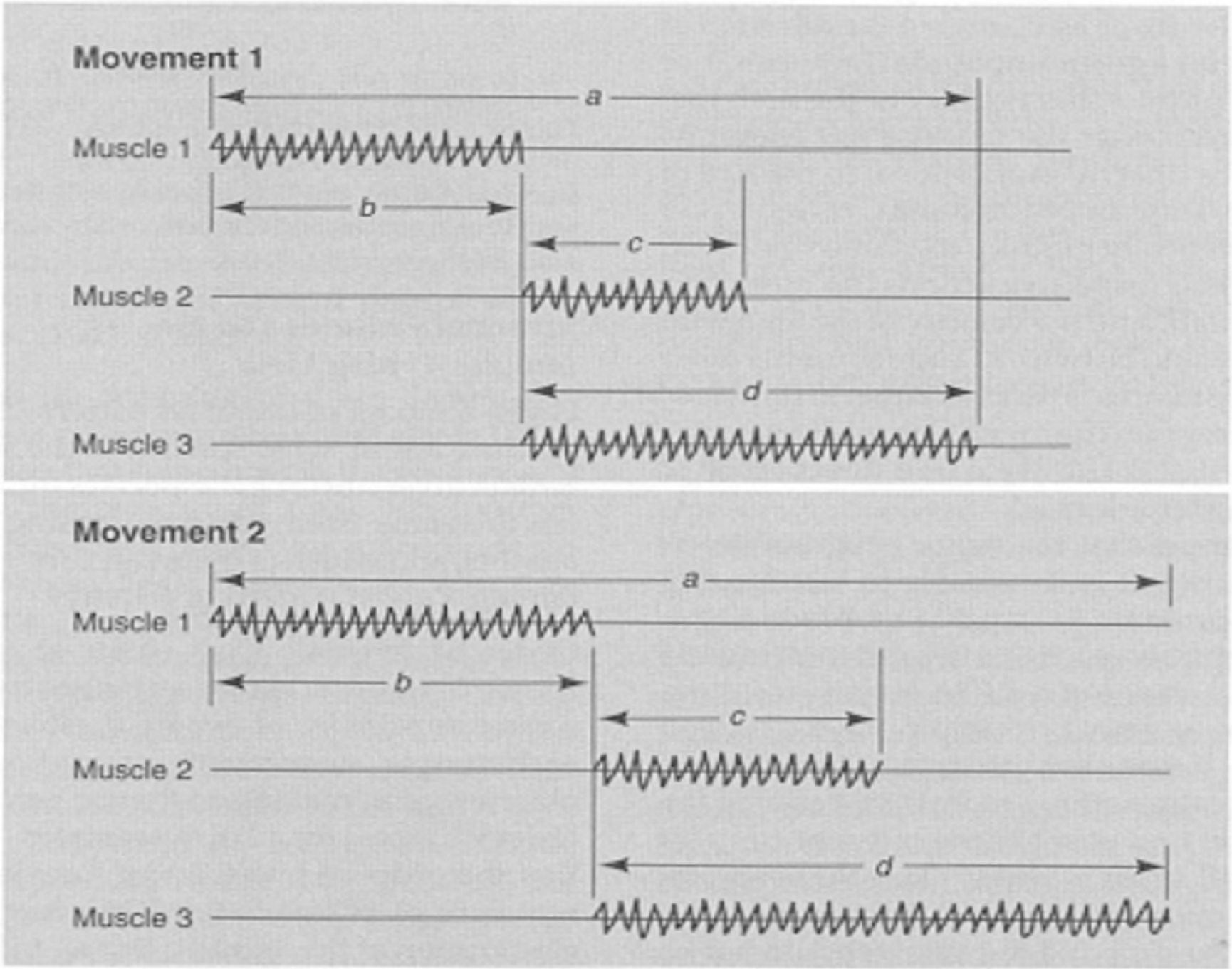
Invariant and Variant Parameters

Invariant Parameters

a. Order of Events

b. Phasing: Temporal Structure

c. Relative Force


Movement 1
a
Muscle 1
b
c
Muscle 2
d
Muscle 3
Movement 2
a
Muscle 1
b
c
Muscle 2
d
Muscle 3

Variant Parameters

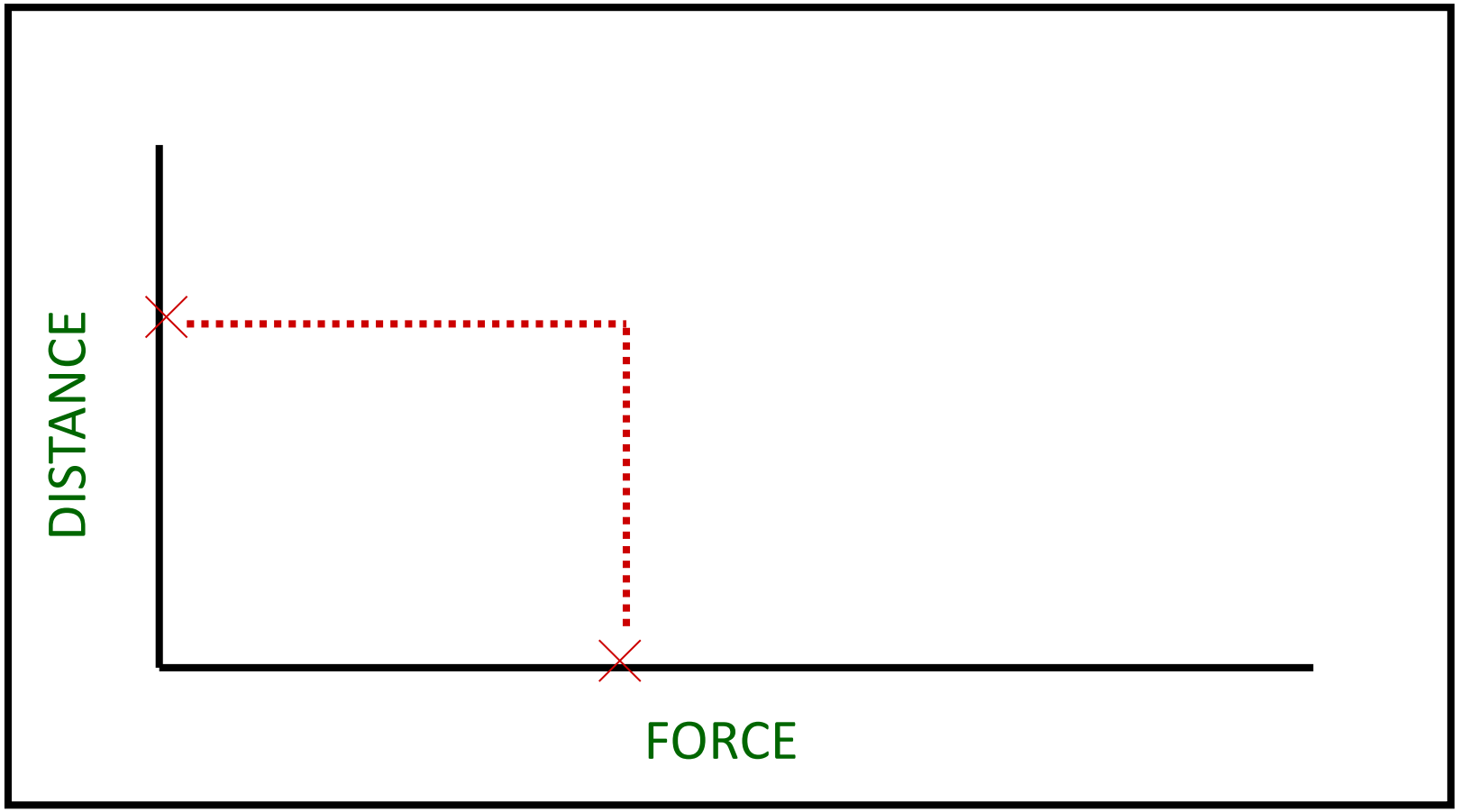
a. Movement Time

b. Movement Amplitude

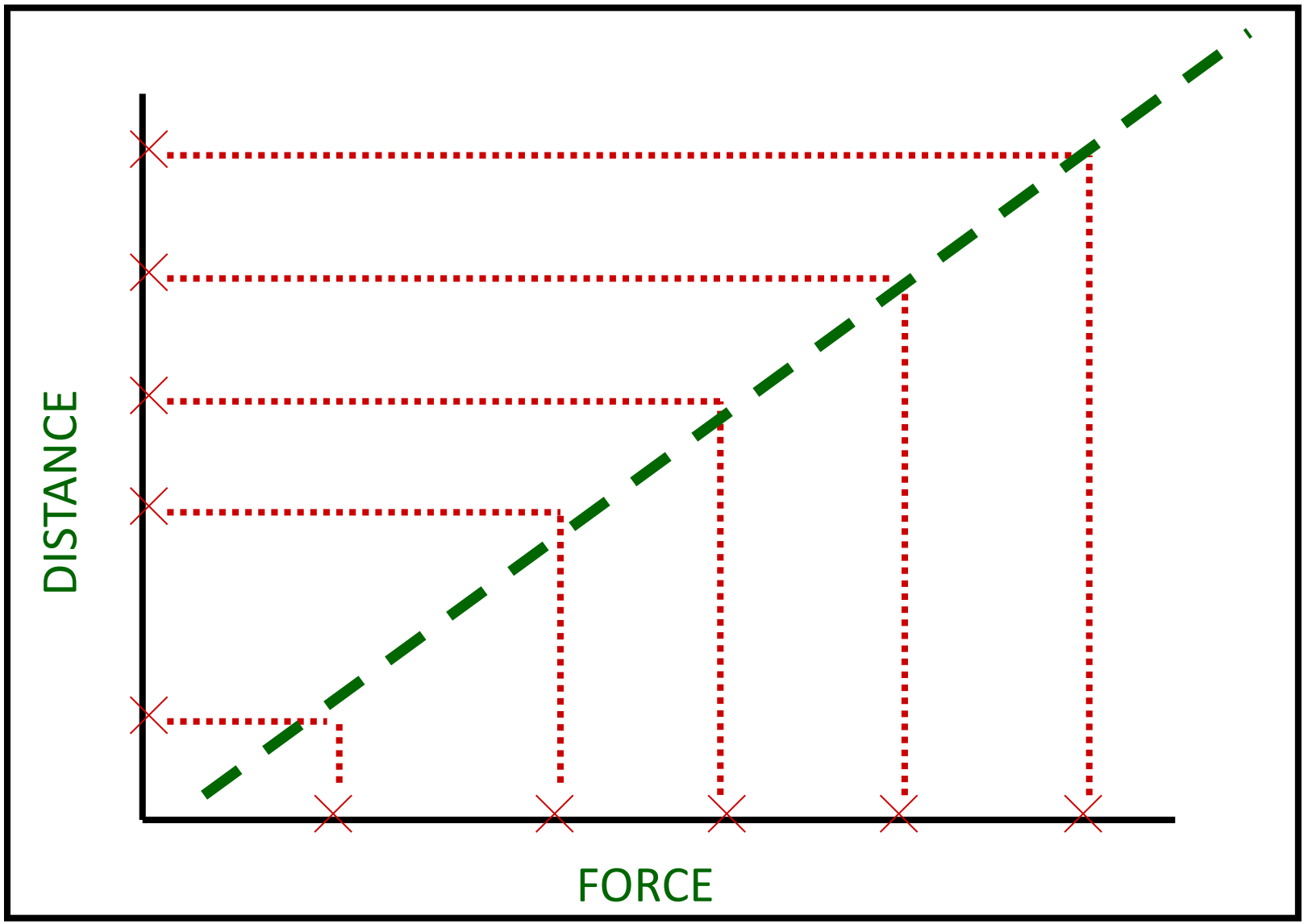
Schema Theory

Recall **General Motor Program** Theory:

INVARIANT vs VARIANT Features



Schema Theory



Schema Theory

Schema:

A set of general rules that relate INPUT parameters to movement OUTPUT

WARNING:

If variation exceeds GMP then a new GMP will be developed and utilised!

Both the Hippocampus and Striatum Are Involved in Consolidation of Motor Sequence Memory

Geneviève Albouy,[1,2,3,4] Virginie Sterpenich,[1] Evelyne Balteau,[1] Gilles Vandewalle,[1] Martin Desseilles,[1] Thanh Dang-Vu,[1] Annabelle Darsaud,[1] Perrine Ruby,[3,4] Pierre-Hervé Luppi,[2,4] Christian Degueldre,[1] Philippe Peigneux,[1,5] André Luxen,[1] and Pierre Maquet[1,*]

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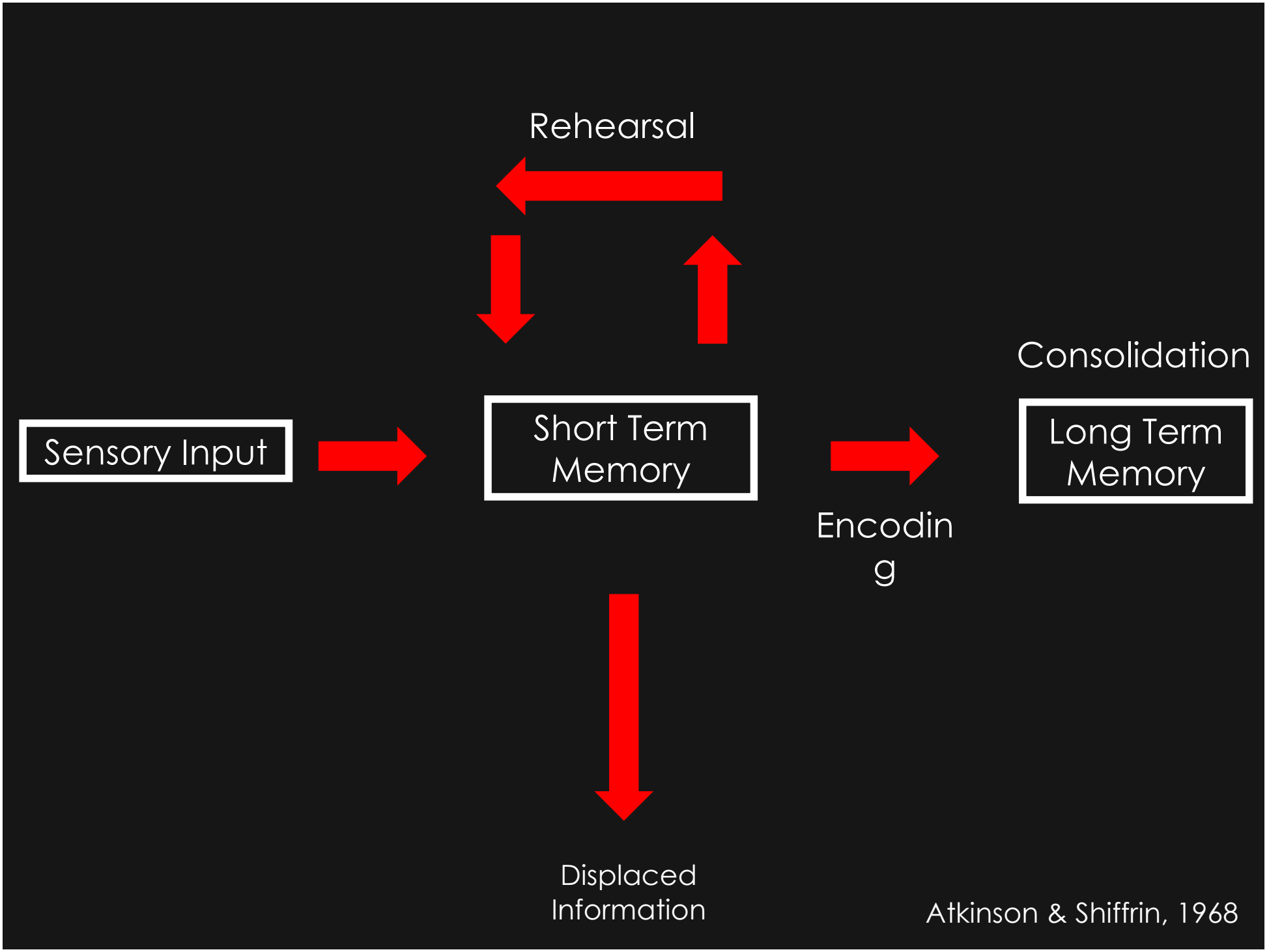
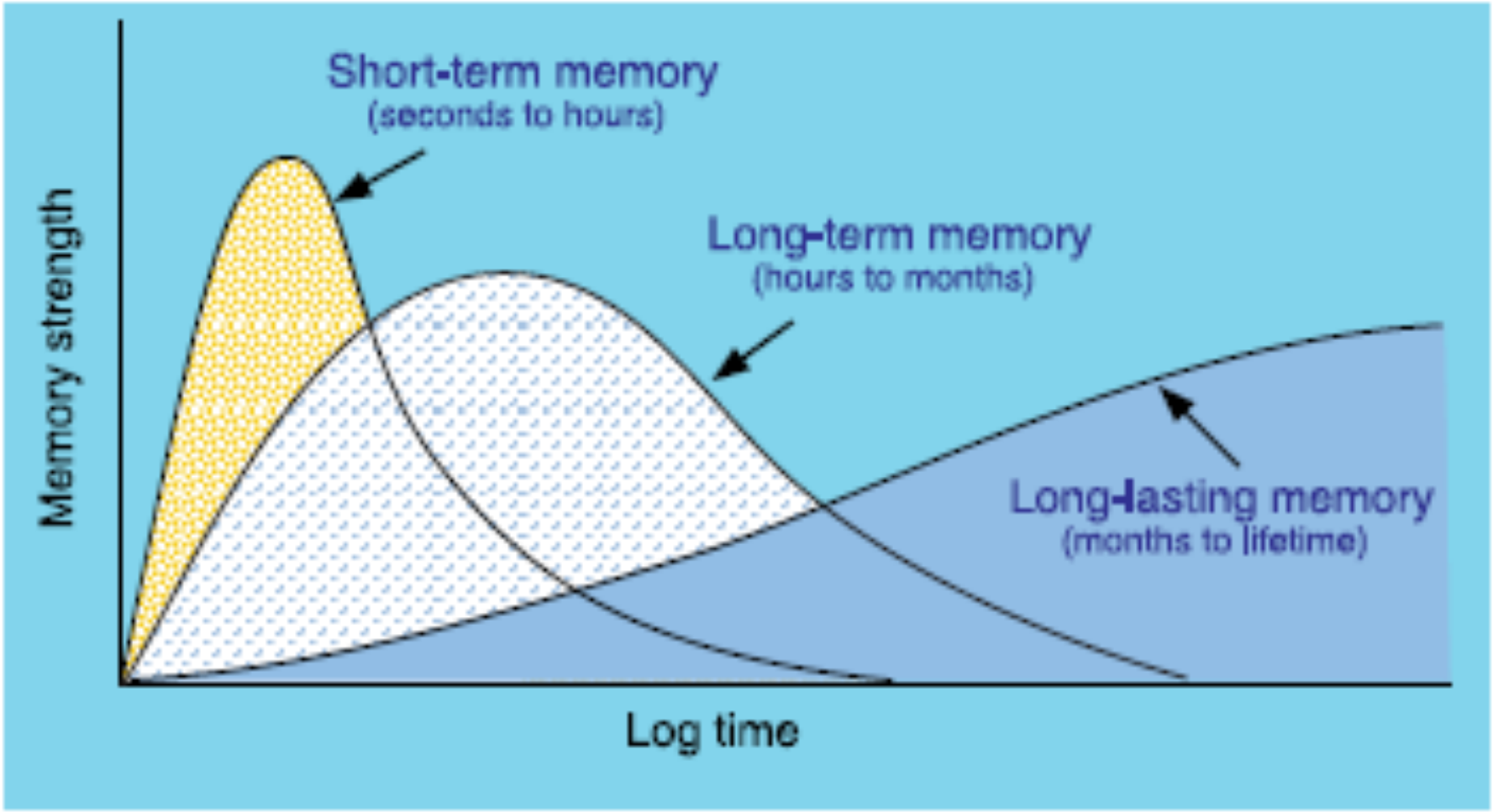
DOI 10.1016/j.neuron.2008.02.008

False Memories


Rehearsal
Consolidation
Sensory Input
Short Term Memory
Long Term Memory
Encodin g
Displaced Information
Atkinson & Shiffrin, 1968


Short-term memory
(seconds to hours)
Long-term memory
(hours to months)
Long-lasting memory
(months to lifetime)
Memory strength
Log time

In 1986 Nadean Cool, a nurse's aide in Wisconsin, sought therapy from a psychiatrist to help her cope with her reaction to a traumatic event experienced by her daughter. During therapy, the psychiatrist used hypnosis and other suggestive techniques to dig out buried memories of abuse that Cool herself had allegedly experienced. In the process, Cool became convinced that she had repressed memories of having been in a satanic cult, of eating babies, of being raped, of having sex with animals and of being forced to watch the murder of her eight-year-old friend. Cool was told, she had experienced severe childhood sexual and physical abuse.

Cool finally came to the realization that false memories had been planted. She sued the psychiatrist for malpractice. In March 1997, after five weeks of trial, her case was settled out of court for $2.4 million.

Nadean Cool is not the only patient to develop false memories as a result of questionable therapy. In Missouri in 1992 a church counselor helped Beth Rutherford to remember during therapy that her father, a clergyman, had regularly raped her between the ages of 7 and 14 and that her mother sometimes helped him by holding her down. Under her therapist's guidance, Rutherford remembered her father twice impregnating her and forcing her to abort the fetus herself with a coat hanger. The father had to resign from his post as a clergyman when the allegations were made public.

Subsequent medical examination of the daughter revealed, however, that she was still a virgin at age 22 and had never been pregnant. The daughter sued the therapist and received a $1-million settlement in 1996.

A picture is worth a thousand lies: Using false photographs to create false childhood memories

KIMBERLEY A. WADE and MARYANNE GARRY
Victoria University of Wellington, Wellington, New Zealand

and

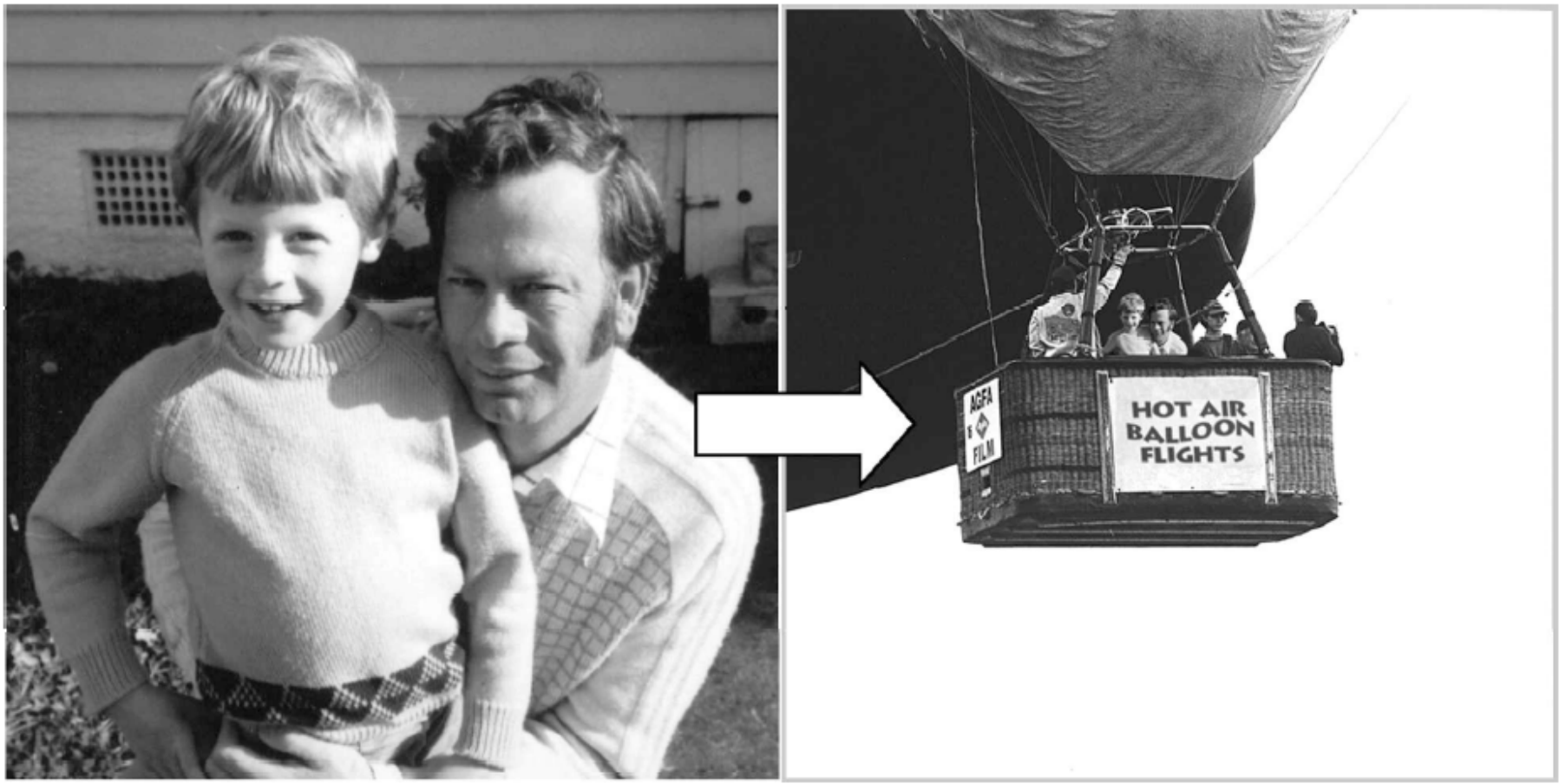
J. DON READ and D. STEPHEN LINDSAY
University of Victoria, Victoria, British Columbia, Canada

Family members took part in the study

3 true photos and 1 false photo

“Step-Wise” interview procedure

– 3 interviews over ~2 week period


AGFA
FILM
HOT AIR
BALLOON
FLIGHTS

Interview 1

Interviewer: And again, if you want to tell me as much as you can recall about this event without leaving anything out.

Subject: Mm . . . no, never actually thought I'd been in a hot air balloon, so there we go.

Interviewer: You can't remember anything about this event?

Subject: Nah. Though it is me . . . no memory whatsoever.

Interviewer: If you want to take the next few minutes and concentrate on getting a memory back, something about the event.

Subject: No, yeah I honestly . . . no I can't. That's really annoying.

Interview 3

Interviewer: Same again, tell me everything you can recall about Event 3 without leaving anything out.
Subject: Um, just trying to work out how old my sister was; trying to get the exact . . . when it happened. But I'm still pretty certain it occurred when I was in form one (6th grade) at um the local school there . . . Um basically for $10 or something you could go up in a hot air balloon and go up about 20 odd meters . . . it would have been a Saturday and I think we went with, yeah, parents and, no it wasn't, not my grandmother . . . not certain who any of the other people are there. Um, and I'm pretty certain that mum is down on the ground taking a photo.

Interview 1

Interviewer: Okay, so if you turn over, same case again. Can you tell me everything you remember?
Subject: I didn't even know I had been in a hot air balloon! I've never seen this photo in my life.
Interviewer: You can't recall anything that happened in this event?
Subject: No, I can't recall, I mean, the only thing I can assume is that when I was a really small child down in (city), at the (city) fair they had hot air balloons there. And that's like the only place that I think that could have happened. I've never even seen that photo before in my life.

Interview 3

Interviewer: If you want to turn over to Event 3 and tell me as much as you can remember about this event.
Subject: Well I don't really remember a lot. Um. I'm pretty sure it happened in City A but I couldn't be 100% certain. Um, at the (city) Fair. Um, I actually, until I had seen this picture I didn't even believe I had been up in a hot air balloon.
Interviewer: Okay, it's okay that you can't recall this event. Like I said last week, many people can't recall certain childhood events because they haven't thought about them for such a long time. So, I'd like you to take the next few moments and just concentrate on getting the memory back for a little while.
Subject: I'm sort of like my mind's playing tricks on me. I sort of think I remember being up in it. But I don't know whether that's just me thinking that I have been. I can see like the road and people and a big paddock.

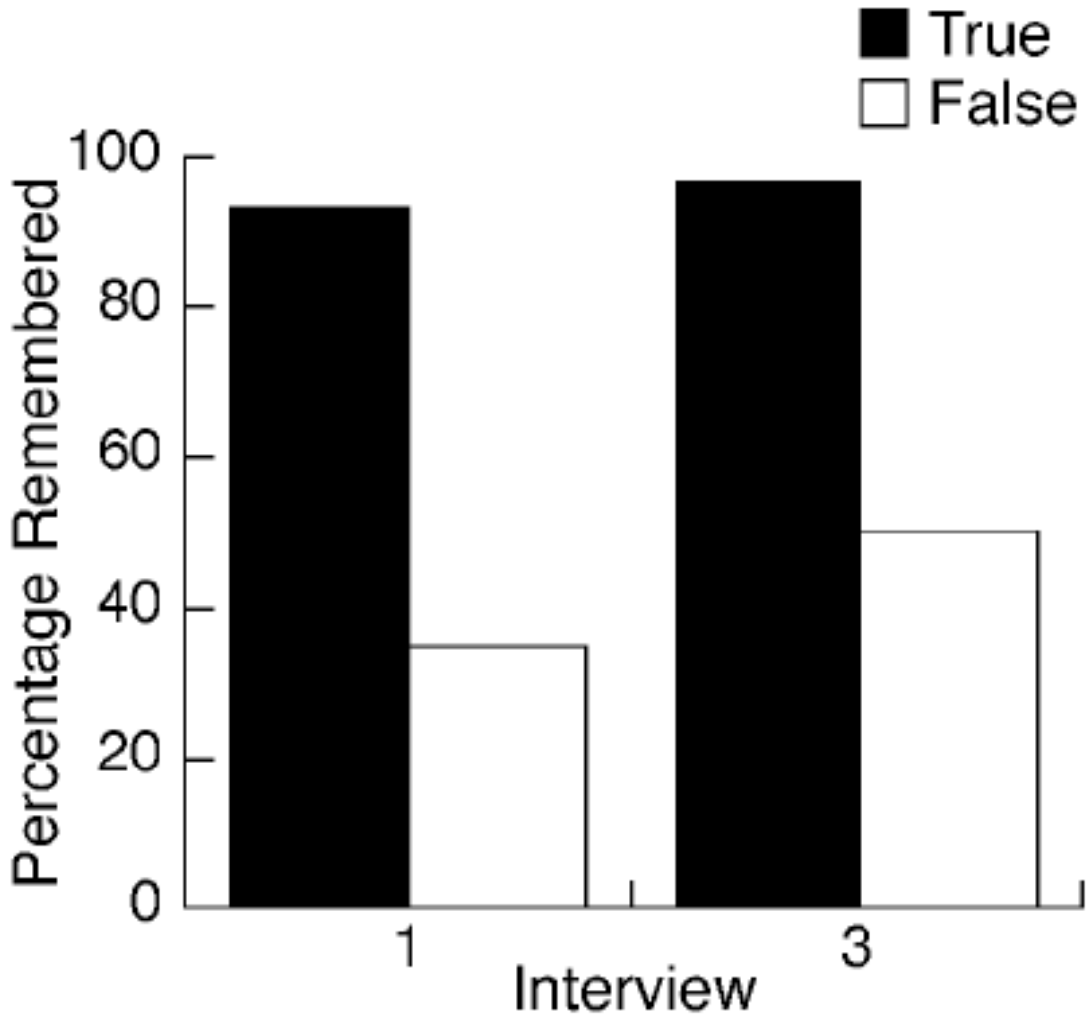


Figure 2. Mean percent of events remembered by event type and interview.

PSYCHOLOGICAL SCIENCE

Research Article

True Photographs and False Memories

D. Stephen Lindsay,[1] Lisa Hagen,[1] J. Don Read,[1] Kimberley A. Wade,[2] and Maryanne Garry[2]

[1]University of Victoria, Victoria, British Columbia, Canada, and [2]Victoria University of Wellington, Wellington, New Zealand


HEATHWOOD PUBLIC
SCHOOL

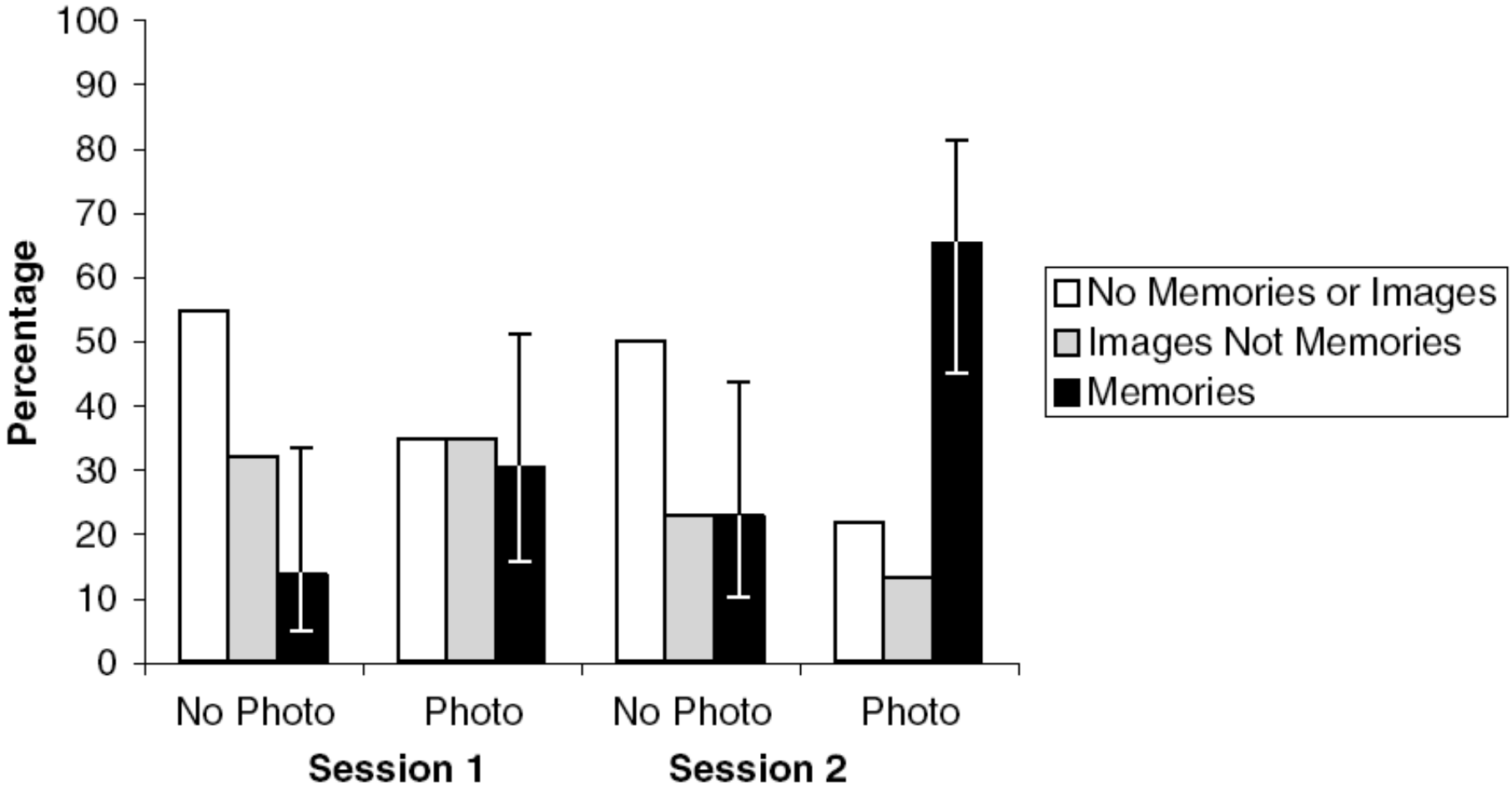


Fig. 2. Percentage of subjects classified as having no memories or images, images but not memories, and memories of the pseudoevent, as a function of experimental condition and session. The error bars represent 95% confidence intervals around the proportion of subjects classified as having memories of the suggested event, calculated using VassarStats (Lowry, 2003).

False Memories in Children

For 10 consecutive weeks, preschool children were interviewed by a trained adult
Child shown set of cards, each w/ different event
Card read to child, asked if event ever happened to them

e.g., Got finger caught in a mousetrap and had to go to hospital to get the trap off.

“Think real hard, and tell me if this ever happened to you. Can you remember going to the hospital with the mousetrap on your finger?”

After 10 wks, tested by new adult.

Tell me if this ever happened to you…e.g., mousetrap

Can you tell me more? What did you see? Who was with you? etc. depending on each child's answers.

"My brother Colin was trying to get Blowtorch from me, and I wouldn't let him take it from me, so he pushed me into the wood pile where the mouse trap was. And then my finger got caught in it. And then we went to the hospital, and my mommy, daddy, and Colin drove me there, to the hospital in our van, because it was far away. And the doctor put a bandage on this finger [indicating which]. "

58% of the preschoolers produced false narratives to one or more of the fictitious events

Engagement of imagination can affect memory

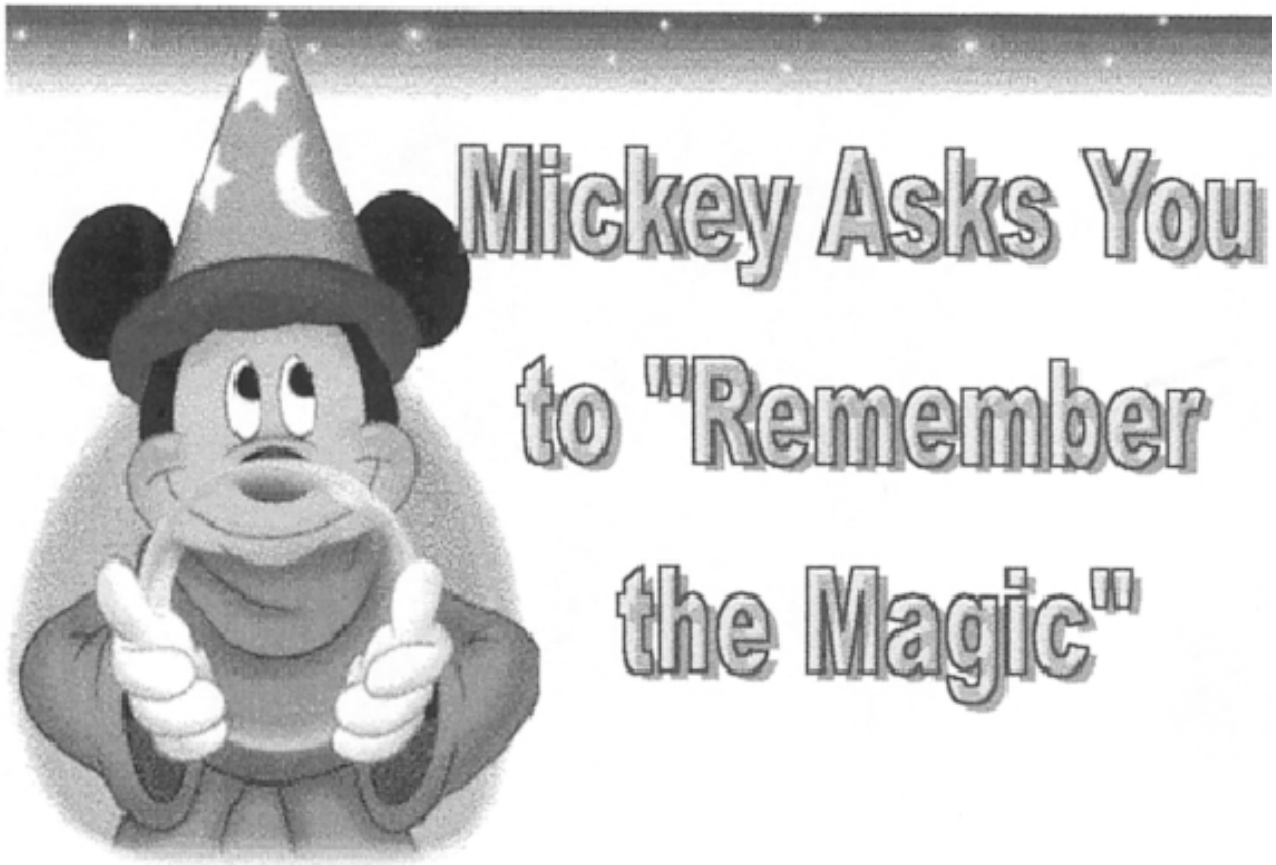
Reference to autobiographical memories can lead to false recollection

Make My Memory: How Advertising Can Change Our Memories of the Past

Kathryn A. Braun
Harvard Business School

Rhiannon Ellis
University of Pittsburgh

Elizabeth F. Loftus
University of Washington



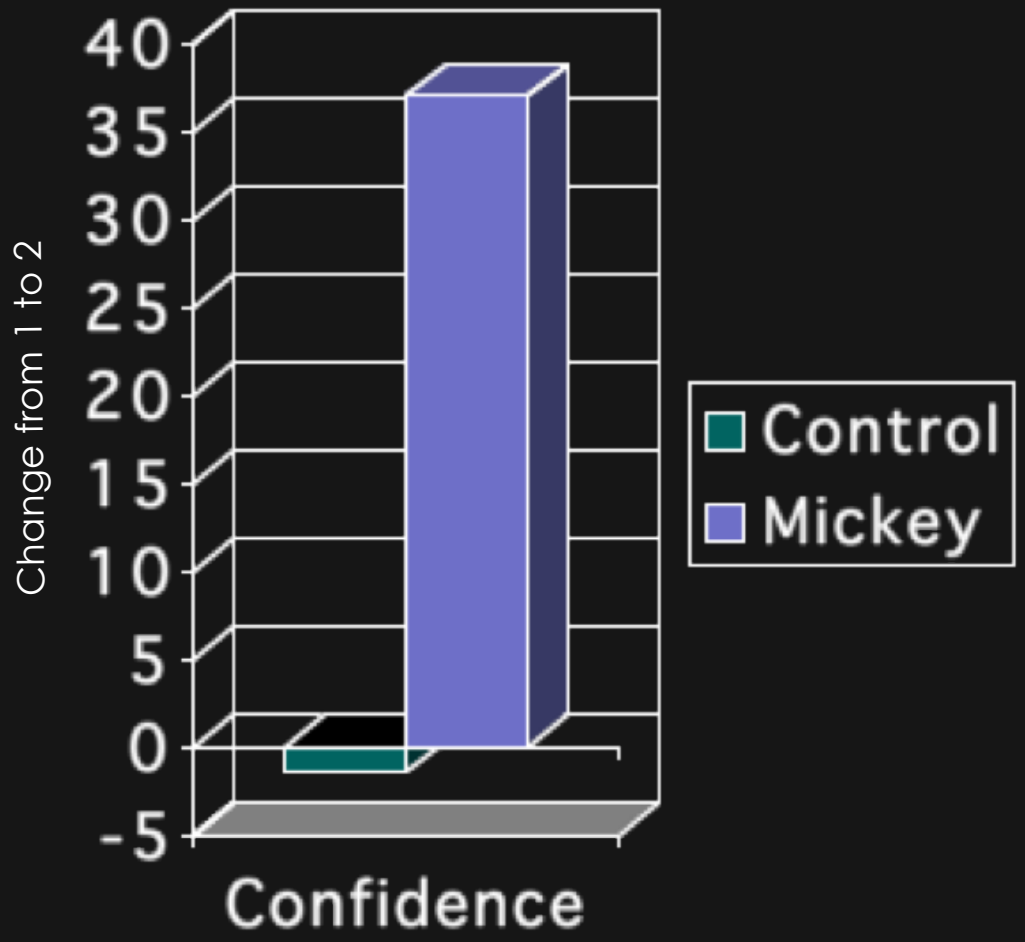
Subjects were given a list of 20 childhood events and asked whether they had occurred under the age of 10

e.g., “Have you ever shaken hands with a character at a theme resort?”

Half of the subjects were given a Mickey ad and half were given a control ad . Asked to rate the ad on various scales.

After, subjects filled out childhood experiences inventory again.

Subjects seeing the Mickey ad showed significantly increased confidence that they had shaken hands with Mickey



“Have you ever shaken hands with a cartoon character in a theme park?”


Bugs
Mickey Asks You
to "Remember
the Magic"

1/3 were given ad with Bugs at Disneyland

1/3 Little Mermaid at Disneyland

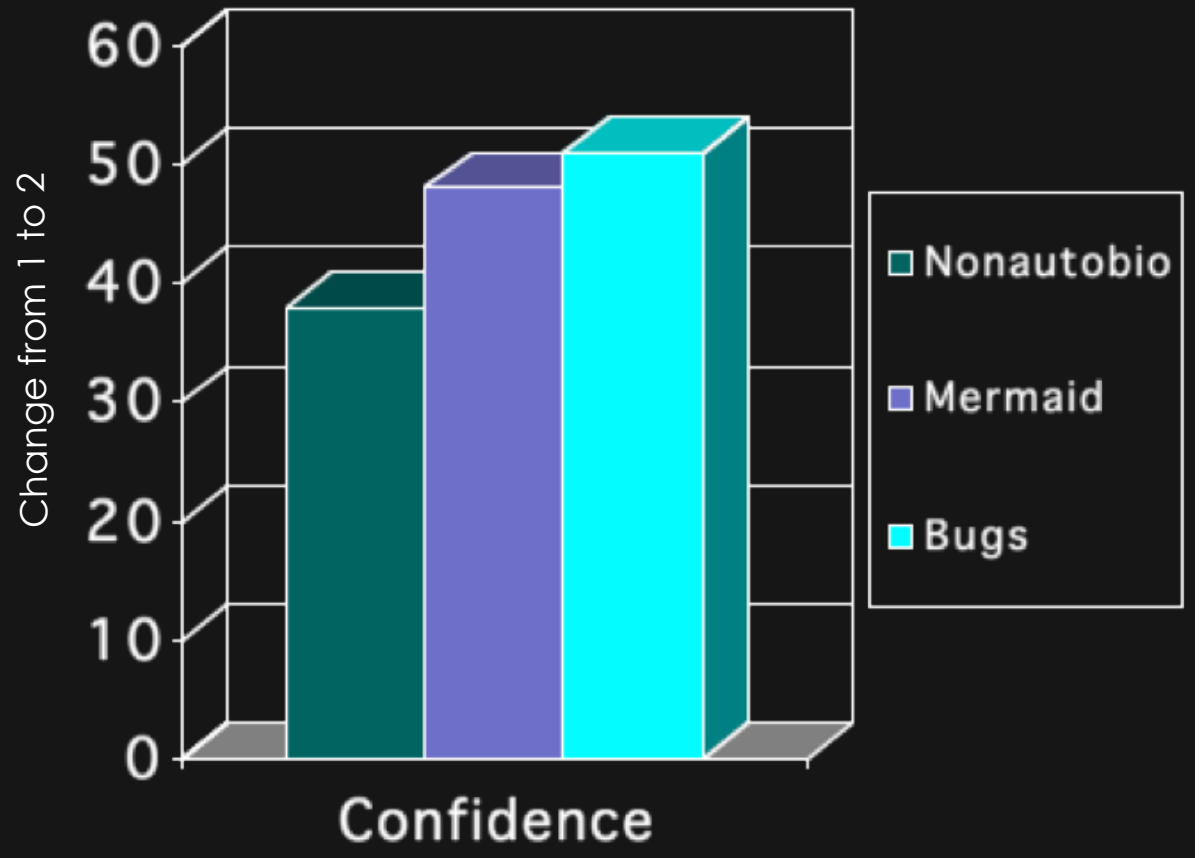
1/3 nonautobiographical Disney ad.

Asked to rate the ads on various scales

After, fill out childhood experiences inventory again.

Subjects who were initially confident that they HAD shaken hands with cartoon character were excluded

Specific mention of 1 of the 2 impossible characters was more effective than non-auto biographical



Memories for personally experienced traumatic events can be altered by new experiences.

Entire events – even impossible ones - that never happened can enter into memory.

Conversely, entire events can be forgotten.

Individuals from preschool to adulthood are susceptible to memory distortion.

Even when memory is vivid and compelling, it does not necessarily mean that it is accurate.

Episodic memories are imperfect, subject to error and reconstruction, distortion and dissociations from confidence and accuracy.

False memories are constructed by combining actual memories with the content of suggestions received from others. During the process, individuals may forget the source of the information.

Imagination also helps form false memories.

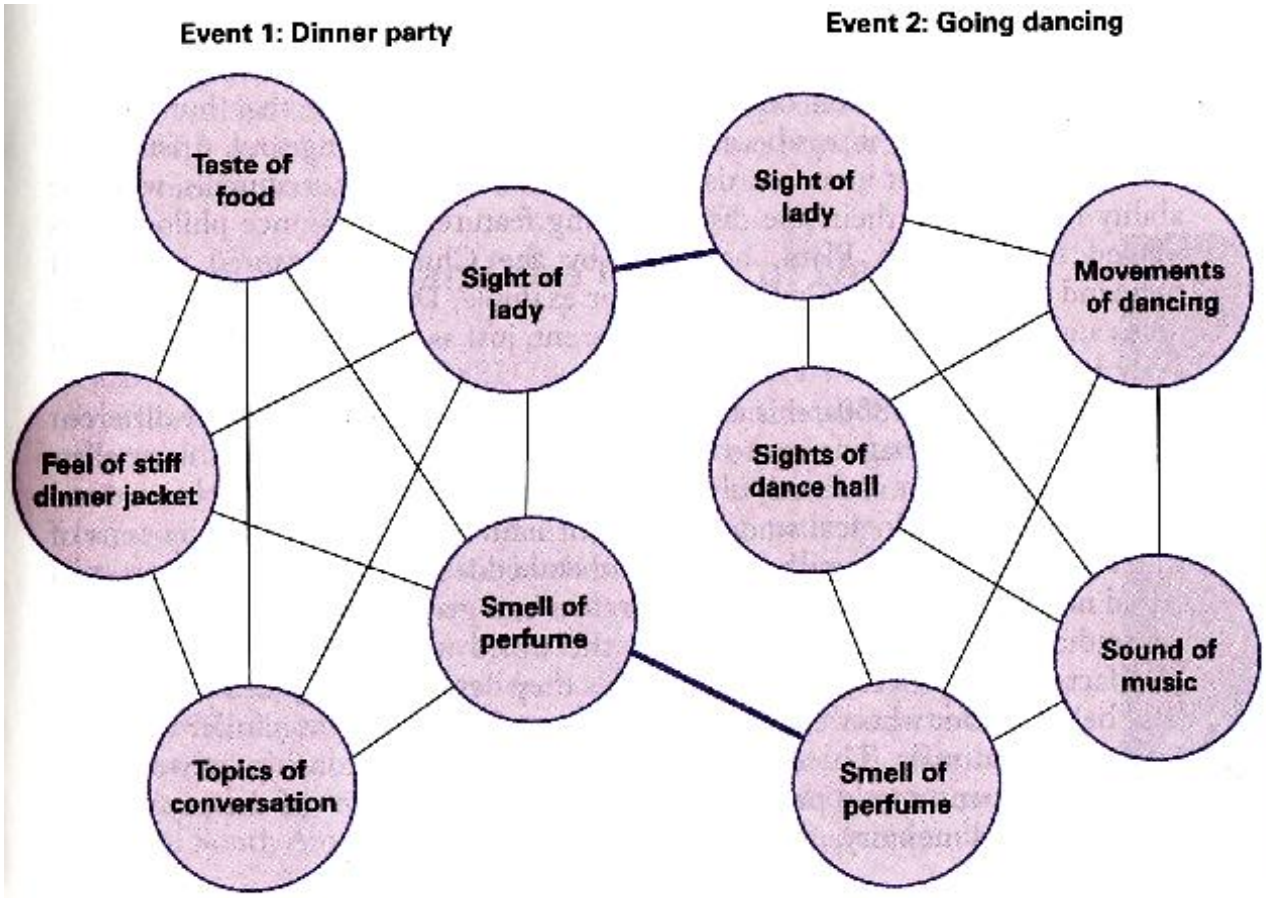


Figure 1.2 William James's memory model
Memory of an event, such as a dinner party, has multiple components, such as the taste of the food, the topics of conversation, and the smell of perfume, all linked together. Another event, such as going dancing with a lady from the dinner party, also has component parts linked together. An association between the two events in turn consists of multiple connections between the underlying components.