Outline

- Conditioning
- Emotion and Memory

Conditioning

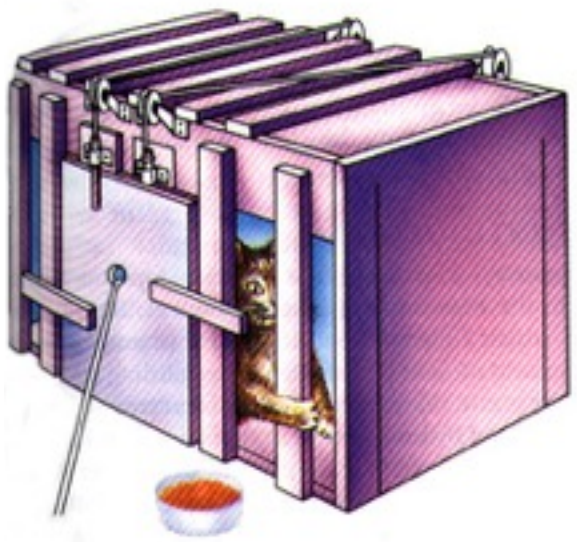
Classical Conditioning

- Principles and Stages of conditioning
- Model of Classical Conditioning

Operant Conditioning

- Schedule of Reinforcement

Operant Conditioning
(aka Instrumental Conditioning)



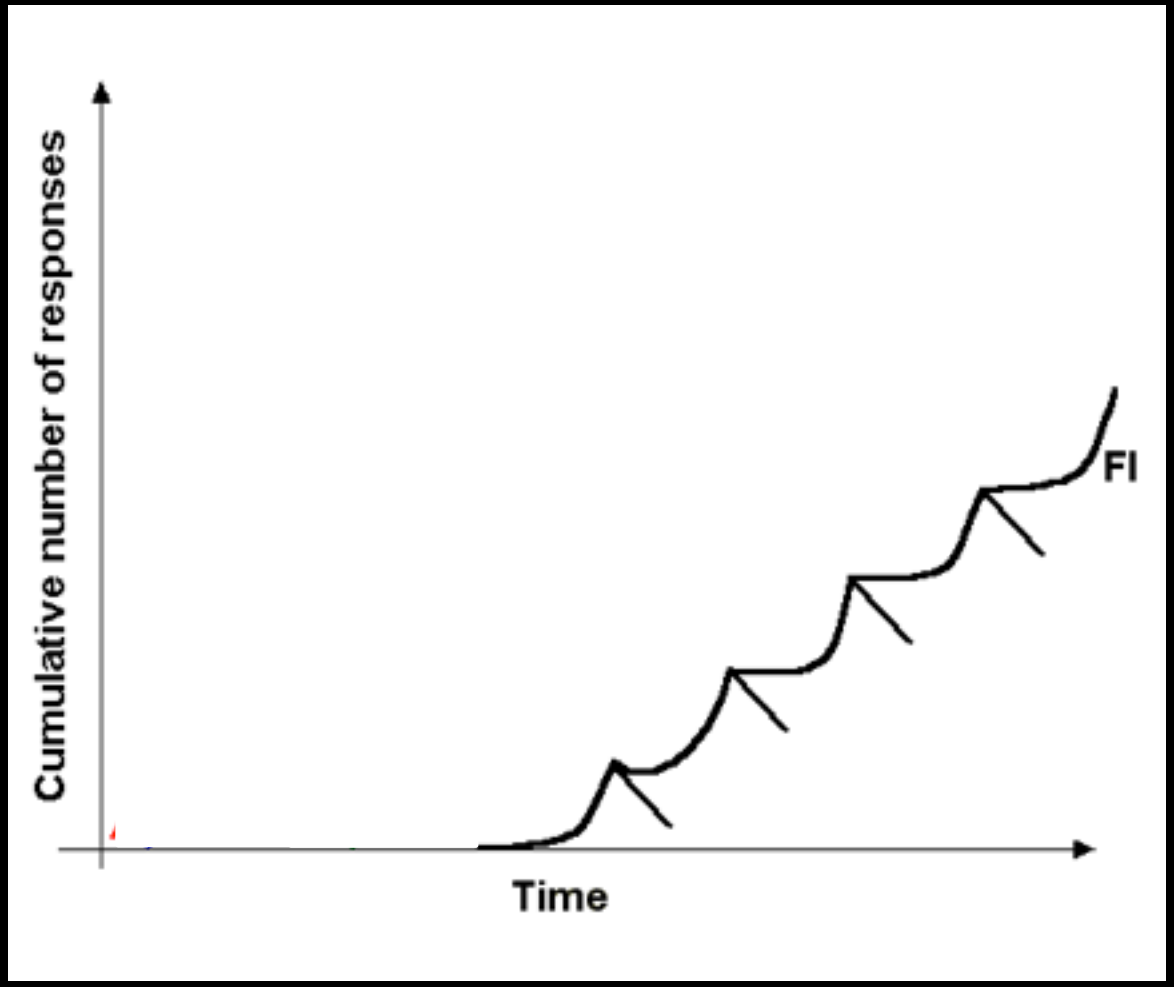
Thordike studied rate at which cats learned to press lever to escape box

CS = puzzle box; **CR** = press lever; **US** = escape + food (reward)

In **classical conditioning**, learn Stim1 (CS) predicts Stim2 (US)
In **operant conditioning**, learn CR elicits US (reward)

Operant Conditioning & Reward Schedules

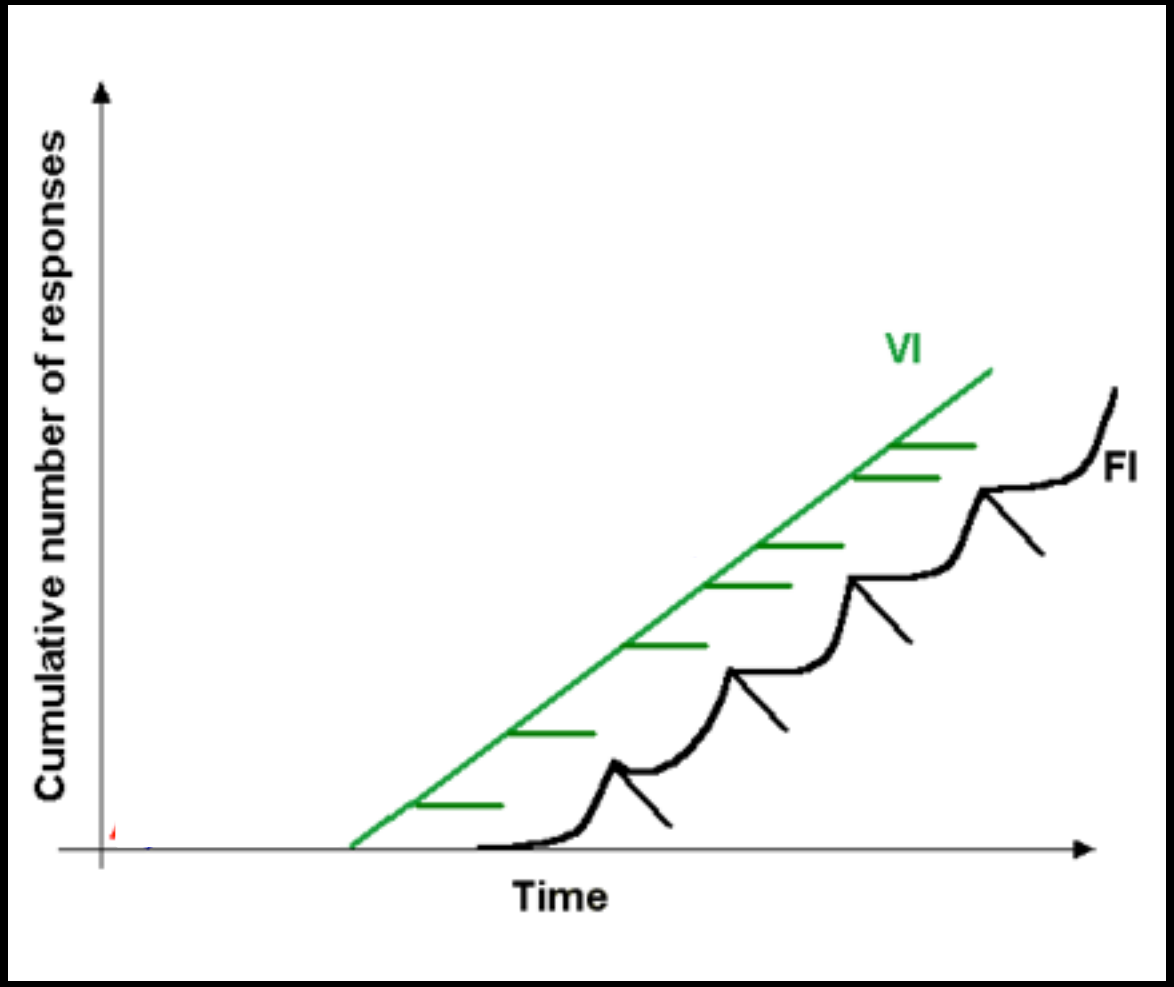
FI = fixed interval; rewarded after fixed amount of time



Operant Conditioning & Reward Schedules

VI = variable interval; rewarded after variable amount of time

FI = fixed interval; rewarded after fixed amount of time

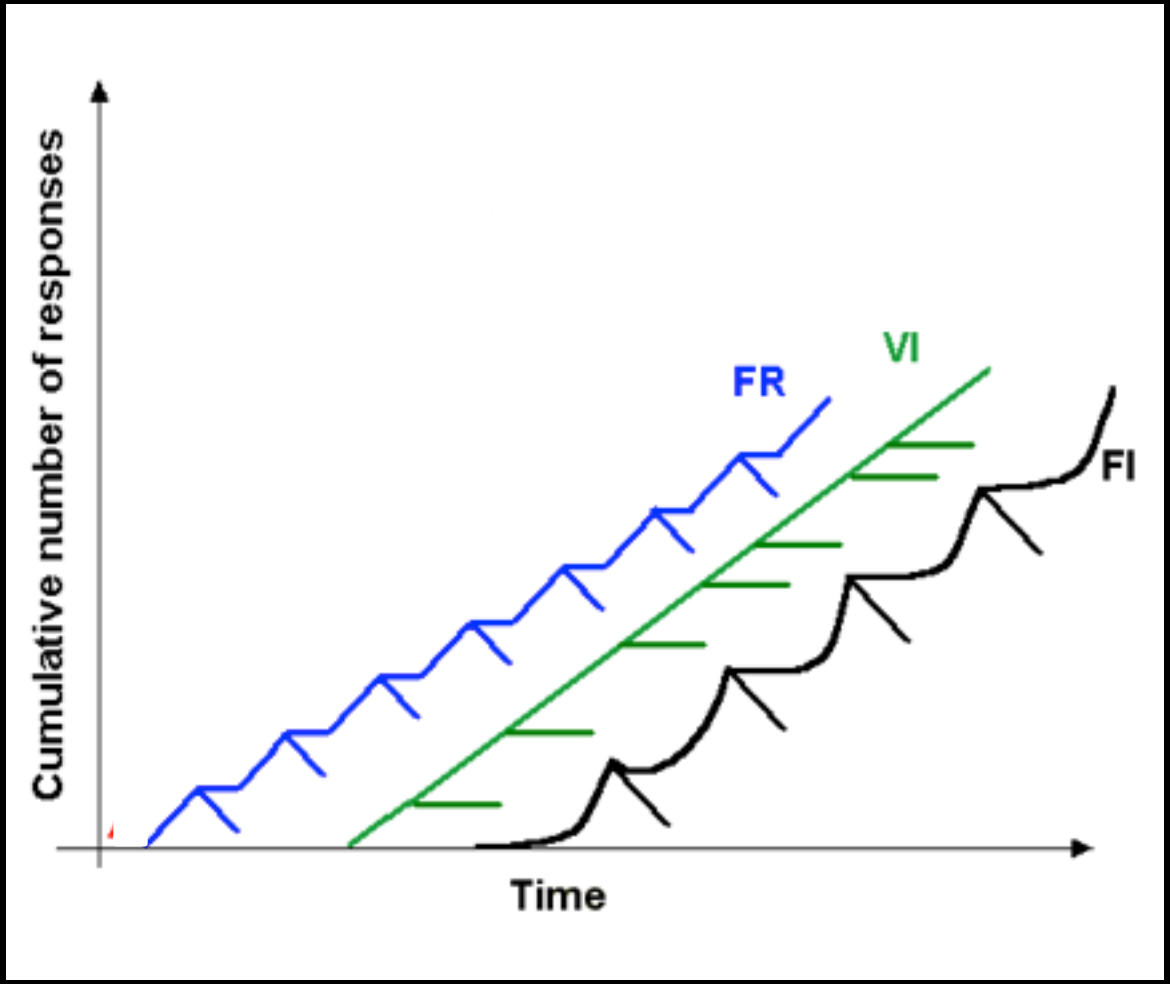


Operant Conditioning & Reward Schedules

FR = fixed ratio; rewarded after fixed # of responses

VI = variable interval; rewarded after variable amount of time

FI = fixed interval; rewarded after fixed amount of time



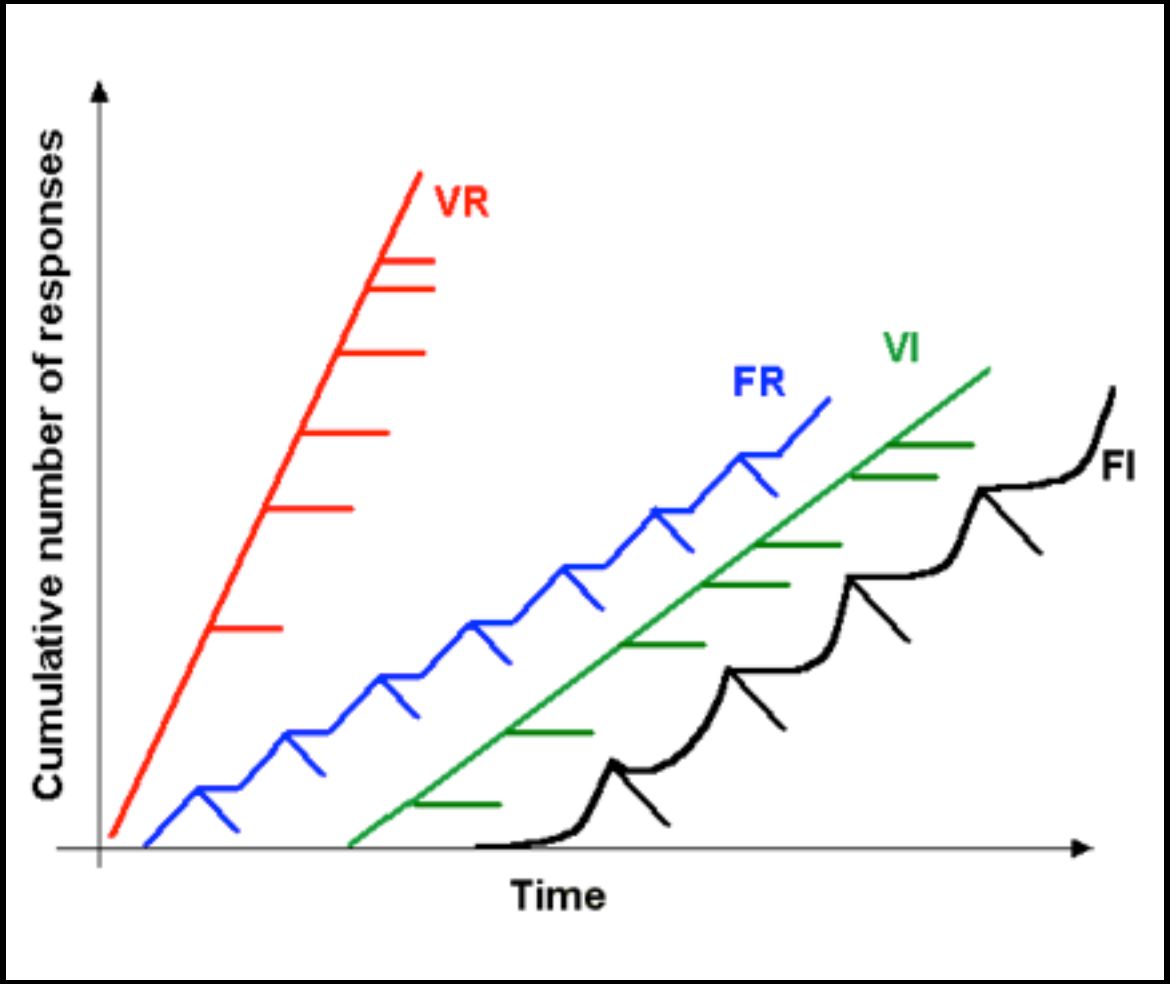
Operant Conditioning & Reward Schedules

VR = variable ratio; rewarded after variable # of responses

FR = fixed ratio; rewarded after fixed # of responses

VI = variable interval; rewarded after variable amount of time

FI = fixed interval; rewarded after fixed amount of time



Reward Schedules

Variable reinforcement schedule

Will yield greater rate of responding

Extinction occurs slowly

Fixed reinforcement schedule

Will yield lower rate of responding

Extinction occurs quickly

Conditioning Recap

Classical Conditioning

- Principles and Stages of conditioning
- Rescorla-Wagner model of conditioning: Prediction Error drives conditioning/learning

Operant Conditioning

- Response rate depends on reward schedule

Outline

- Conditioning
- Emotion and Memory
  - What is emotion and how is it measured
  - Amygdala and emotion
  - Fear conditioning
  - Episodic memory for emotional events

Emotion and Memory

Selection is the very keel on which our mental ship is built. And in the case of memory, its utility is obvious. If we remembered everything, we should on most occasions be as ill off as if we remembered nothing.

-- William James

An impression may be so exciting emotionally as almost to *leave a scar upon the cerebral tissues.*

-- William James

What is Emotion?

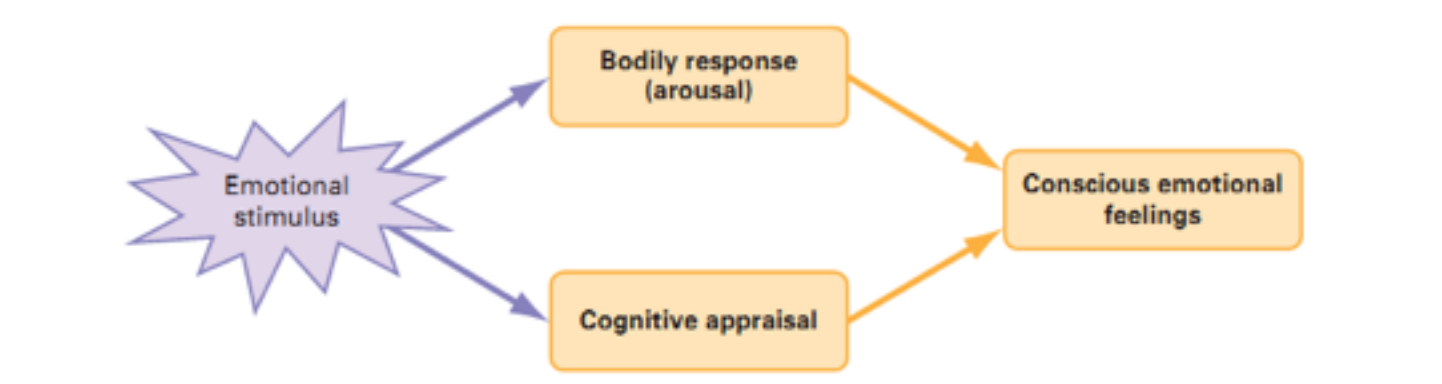
- A brief episode of synchronized responses including:
  - Physiological responses (e.g., increased heart rate)
  - Overt behaviors (e.g., jumping)
  - Conscious feelings (e.g., being afraid)

- Emotions help us:
  - Coordinate our physiology and behavior to adaptively react to a situation
  - Communicate

Experiencing Emotions

- Physiological arousal and the context in which it's experienced are combined to generate conscious feelings

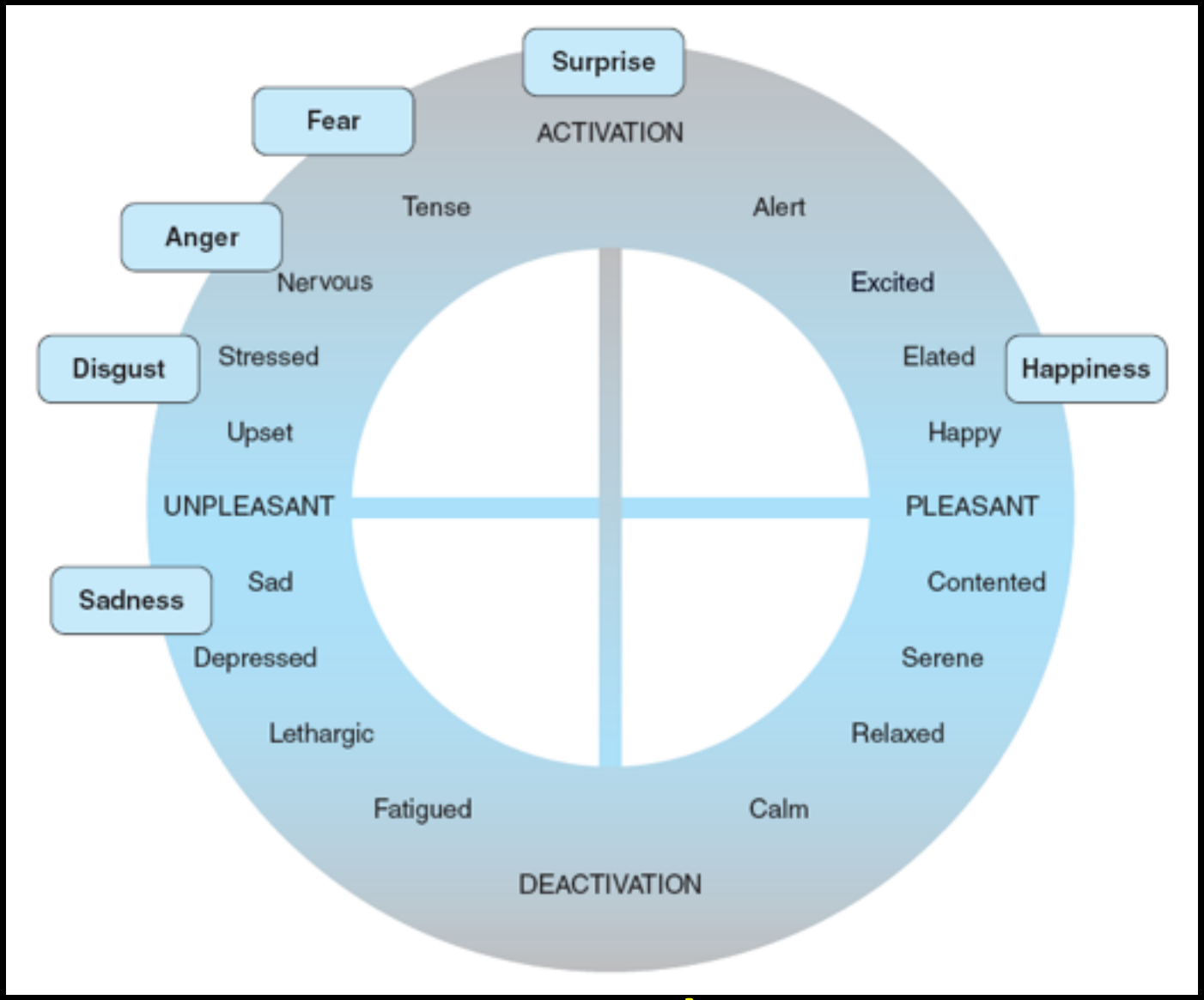
- i.e., emotions are based on our cognitive appraisal of a situation



Dimensions of Emotions

- Subjects are often asked to rate their emotional responses along two dimensions…
- **Arousal**
  - Degree of bodily changes that occur during an emotional response
- **Valence**
  - Subjective quality (positive or negative) of an emotional response

Dimensions of Emotions



Valence

Arousal

Measuring Emotions

- Emotions can also be measured *indirectly* by observing behavior or taking physiological measurements
  - Particularly useful when studying animals
- Popular physiological measure in humans is the **skin conductance response** (SCR)
  - Change in electrical conductivity of the skin dependent upon perspiration level (regulated by autonomic nervous system; ANS)
  - Often used in “lie detector” tests

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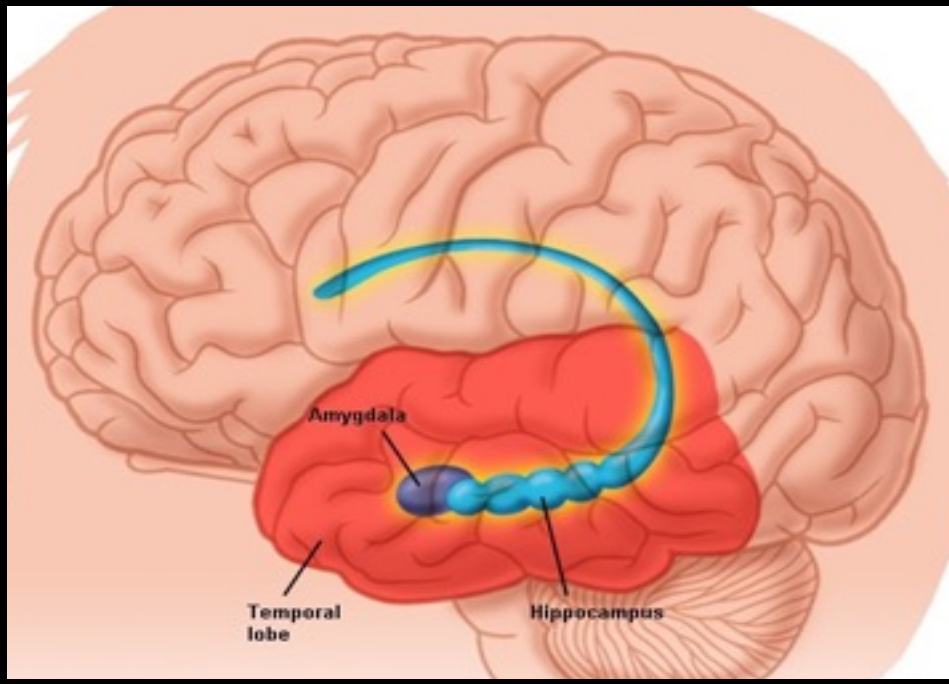
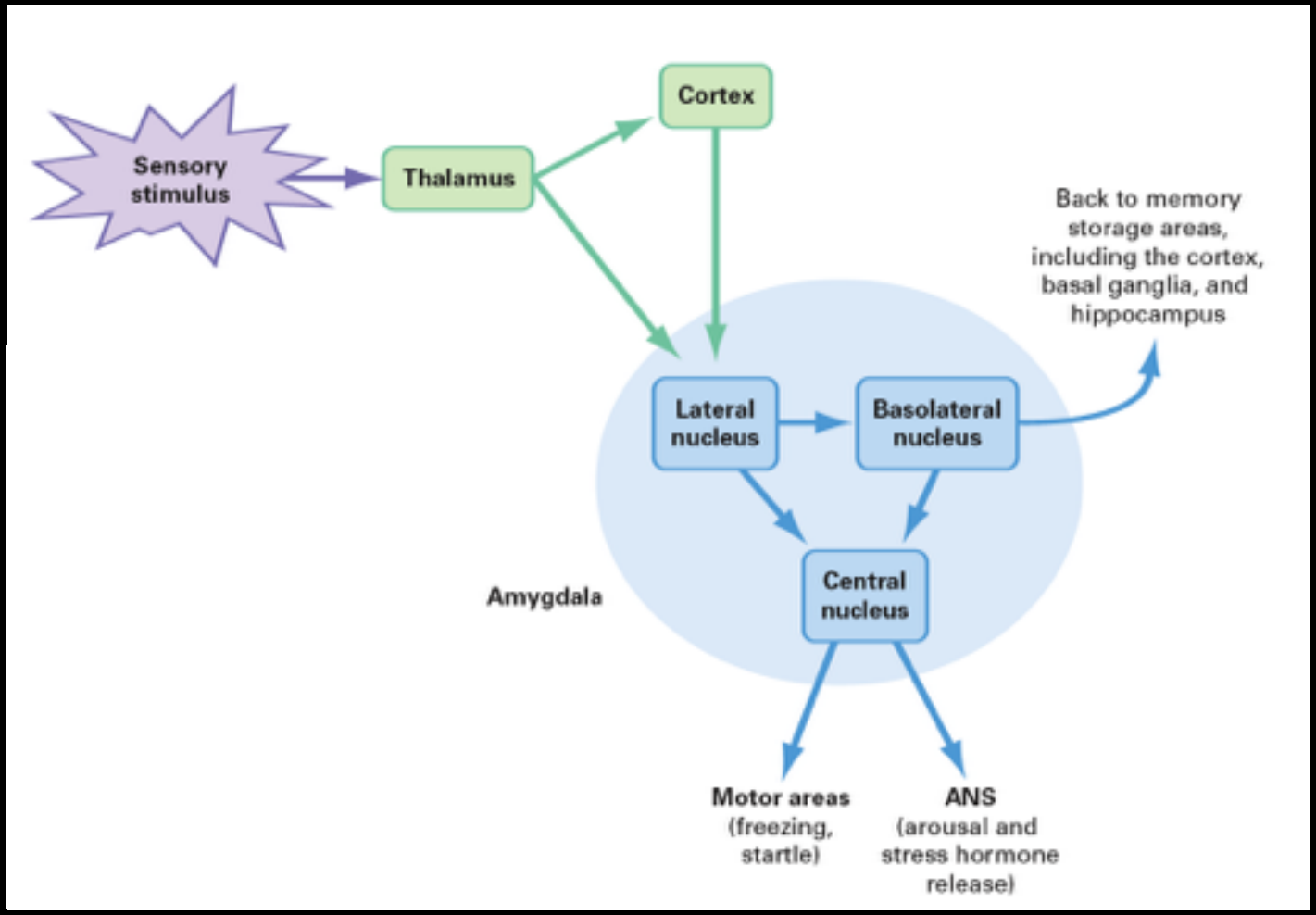
Emotion In the Human Brain

Amygdala

- Small structure located anterior to hippocampus in the medial temporal lobe
- Critical for processing emotion (both negative and positive), expressing emotions, and emotional learning
- Dysfunction linked to many types of emotional psychopathology



Emotion in the Human Brain



Amygdala input and output pathways

- receives multimodal sensory input from thalamus and cerebral cortices
- outputs to PFC, MTL, temporo-occipital cortex, and basal ganglia

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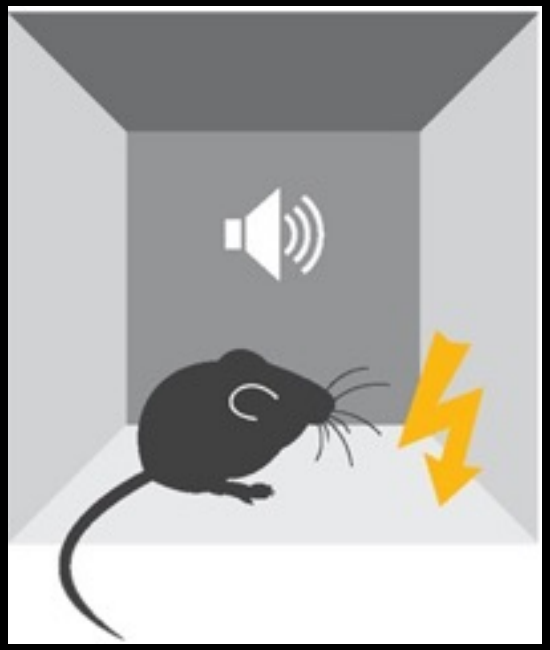
Fear Conditioning

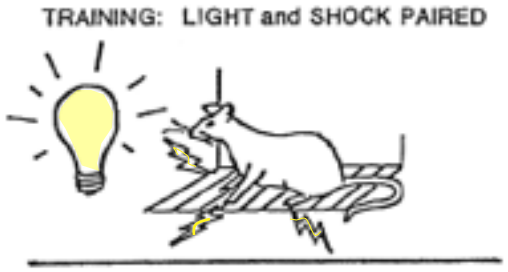


- With repeated CS (tone) – US (shock) pairings, animals show a fear response to the CS alone
  - Behavior: freezing
  - Physiological response: e.g., increased blood pressure
- Important in that it allows us to learn to predict danger

Amygdala & Fear Conditioning

Experimental Example

Light paired with shock (US); light becomes CS



When rat hears noise (US), it startles (UR)

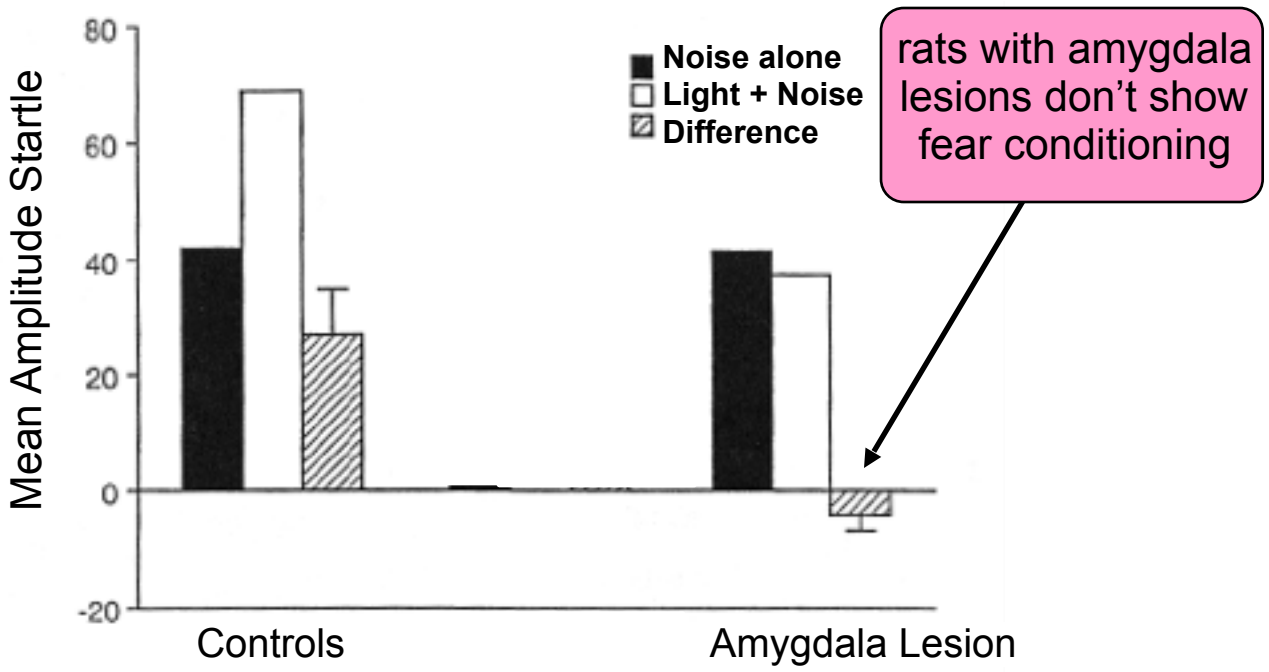
Testing:

noise alone

When rat sees light then hears noise, it *really startles*

light + noise

Amygdala & Fear Conditioning



Phobias

- Phobias often arise through fear conditioning

CS (sight of dog)

US (bite)

Phobias

- Phobias often arise through fear conditioning

CS (sight of dog)

US (bite)

CR (fear

Phobias

- Phobias often arise through fear conditioning
- Common therapeutic approach is **exposure therapy**
  - Very similar to the extinction phase of classical conditioning
  - Incremental exposure to the fear-inducing stimulus (CS) without an aversive event (US)

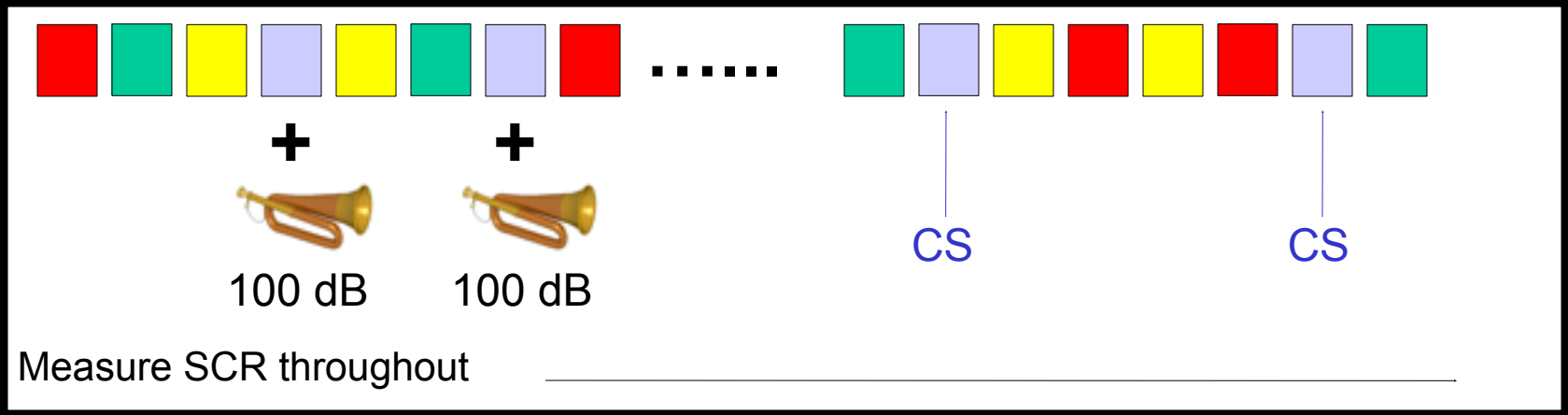
CS (sight of dog)

US (bite)

CR (fear

Aversive Autonomic Conditioning: Skin Conductance Response

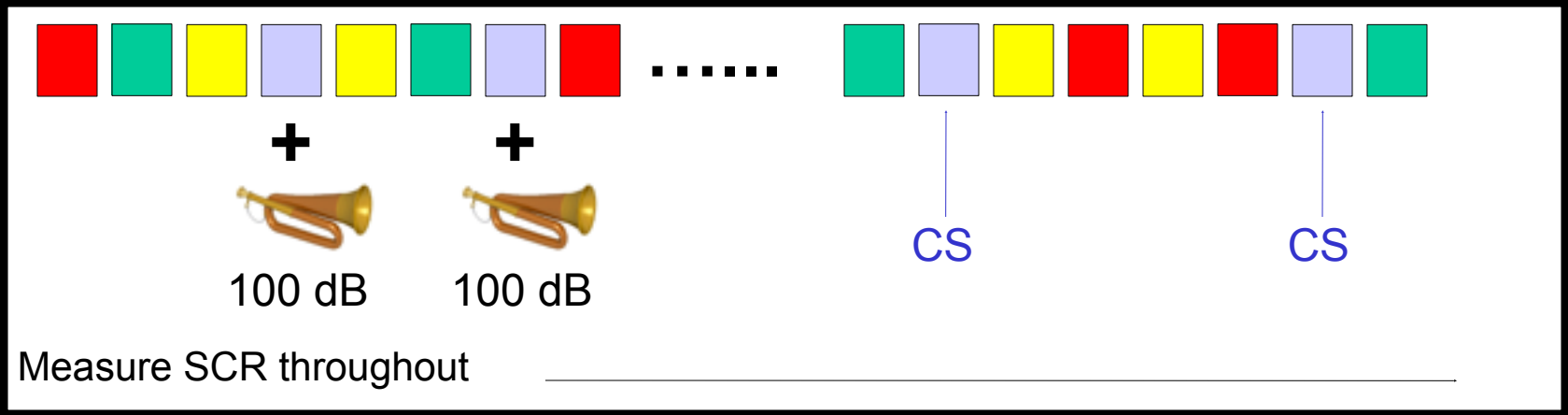
Experiment 1: Visual–Auditory conditioning



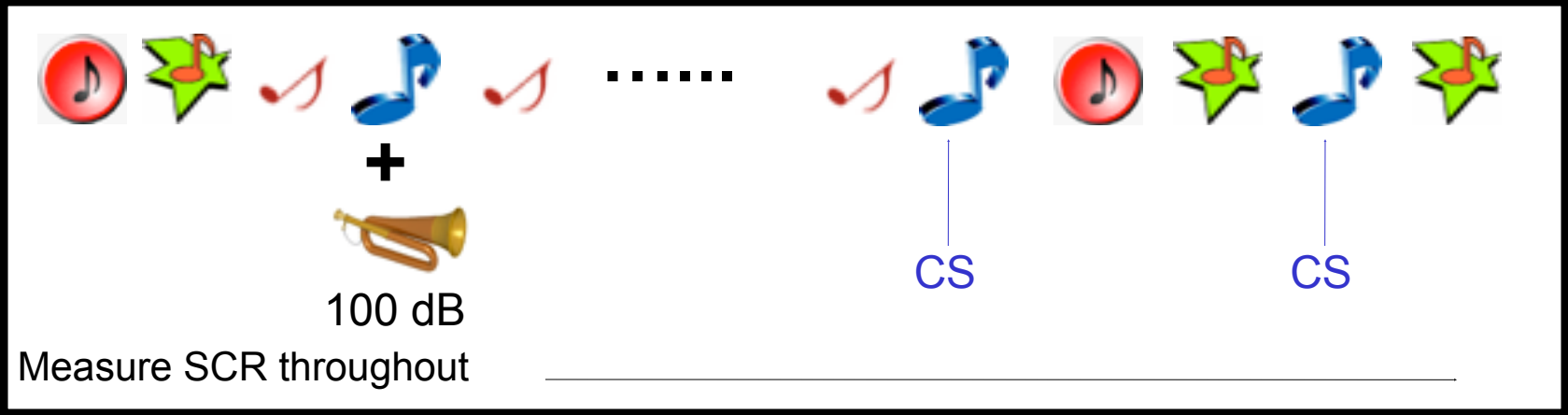
(Bechara et al. 1995)

Aversive Autonomic Conditioning: Skin Conductance Response

Experiment 1: Visual–Auditory conditioning



Experiment 2: Auditory–Auditory conditioning



(Bechara et al. 1995)

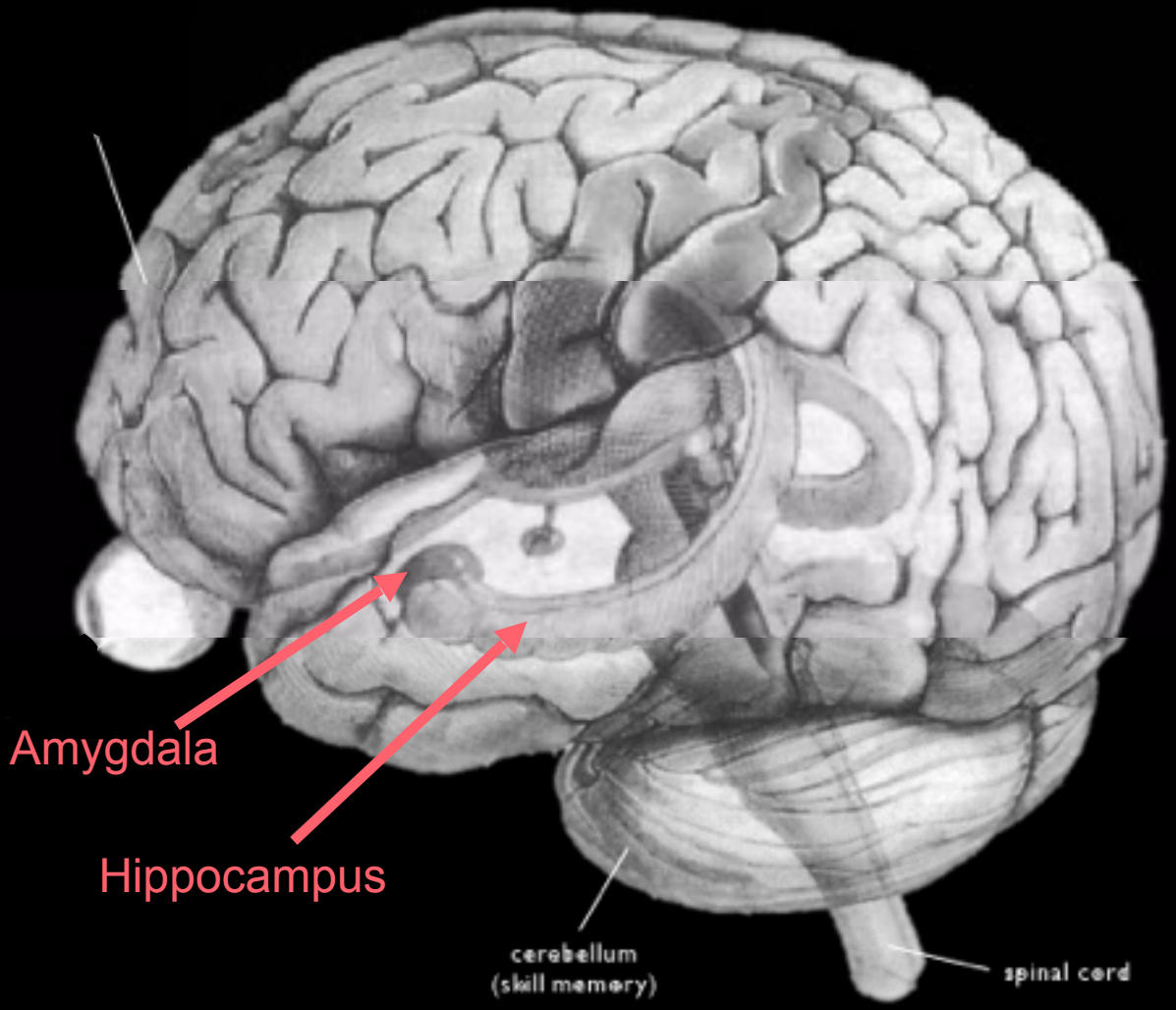
Aversive Autonomic Conditioning: Declarative Memory Test After Conditioning

Please answer the following:

- How many different colors did you see? _____
- Tell me the names of those colors. _____
- How many different colors were followed by the horn? _____
- Tell me the name(s) of the color(s) that were followed by the horn. _____

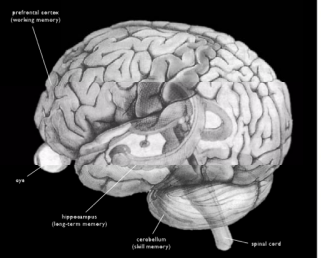
(Bechara et al. 1995)

Aversive Autonomic Conditioning: Role of Amygdala vs. Hippocampus



Double Dissociation between Classical Conditioning and Declarative Memory

Controls



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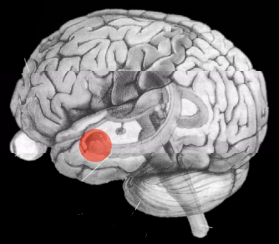
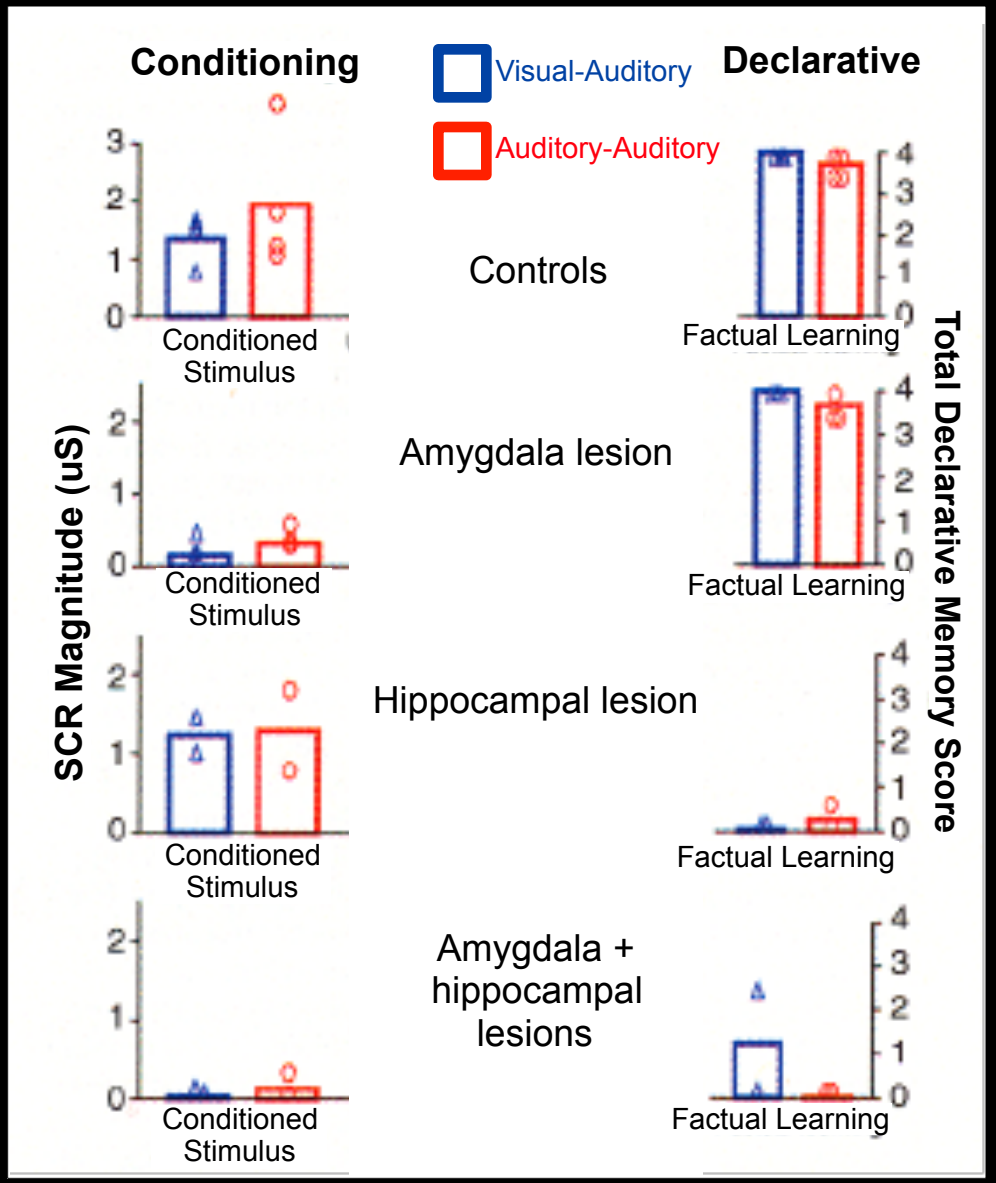


WC1606

RH1951

(Bechara et al. 1995)



Outline

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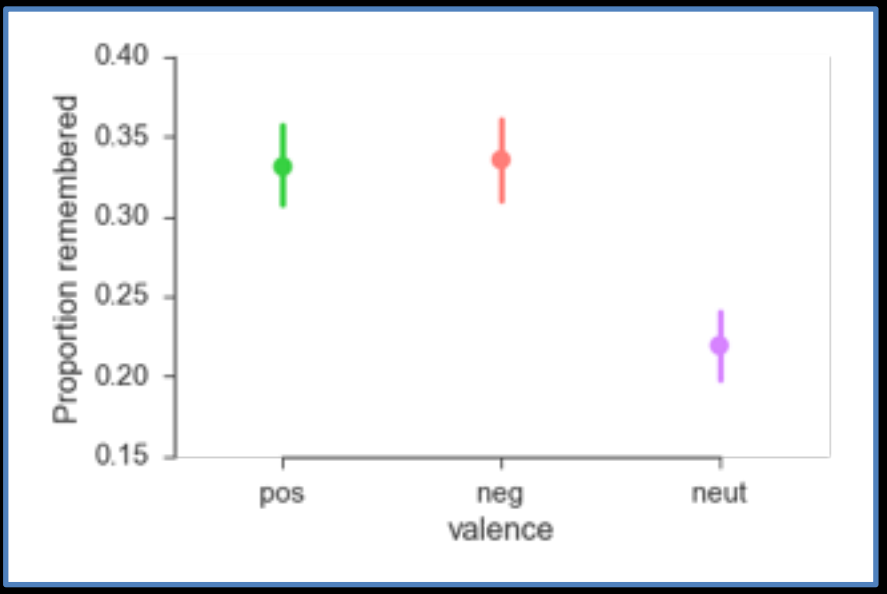
Are Episodic Memories for Emotional Events Special?

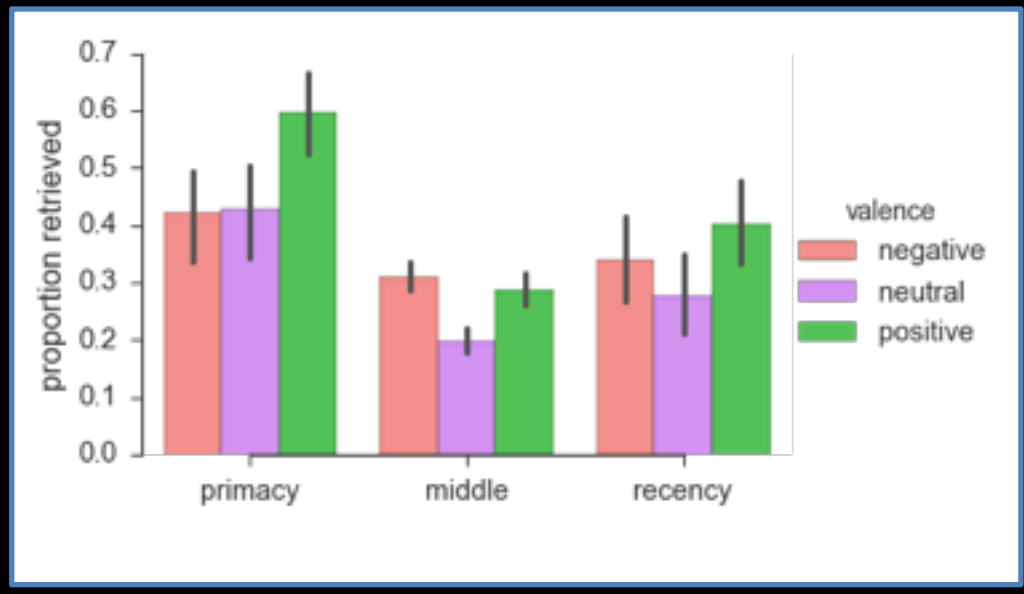
1) Probability of learning

2) Subjective vividness

3) Confidence in memory accuracy

Emotion Enhances Episodic Memory: Memory in Action

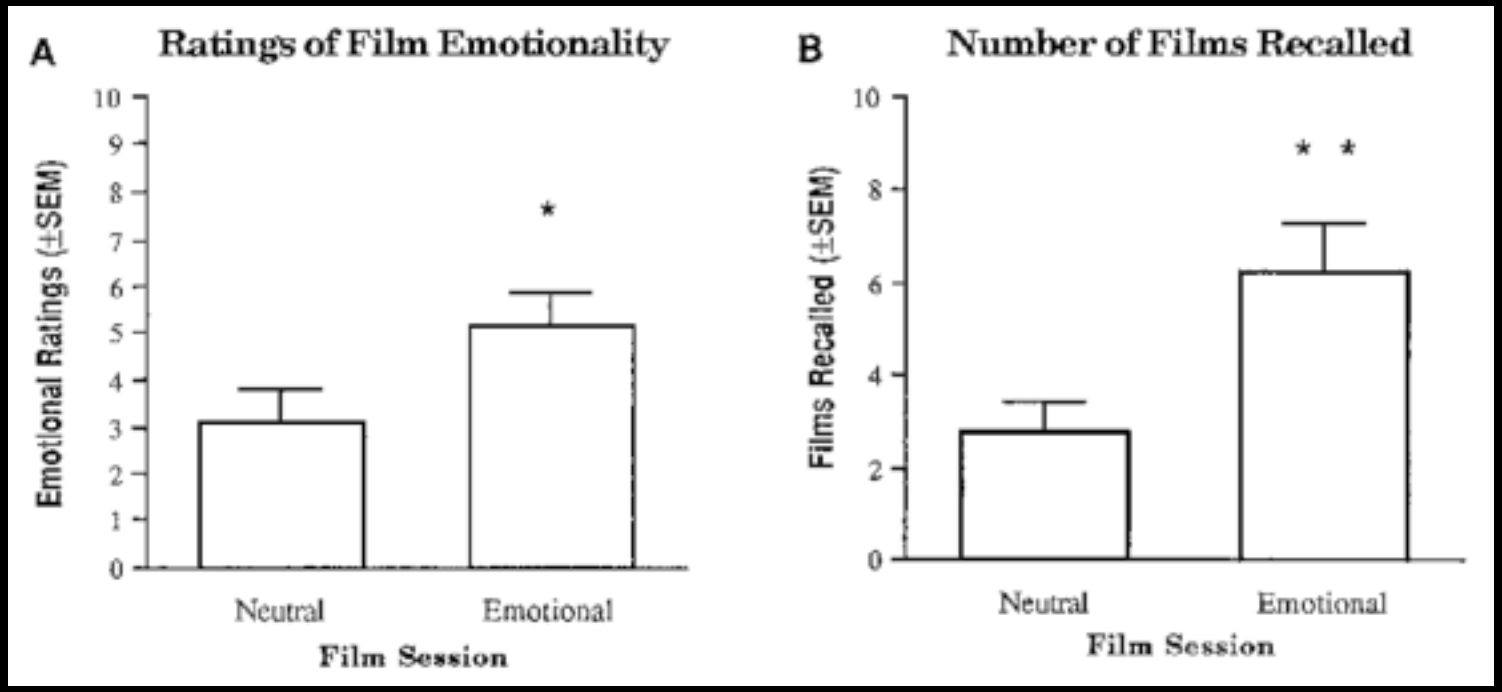




Emotion Enhances Episodic Memory

Task

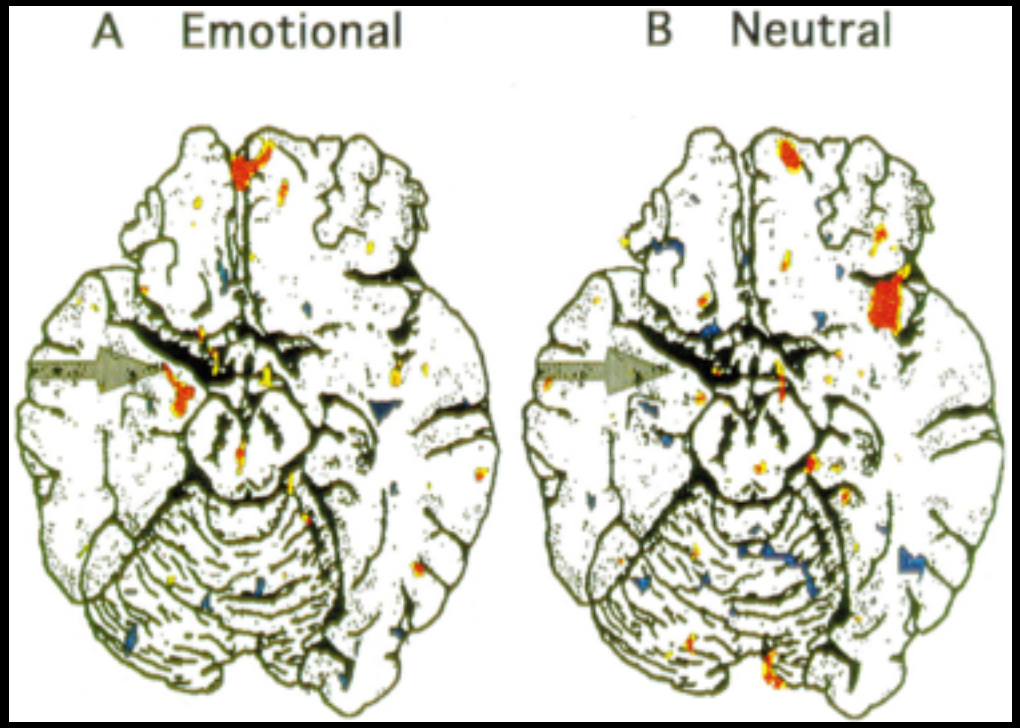
- watch 12 negative and 12 neutral film clips
- probe explicit memory for each clip

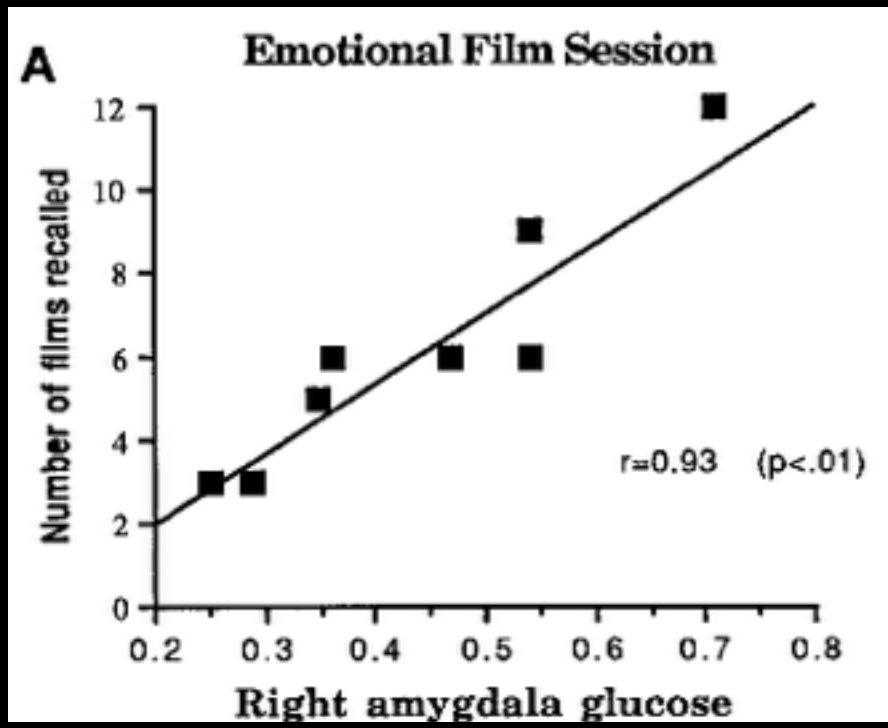


(Cahill et al., 1996)

Emotion Enhances Episodic Memory

Amygdala is differentially active during emotional events and modulates declarative memory formation

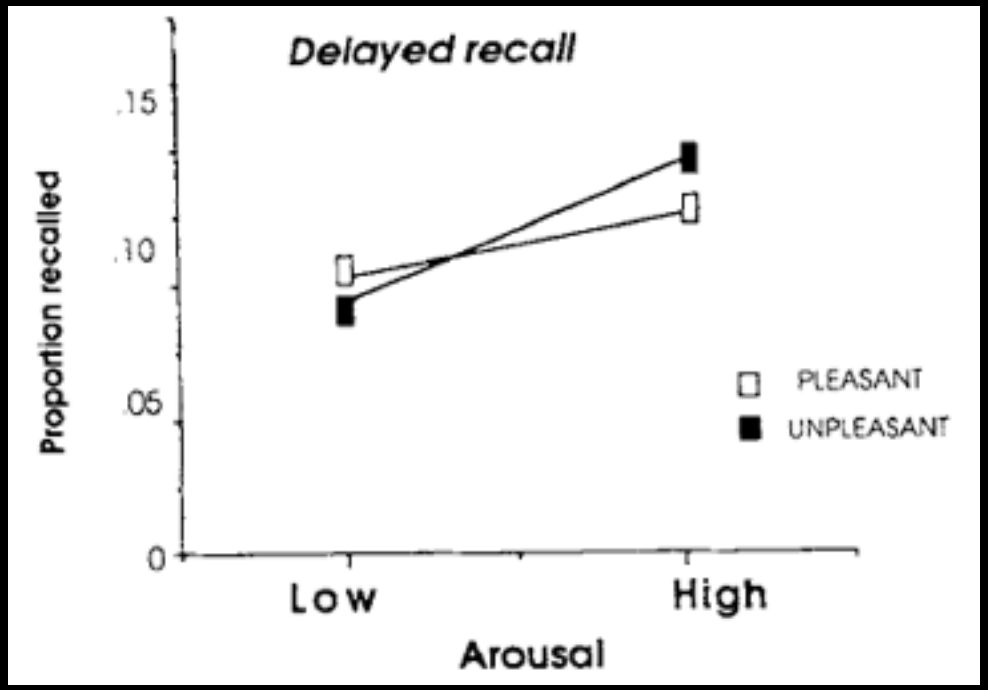




(Cahill et al., 1996)

Emotion Enhances Episodic Memory

Participants rated pleasant and unpleasant pictures on levels of valence and arousal. They were given a free-recall test of these pictures 1-year later:



Arousal, rather than valence, has biggest impact on episodic memory

(Bradley et al., 1992)

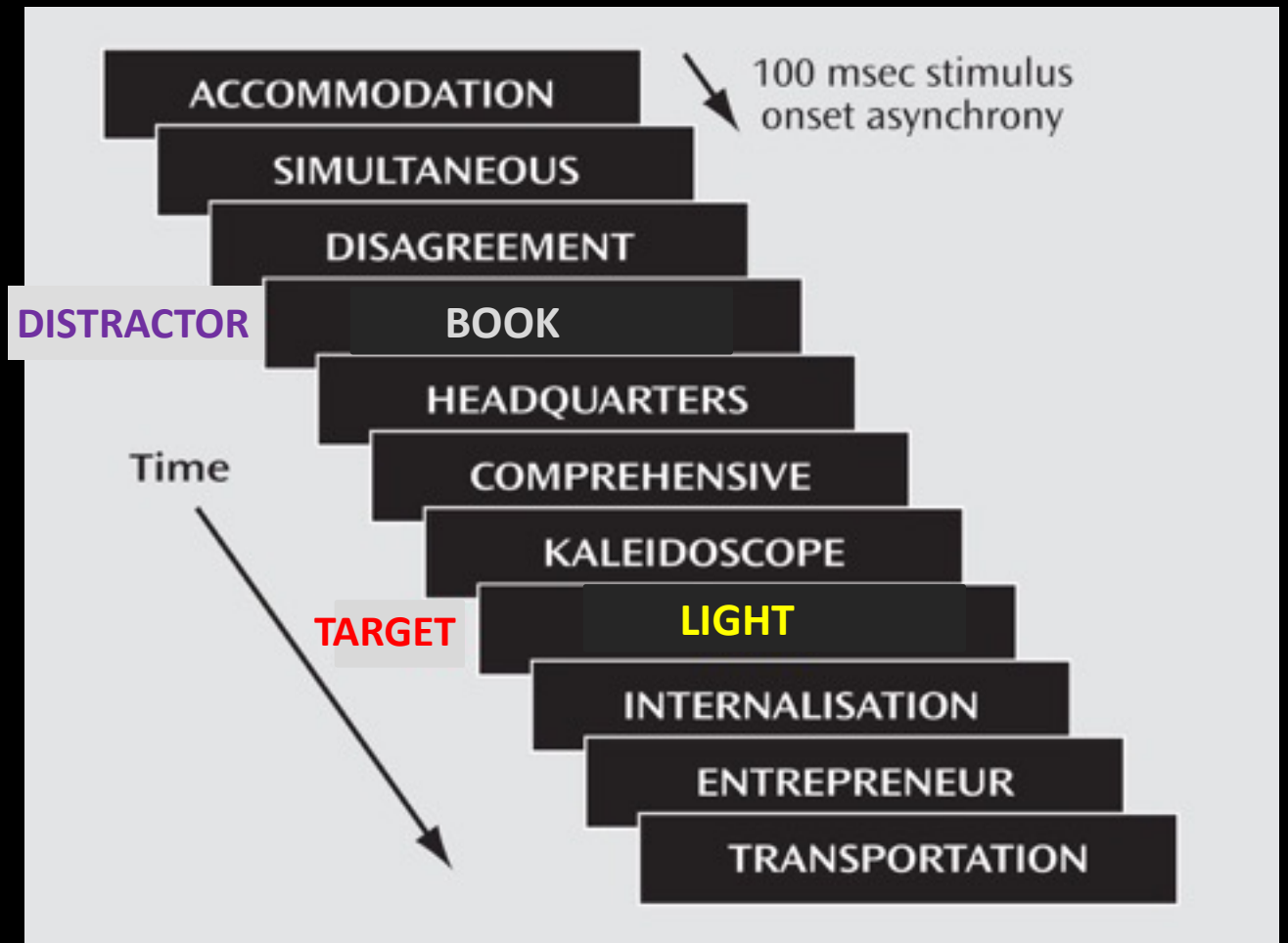
How Does Emotion Enhance Episodic Memory?

Factors related to encoding

Factors related to consolidation

Encoding of Emotional Events: Attentional Engagement

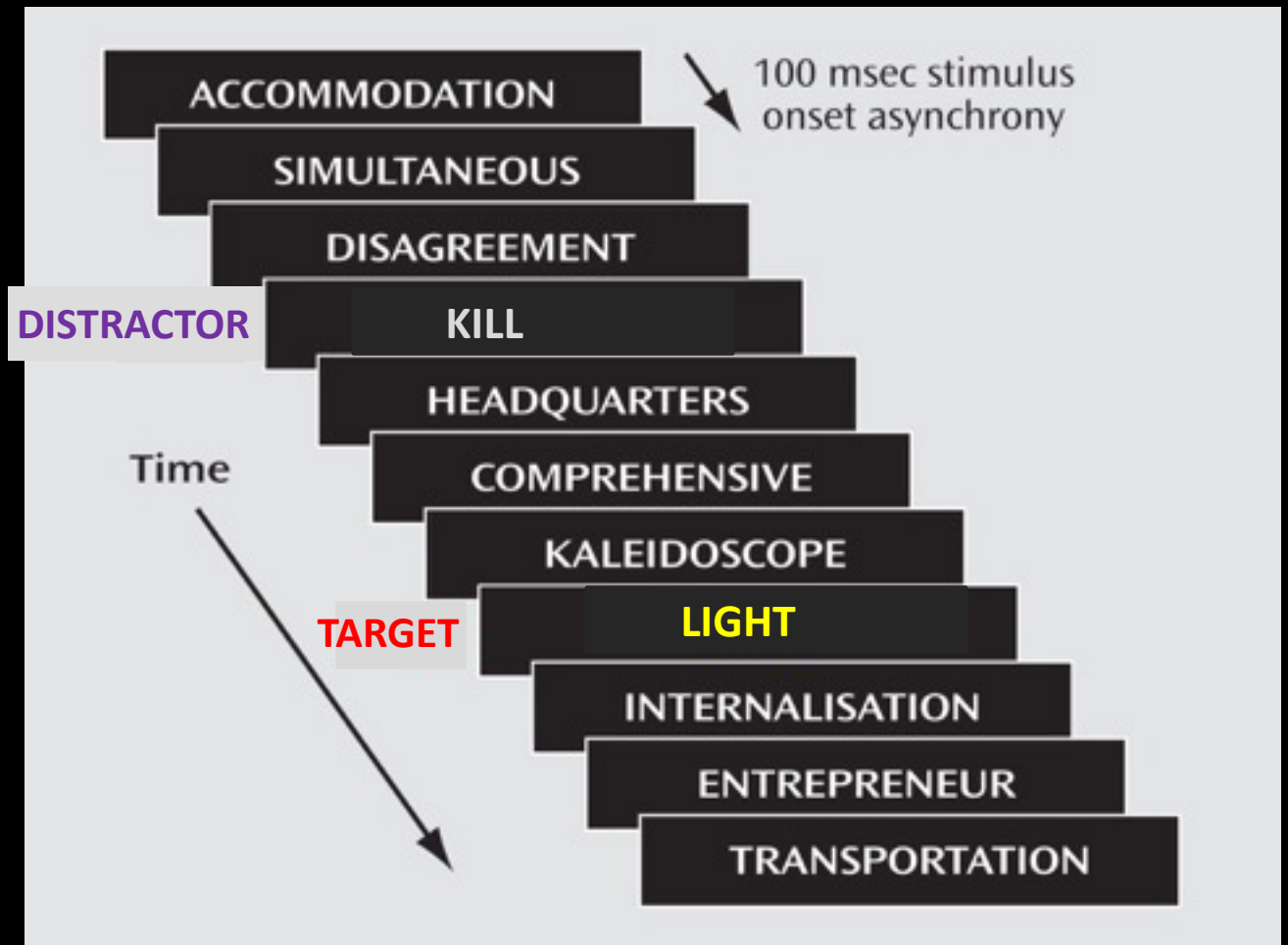
Attentional Rubbernecking Task



What was the target word?

Encoding of Emotional Events: Attentional Engagement

Attentional Rubbernecking Task



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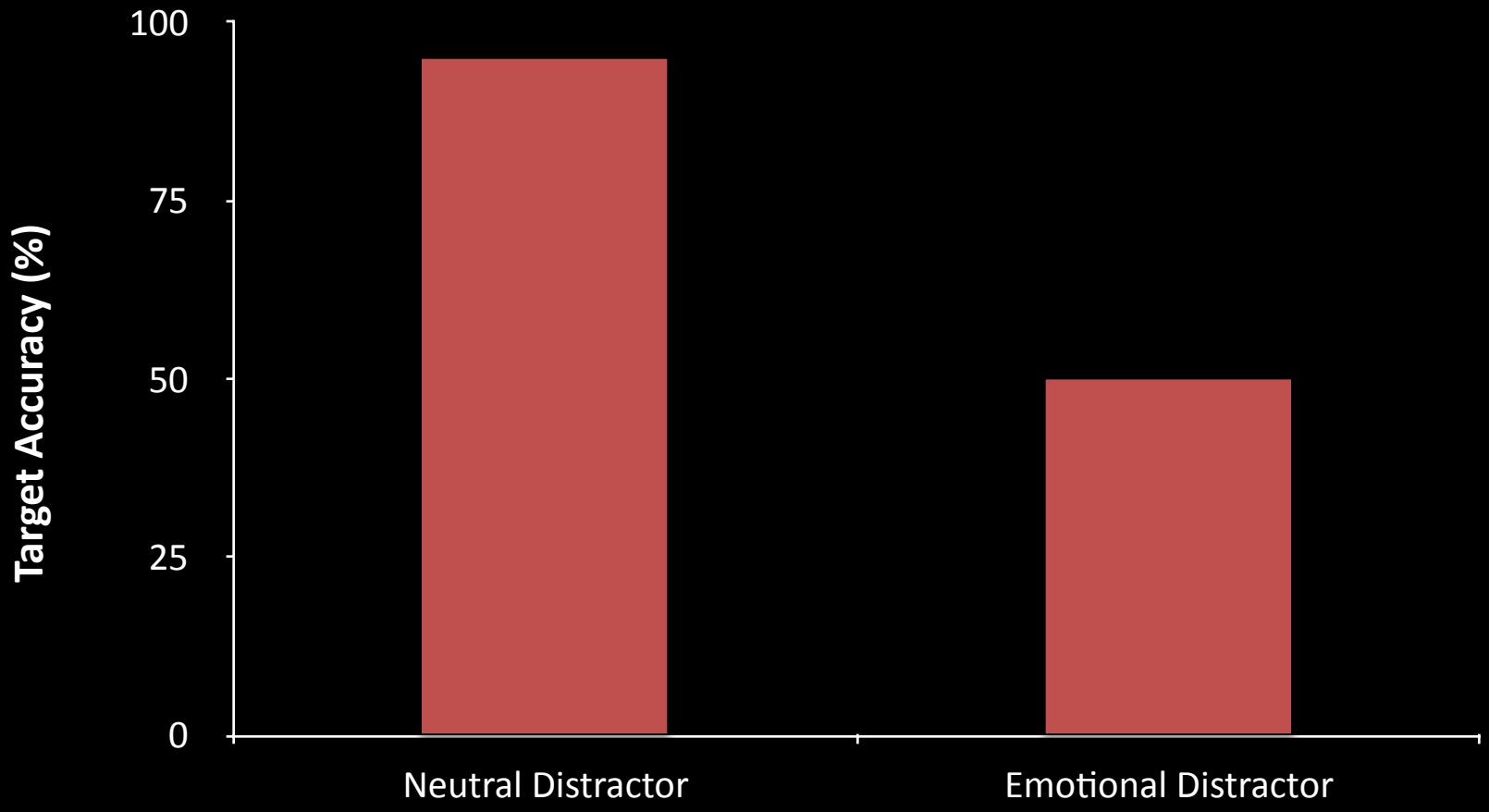
Encoding of Emotional Events: Attentional Engagement



Typical finding in attentional rubbernecking tasks (i.e., Arnell et al., 2007)

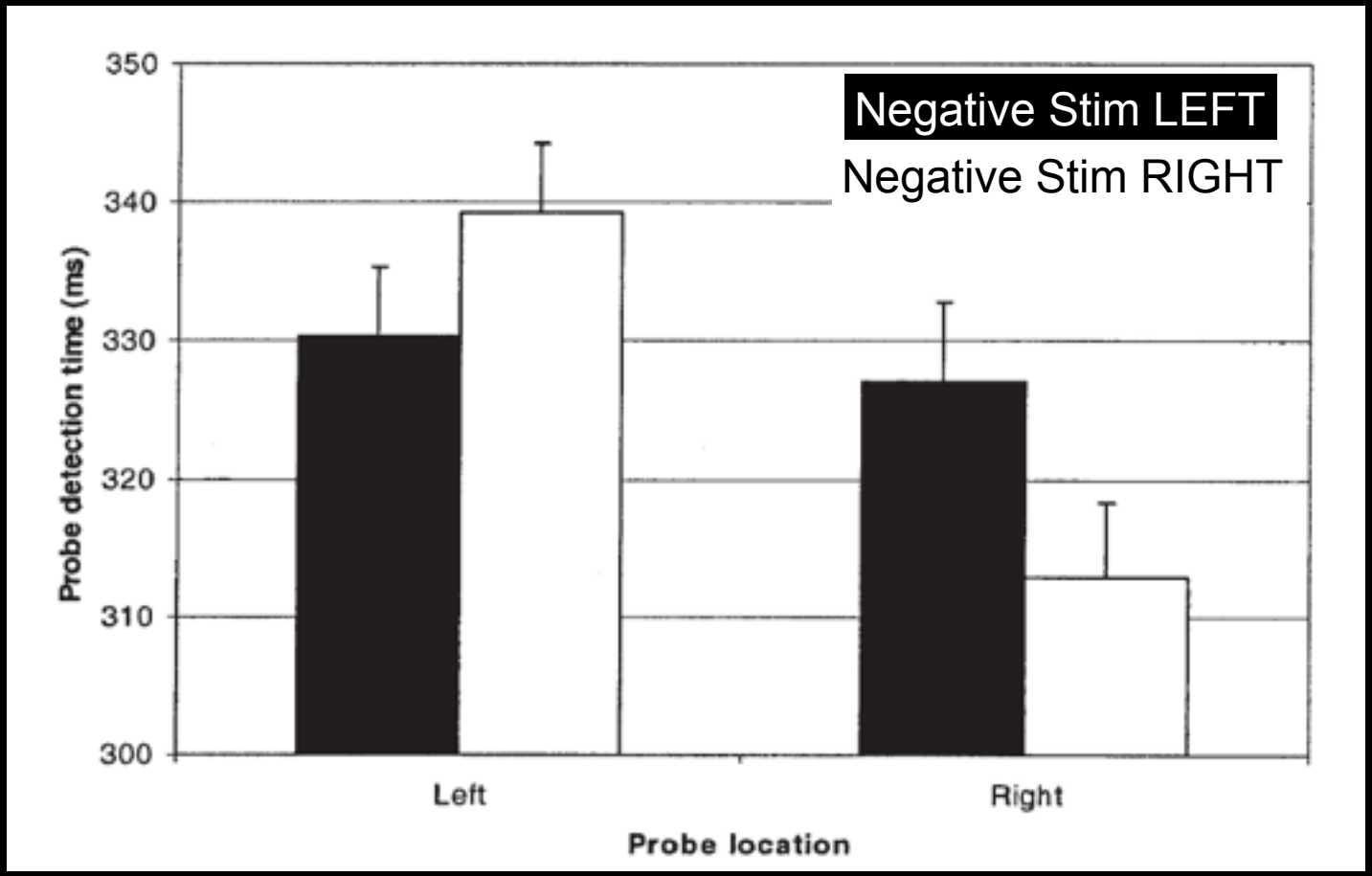
Encoding of Emotional Events: Attentional Engagement

The dot probe task

Encoding of Emotional Events: Attentional Engagement

The dot probe task

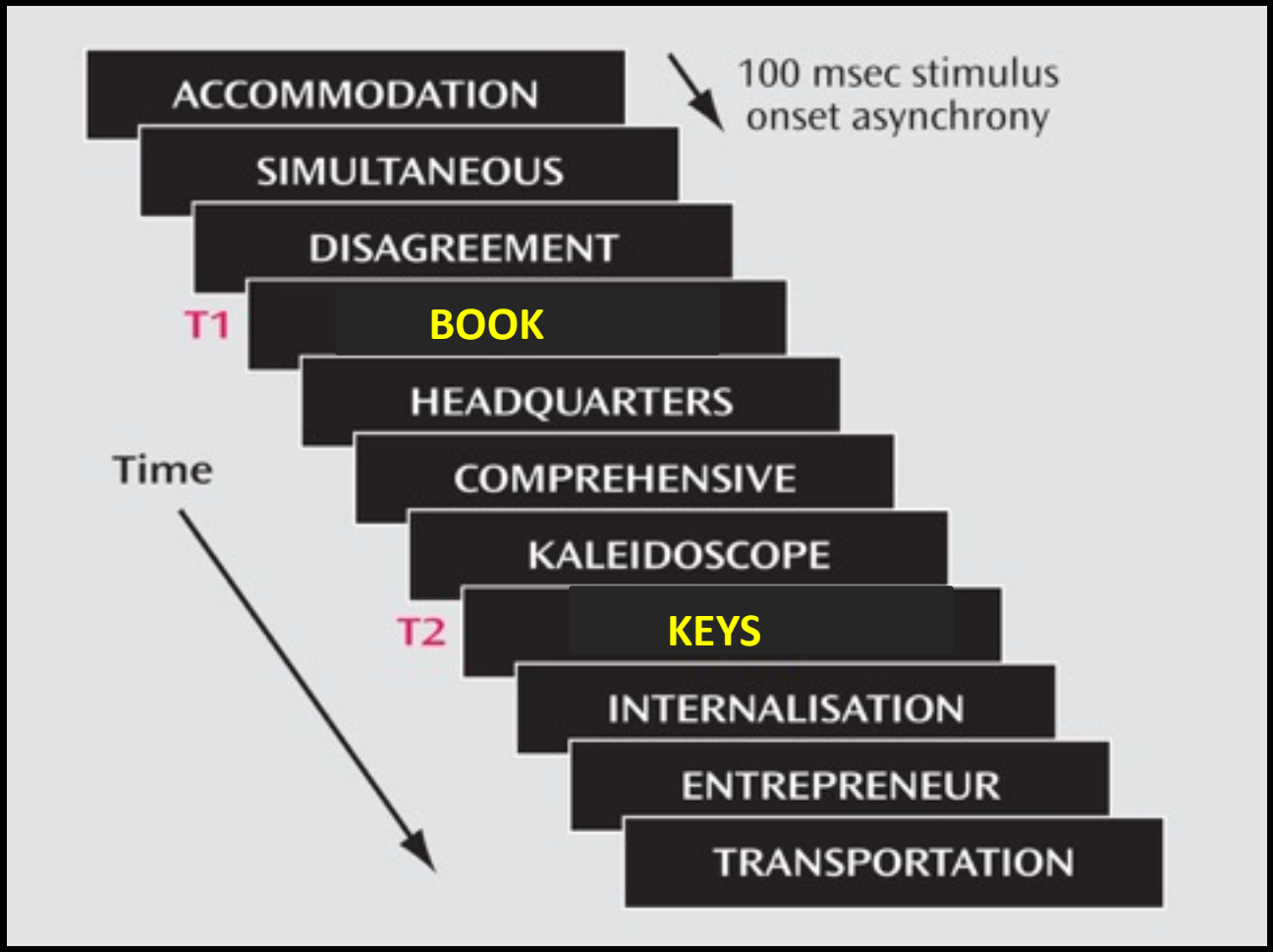
Encoding of Emotional Events: Attentional Engagement



Lipp and Derakshan, 2005

Encoding of Emotional Events: Access to Working Memory

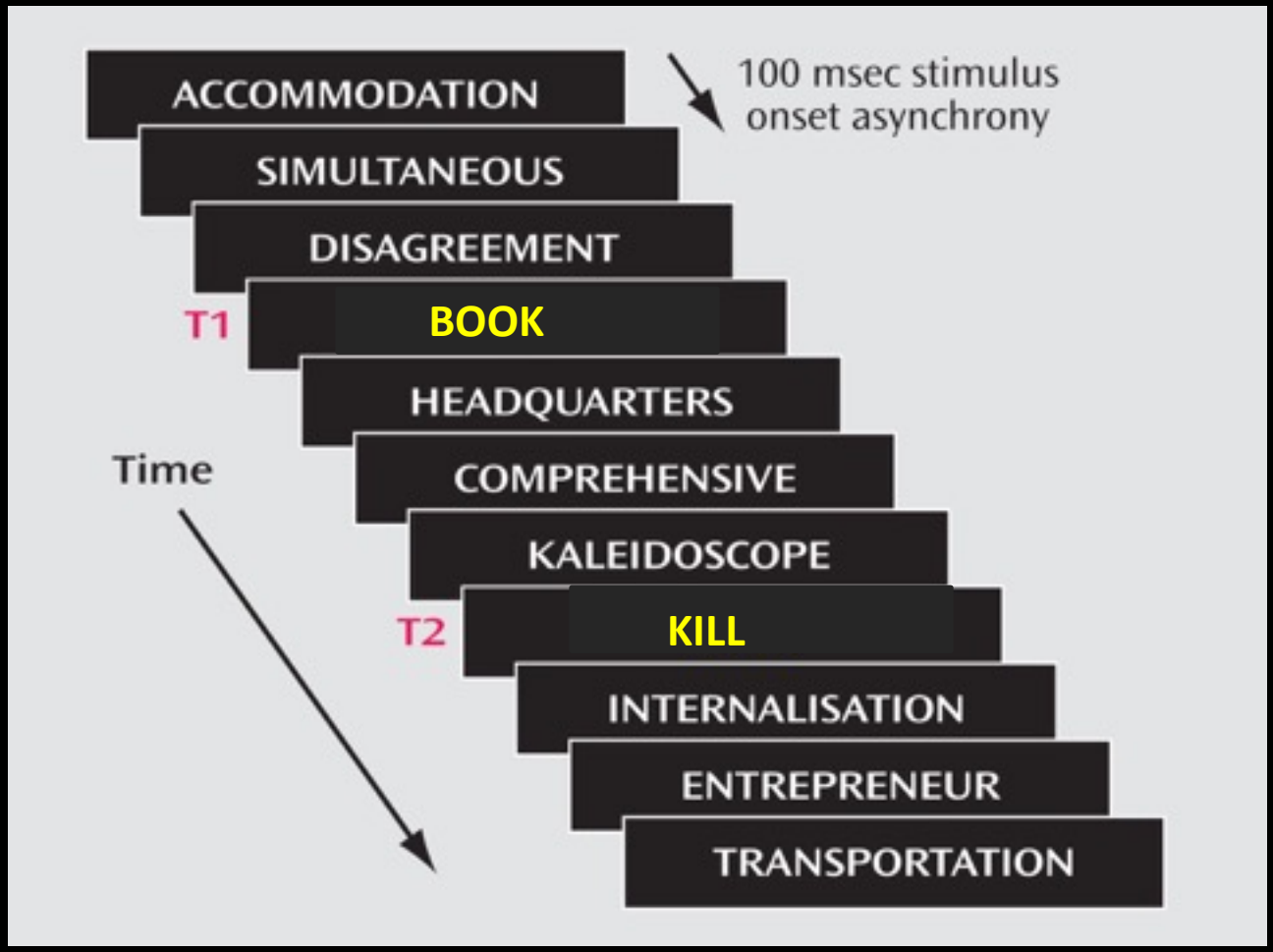
Attentional Blink Task



What were the two target words?

Encoding of Emotional Events: Access to Working Memory

Attentional Blink Task



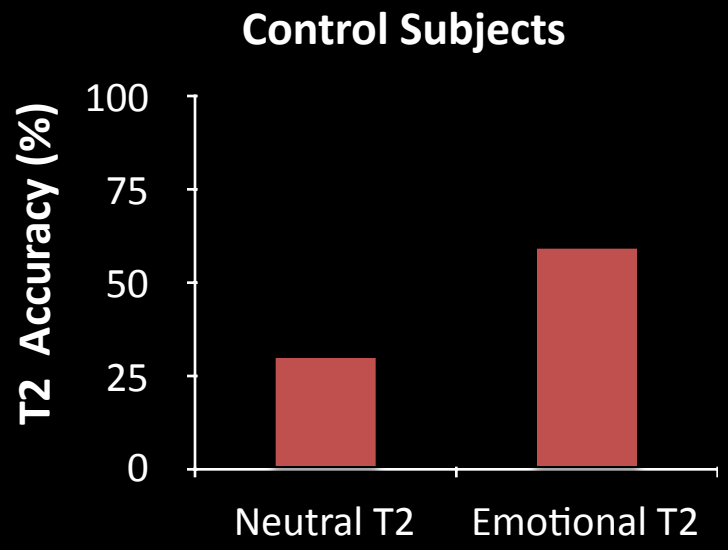
What were the two target words?

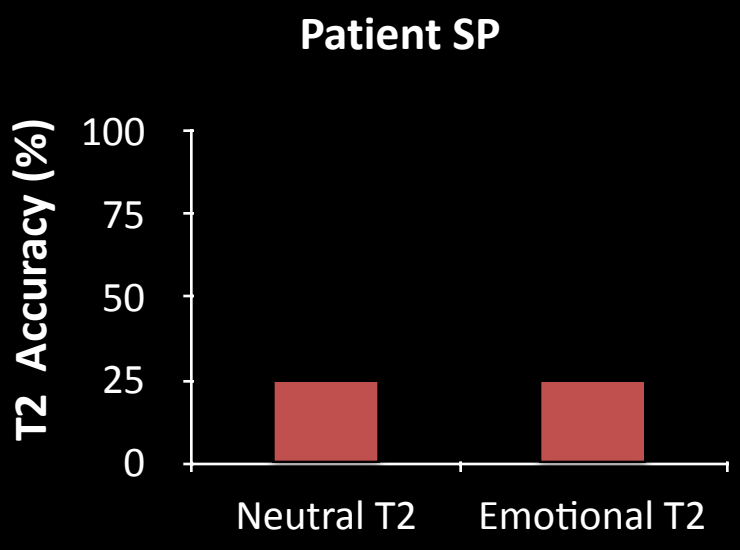
Encoding of Emotional Events: Access to Working Memory

Patient SP:

→ 54-year-old woman who had severe, intractable epilepsy

→ Parts of her temporal lobe were surgically removed, including the amygdala





Adapted from Anderson and Phelps (2001)

Encoding of Emotional Events

Emotion may not enhance memory equally for all aspects of an arousing event (Kensinger, 2009)

Hypothesis: Emotion tends to enhance memory for central aspects of an event, but may actually impair memory for peripheral aspects

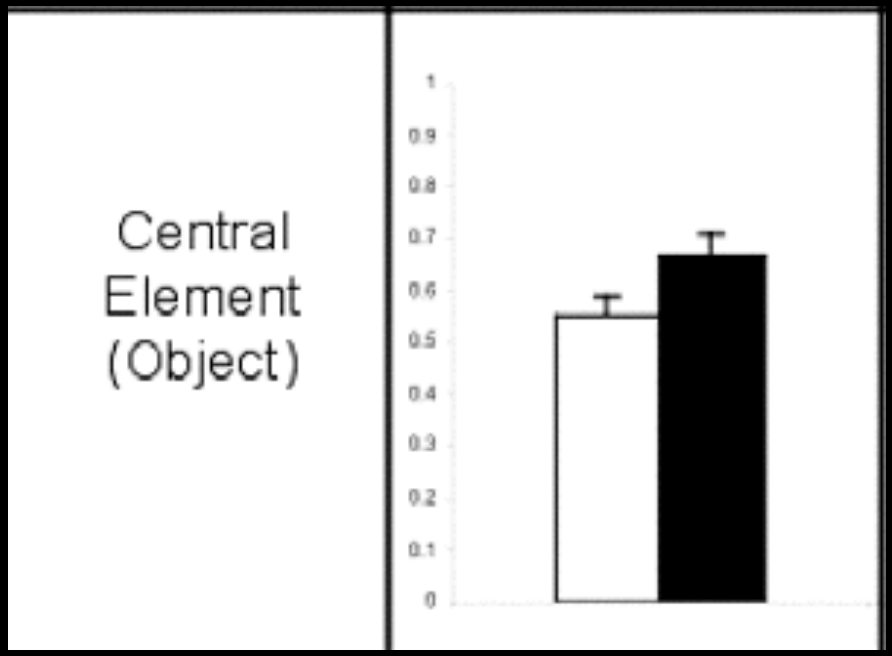
Encoding of Emotional Events

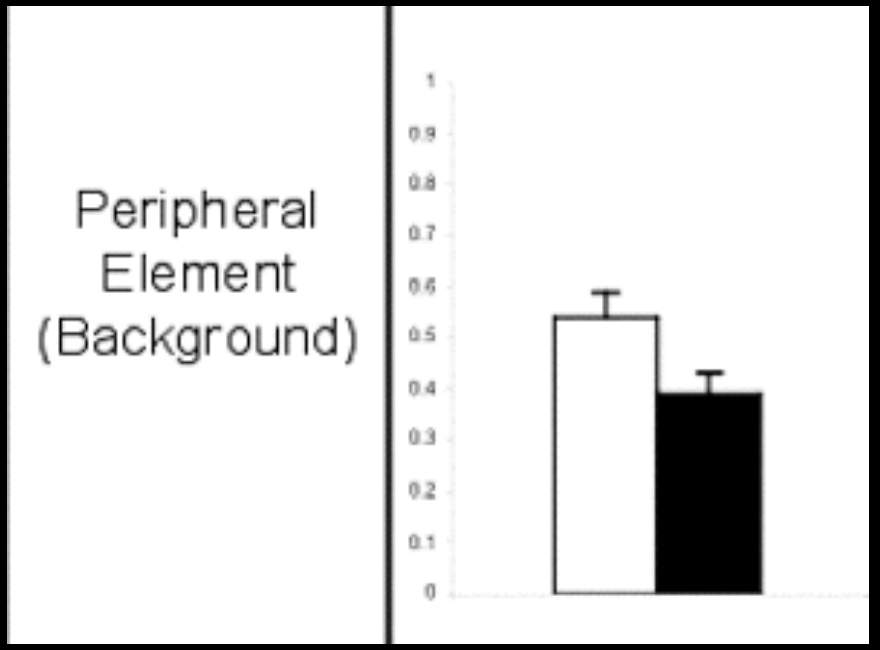
Learning Phase

Test Phase

Kensinger et al., 2007

Encoding of Emotional Events





Neutral central object

Negative central object

Emotion enhances memory for "central" features of an event (those that capture attention), but may impair memory for "peripheral" features (Kensinger, 2009)

Kensinger et al., 2007

How Does Emotion Enhance Episodic Memory?

Factors related to encoding

Factors related to consolidation

Consolidation of Emotional Events

→ Endogenous stress hormones (epinephrine and corticosterone) are believed to affect memory cellular consolidation

→ Can manipulate these stress hormones *after encoding* in order to test whether these contribute to consolidation

Logic:

If cellular consolidation plays a role in the memory enhancement for emotional events, then manipulating stress hormones *post-encoding* should affect the degree of enhancement

Consolidation of Emotional Events

Day 1 procedure:

1) Subjects' saliva collected at baseline (pre-stress cortisol measure)

2) Then viewed emotional and neutral images

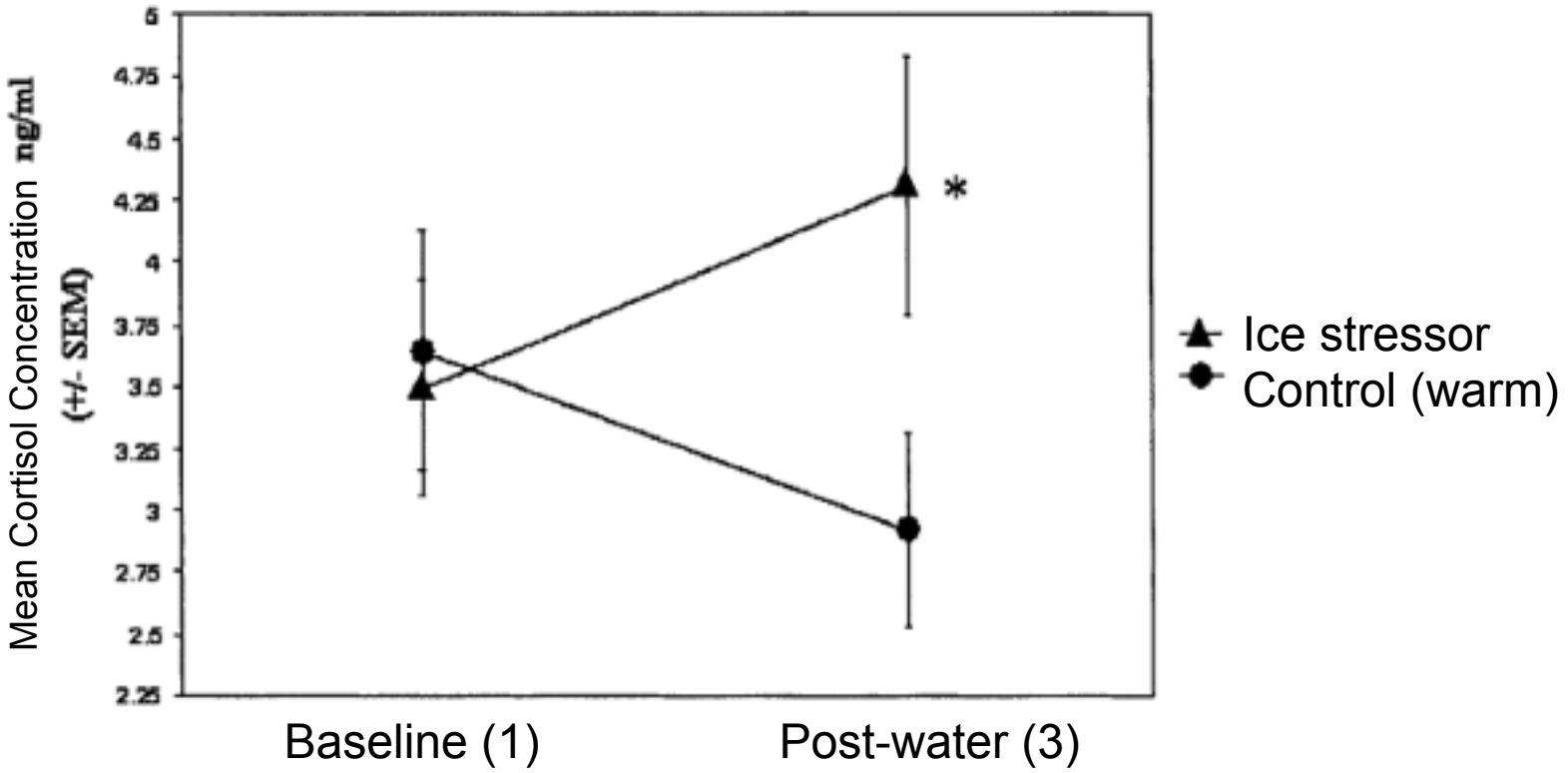
3) Immediately after viewing, performed a highly stressful task (placing hand in freezing water) OR a neutral task (placing hand in warm water)

4) Saliva levels were collected again (post-stress cortisol measure)

Day 7 procedure: 1 week later, free-recall test on the images

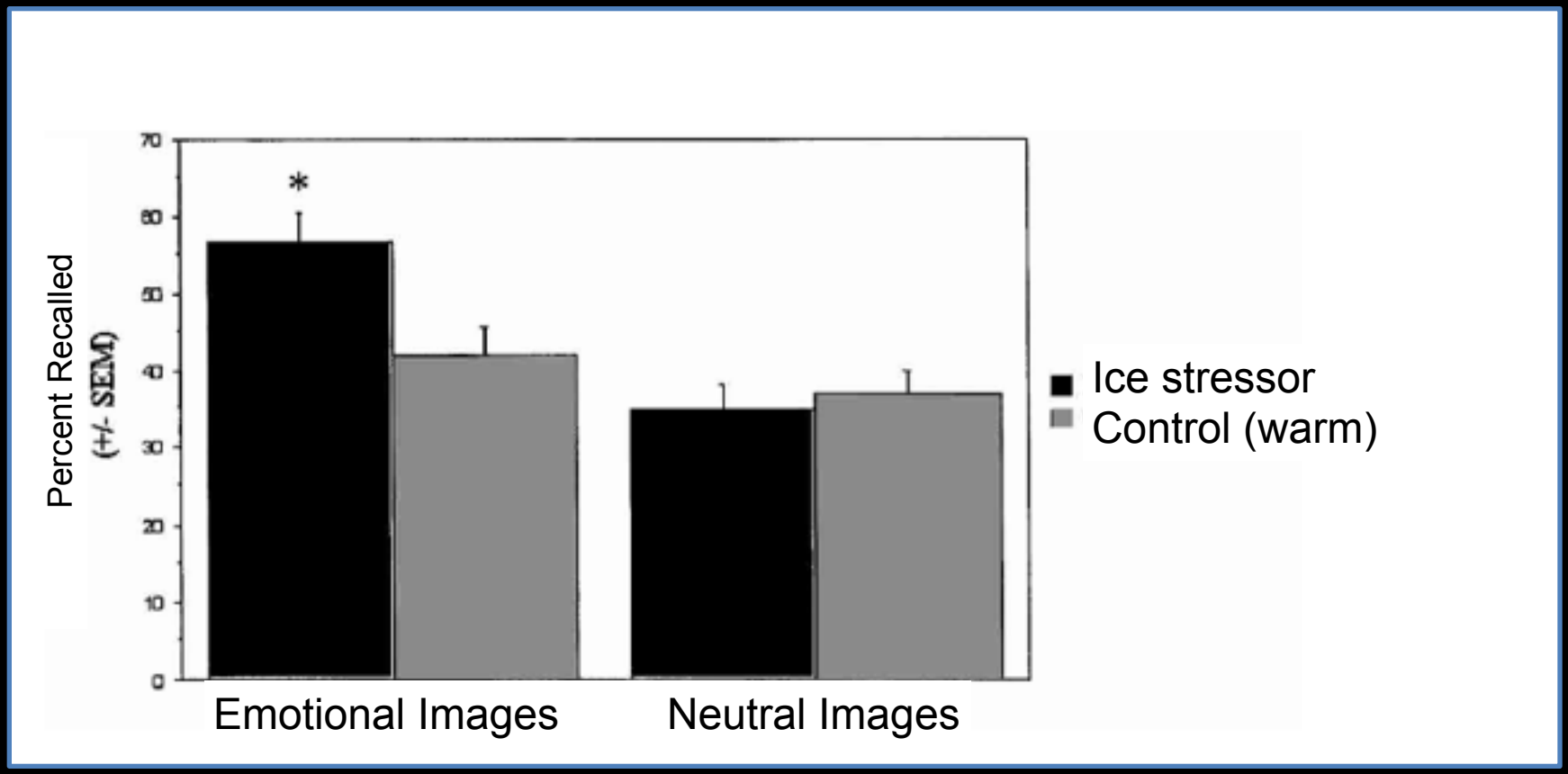
Cahill et al., 2003

Consolidation of Emotional Events



Cahill et al., 2003

Consolidation of Emotional Events



Endogenous stress hormones released after encoding interact with initial arousal during encoding to influence memory consolidation

Cahill et al., 2003

Are Episodic Memories for Emotional Events Special?

1) Probability of learning

2) Subjective vividness

3) Confidence in memory accuracy

Emotion Enhances Subjective Vividness

Remember/know task (Tulving, 1985):

→ Remember: Can vividly recollect details about the event's original occurrence and context (i.e., when/where it occurred)

→ Know: A sense that the event was previously encountered, but lacks detailed, vivid information about its occurrence

Emotion Enhances Subjective Vividness

Learning phase:

→ Neutral (i.e., “carpet”) & negative words (i.e., “disease”)

→ Incidental encoding: categorize each as *concrete* or *abstract*

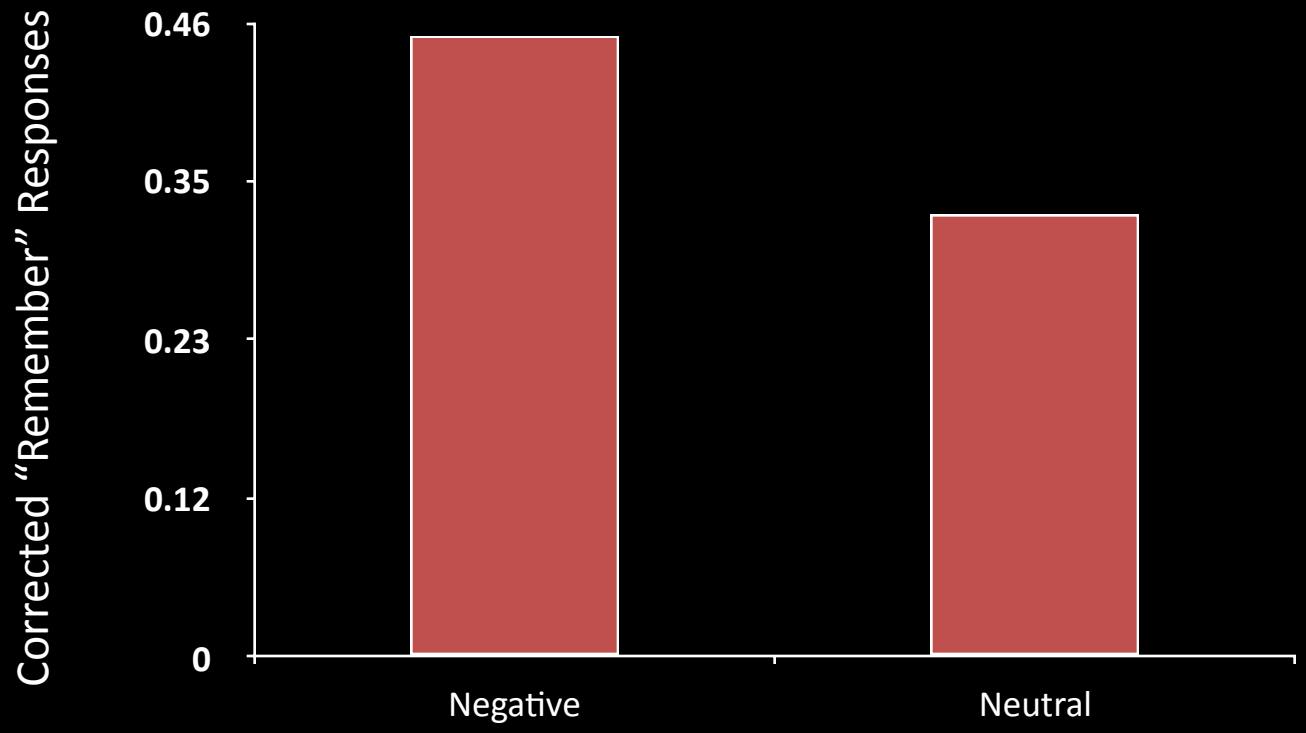
Test phase:

→ 15 minutes later, words presented again

→ Recognition: indicate if word was *remembered*, *known*, or *novel*

Kensinger and Corkin, 2003

Emotion Enhances Subjective Vividness (i.e., "Remembering")



Adapted from Kensinger and Corkin, 2003

Emotion Enhances Source Memory

Does emotion objectively enhance source memory?

Learning phase:

Glass Terror Abuse Wallet Cancer Physics…

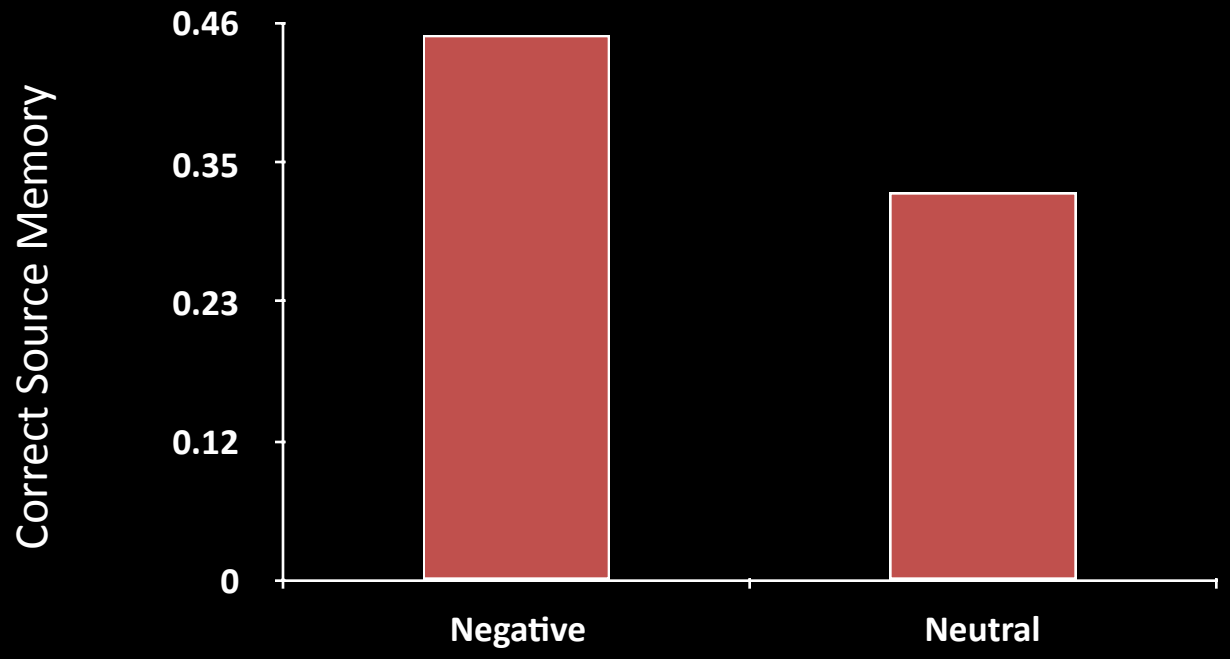
→ Indicate whether each word is concrete or abstract

Test phase:

→ Shown old and novel words in black ink
→ Recognition+Source memory: indicate if word was *presented in red*, *presen*
in blue, or is *novel*

Kensinger and Corkin, 2003

Emotion Enhances Source Memory



Adapted from Kensinger and Corkin, 2003

Are Episodic Memories for Emotional Events Special?

1) Probability of learning

2) Subjective vividness

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Participation Prompt #4

- Try to remember a public emotional event (it can be positive or negative) that has happened in your lifetime. What was the event?
- When remembering, try to retrieve what you were doing and who you were with when you found out about the event.
- How vivid is your memory for this event? How confident are you in the accuracy of your memory?
- As you are remembering the event, reflect on the emotions you are currently feeling.

Do "Flashbulb" Memories Exist?

Flashbulb memory

> "Flashbulb memories are thought to be distinctly vivid, precise, concrete, long-lasting memories of a personal circumstance surrounding a person's discovery of shocking events. People remember with almost perceptual clarity details of the context in which they first heard about the news, such as what they were doing, … whom they were with and where they were."

Hypothesis: People remember highly arousing emotional events as if they are a 'scar upon the cerebral tissues' — memory is unusually precise and accurate, like a photograph

Do "Flashbulb" Memories Exist?

<u>September 12, 2001</u>

Duke students recorded their memory of first hearing about the terrorist attacks of Sept. 11 and of a recent everyday event (e.g. party, sporting event, studying)

For memory of 9/11 attacks, answered questions such as:

- → who/what told you the information?
- → where were you when you first heard the news?
- → were there others present when you heard the news?
- → what were you doing prior to hearing the news?

For memory of ordinary event, answered questions such as:

- → what was the event?
- → were there others present?
- → what were you doing prior to the event?

(Talarico & Rubin, 2003)

Do “Flashbulb” Memories Exist?

At test: 1, 6, or 32 weeks later

Objective measures:

- Subjects answered the same questions again about the circumstances surrounding the event
- Level of “objective memory” for event was measured as the amount of *consistency* between follow-up report and initial report

Subjective measures:

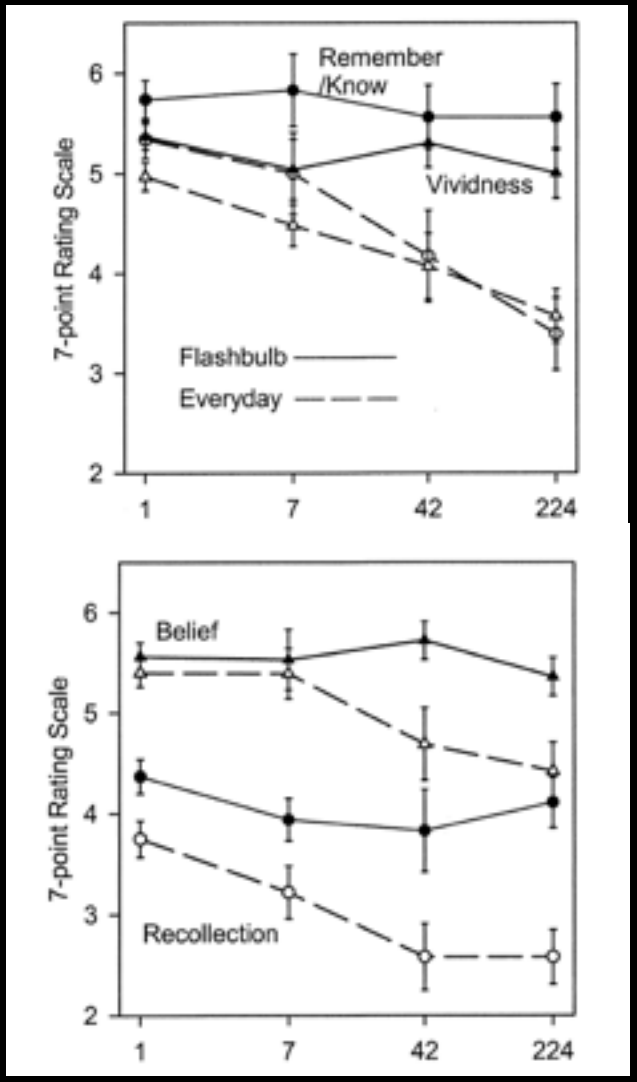
- *Belief*: “I believe the event really occurred the way I remember it”
- *Recollection*: “I feel as though I am reliving the experience”
- *Vividness*: “I can clearly see the event in my mind”
- *Remember/Know*: “I actually remember the event rather than just knowing that it happened”

(Talarico & Rubin, 2003)

The Myth of "Flashbulb" Memories

Ratings of vividness, recollection, and belief in the accuracy of memory declined only for everyday memories.

Subjective

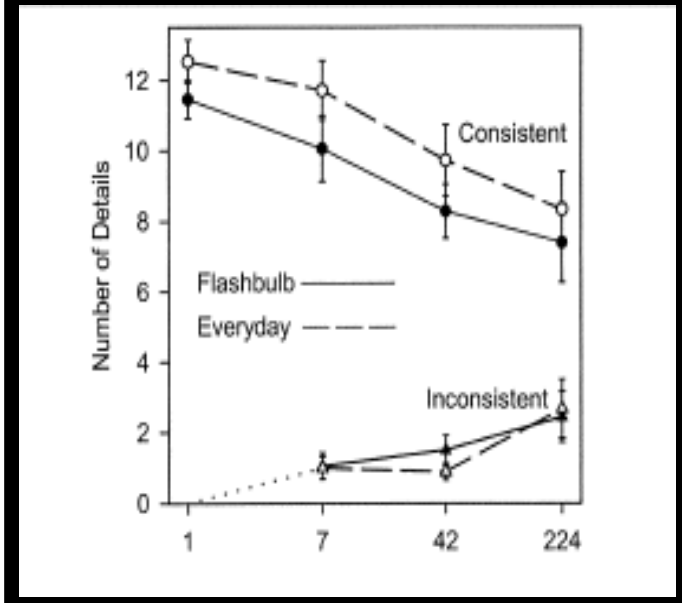


(Talarico & Rubin, 2003)

The **Myth** of "Flashbulb" Memories

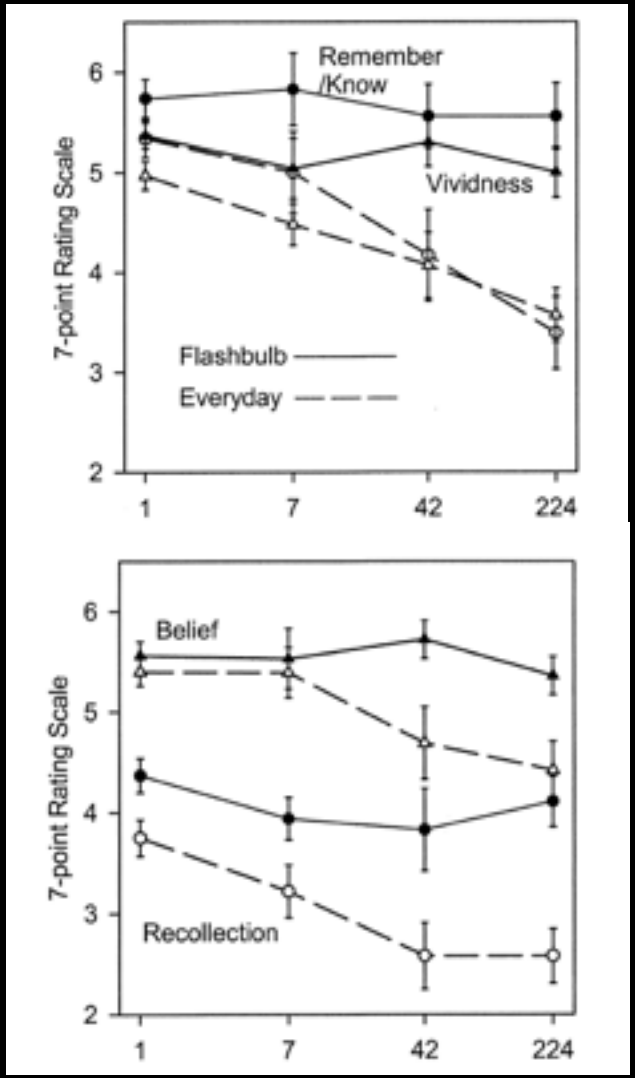
Ratings of vividness, recollection, and belief in the accuracy of memory declined only for everyday memories.

Objective



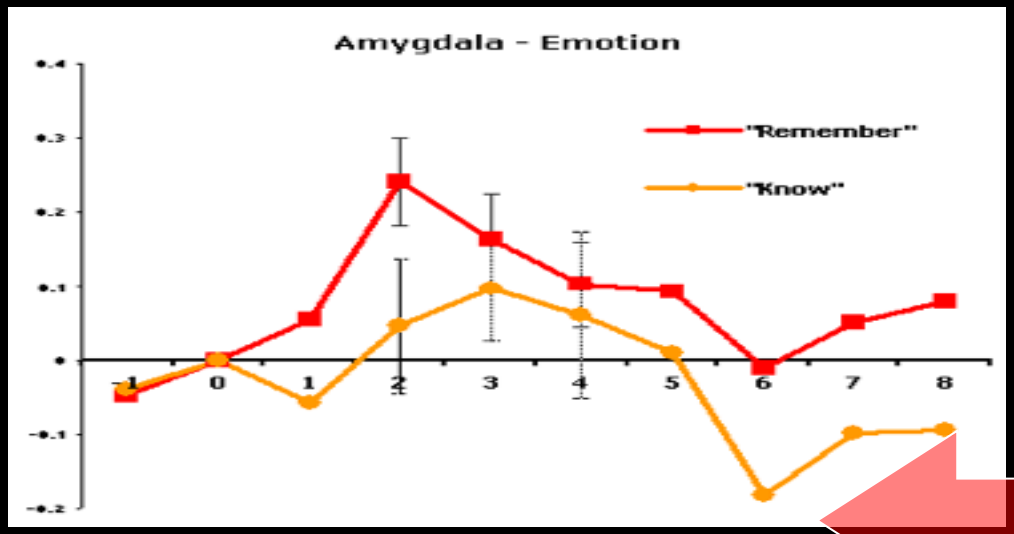
However, tue accuracy declined for BOTH everyday and "flashbulb" memories.

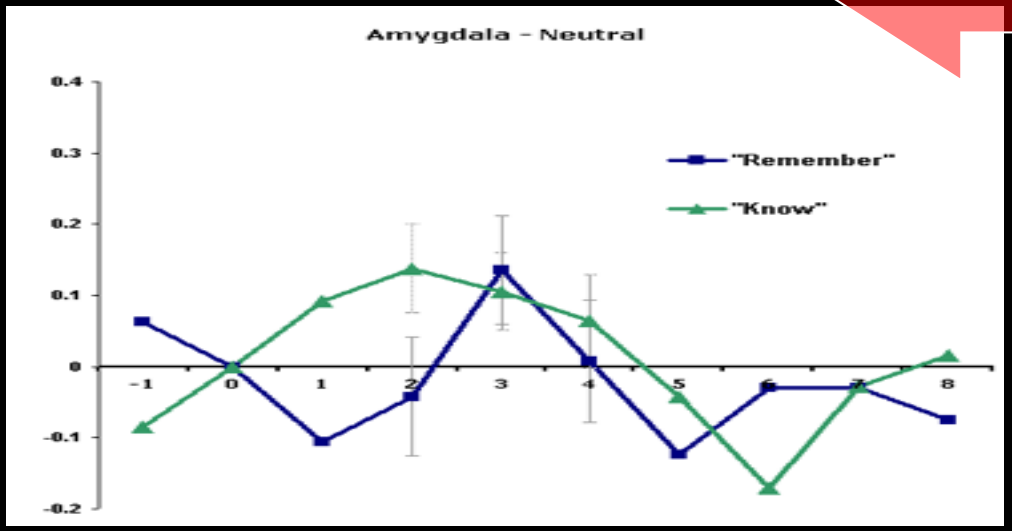
Subjective

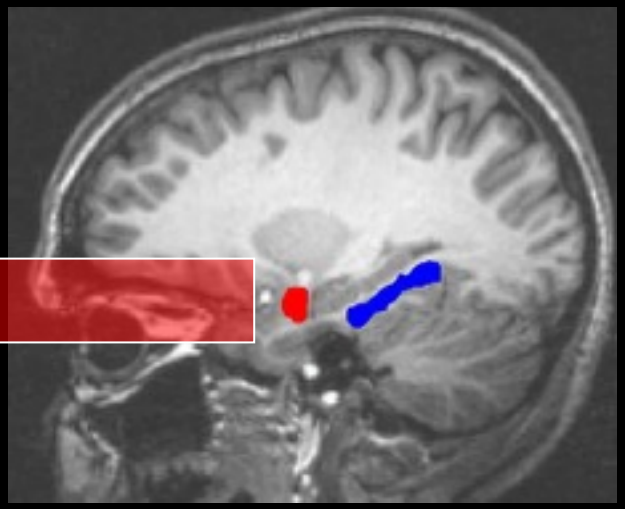


(Talarico & Rubin, 2003)

Emotion Enhances the Subjective Sense of Remembering when Re-experienced at Retrieval







Amygdala selectively related to "remembering" for emotional photos

Sharot, Delgado & Phelps. (2004) – *Nature Neuroscience*

Outline

- Emotion and Memory
  - What is emotion and how is it measured
  - Amygdala and emotion
  - Fear conditioning
  - Episodic memory for emotional events