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# LEARNING AND MEMORY

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PAPER DISCUSSION

## ADAPTIVE FUNCTION OF MEMORY

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- What is memory?
  - the encoding, storage, and retrieval (or forgetting) of information about past experience
- Memory systems co-opted endocrine signals of physiological stress to signal important events.
- Marking of important events could enhance learning about adaptively significant aspects of the world.

## FEATURES OF MEMORY SYSTEMS

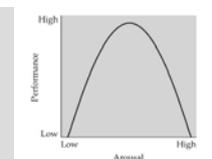
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- All memory systems share the ability to:
  - enter information into storage (acquisition and consolidation)
  - retain information
  - retrieve information from storage
- All needed for learning to occur
  - An adaptive change in behavior in response to experience.
- Hormones can affect components of memory, or affect learning directly and thus memory indirectly

## PSYCHOLOGICAL CONSTRUCTS OF LEARNING

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- Successful learning involves
  - Motivation
  - Attention
  - Arousal

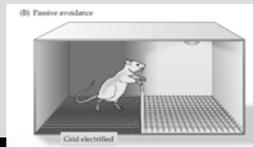
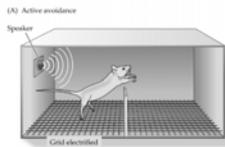


### TYPES OF LEARNING: NONASSOCIATIVE

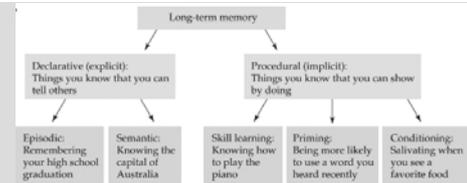
- Nonassociative learning: Change in the strength of response to a stimulus after repeated exposures.
  - Sensitization: Progressive amplification of a response after repeated administrations of a stimulus.
  - Habituation: Decrease in response to a stimulus after repeated exposures.

### TYPES OF LEARNING: ASSOCIATIVE

- Associative learning: The process by which an association between two stimuli is established.
  - Classical conditioning
  - Operant conditioning



### TAXONOMY OF MEMORY

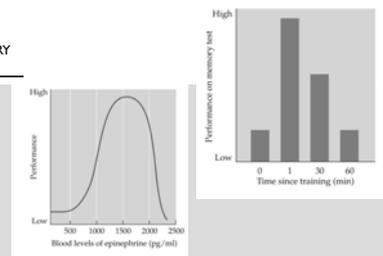


### OTHER WAYS TO CATEGORIZE MEMORY

- Working memory: typically involves short-term memory for information that changes on a regular basis.
- Reference memory: generally refers to associations or discriminations requiring repetitious learning, as in learning the rules of a task or how to navigate around an environment such as a maze.

### HORMONES AND LEARNING AND MEMORY

- Epinephrine: Dose and time dependence
- How can epinephrine secreted by the adrenal glands affect learning and memory processes if it cannot get to the neurons in the brain?



### HYPOTHESES

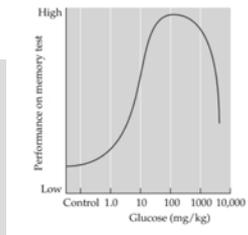
- (1) epinephrine activates peripheral receptors that directly influence brain function
- $\alpha$ - and  $\beta$ -epinephrine receptor antagonist injected in rats (phenoxybenzamine or propranolol) 30 minutes before they received either an injection of epinephrine or a foot shock (which caused natural levels of epinephrine to rise).
  - Study showed effects on memory and learning suggesting peripheral effects.

### HYPOTHESES

- (1) epinephrine activates peripheral receptors that directly influence brain function
- Role of amygdala in memory formation – especially emotionally charged memories in humans \*(sex differences as well).

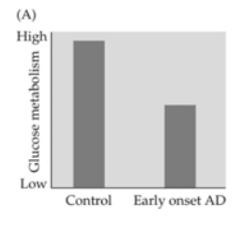
### HYPOTHESES

(2) epinephrine affects memory via its effect on blood glucose levels. Epinephrine elevates blood glucose concentrations, which increases the amount of glucose that enters neurons in the brain. These neurons release higher concentrations of acetylcholine into the synapses.



### GLUCOSE AND MEMORY

Impaired glucose metabolism is associated with Alzheimer's disease.

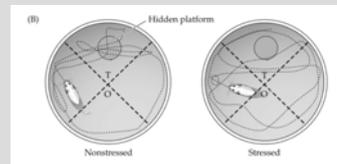


### GLUCOCORTICOIDS

- Chronic stress impairs memory & spatial memory as well as appetitively motivated tasks (e.g., radial arm maze)
- Under testing conditions where arousal is increased (such as the radial arm maze filled with water), chronic stress may facilitate learning!

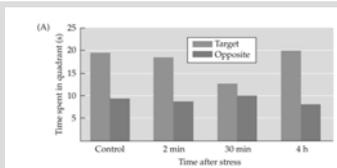
### WATER TESTS IN RATS

- Representative swimming paths of a nonstressed control rat and a stressed rat.
- Note that while the nonstressed rat swam in the general area of the platform, the stressed rat appears to have swam across all areas of the maze randomly.



### STRESS AND WATER TESTS IN RATS

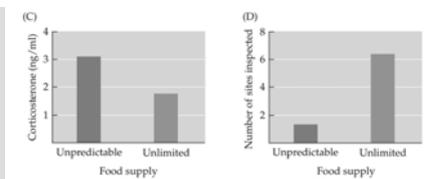
- Time spent in target quadrant (where platform was formerly located) compared with opposite quadrant of Morris water maze.
- Rats spent less time in the target quadrant 30 min after foot shock, but this impairment was reversed 4 hours after foot shock.



### STRESS AND SPATIAL LEARNING: FOOD CACHING IN BIRDS



### STRESS AND SPATIAL LEARNING: FOOD CACHING IN BIRDS



### SEASONALITY IN LEARNING AND MEMORY

- Link between breeding and seasonality
- Is there a link between androgens and learning too
  - Importance in birds of song learning
  - In rats, androgens do not have major effects on learning and memory.
  - BUT, in other taxa, enhanced learning and memory are reported during the breeding season, when blood concentrations of androgens are high.

## SONG LEARNING IN BIRDS

- Both estrogens and androgens have **organizational** effects on development of the song control system and on song learning behaviors (brain regions involved with song learning have androgen and estrogen receptors)
- Estrogens:
  - promote learning and memorization of songs
  - maintaining brain plasticity necessary for keeping sensitive phase of learning period open
- Androgens:
  - promote crystallization of song production
  - terminate the song memorization phase

## SONG LEARNING IN BIRDS: SOME MODEL SPECIES

- Song sparrows (*Melospiza melodia*)
- Swamp sparrows (*M. georgiana*)
- White-crowned sparrows (*Zonotrichia leucophrys*)
- Dark-eyed juncos (*Junco hyemalis*)



## ROLE OF T IN SONG LEARNING IN BIRDS

- 'closed-ended' learners
- song memorization occurs in the bird's natal summer
- Role of T?
  - Castrated young song sparrows and swamp sparrows failed to crystallize their songs within the first year.
  - Application of T when the birds > 1 year induced rapid song crystallization
  - Removal of T = birds regressed to plastic song.

## ROLE OF T IN SONG LEARNING IN BIRDS

- Open questions about timing though.
- Does early song crystallization induced by T administration lead to normal song development?
  - White-crowned sparrows & zebra finches developed abnormal song
  - Juncos developed normal song