

Agenda

I. Nondeclarative Memory: Priming

- Priming phenomena
- Forms of priming
- Theories of priming
 - Processing vs. Systems accounts
- Neural bases of priming
- Priming for novel stimuli
- Implicit/Explicit interactions

II. Nondeclarative Memory: Skill Learning

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Nondeclarative Memory: Priming

- Priming phenomena
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Are there Interactions between Forms of Long-Term Memory?

Explicit / Implicit Interactions?

Explicit / Implicit Interactions?

Shorter Lags Yield Greater Behavioral Priming

Shorter Lags Yield Greater Neural Priming

Superior Explicit Memory following

Less Priming

Behavioral Priming and High Confidence Recognition

Neural Priming and High Confidence Recognition

Priming Yields Stereotyped Re-encoding

Recognition Memory:

Dual-Process Theory

Explicit / Implicit Interactions:

Does Familiarity Derive From Priming?

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Non-declarative Memory: Skill Learning

- Characteristics of skill learning
- Theories of skill learning
 - ACT-*
 - Instance theory
- Varieties of skill learning
 - Motor skill
 - Perceptual skill
 - Cognitive skill

Acquisition of new behavioral abilities with practice

Contrast with repetition priming:

- Repetition priming is defined as facilitation on a particular stimulus
- Skill learning is defined as facilitation on a range of stimuli in a particular task

1) Cognitive stage

- Initial (often verbal) characterization of skill used to guide behavior
- Requires working memory capacity

2) Associative stage

- Behavior becomes tuned, errors are eliminated
- Verbal mediation drops out

3) Autonomous stage

- Gradual continued improvement of skill
- Little reliance upon working memory

Skill learning: associated with automatic (as opposed to controlled) processing

- Less attention-demanding
- Reduced interference with other ongoing processes or tasks
- Reduced need for conscious control

However, automaticity does not imply that behavior is uncontrollable

- Many examples of skill (driving, reading, typing) are highly controllable, in that they can be stopped at any time

Decrease in response times with skill learning on a wide range of tasks can be described by a power function:

$$RT = A + BN^{-\beta}$$

A=asymptote

B=start-asymptote

$^{-\beta}$ =learning rate

Production system model of memory

- If-then rules triggered by contents of working memory

Learning involves transition from declarative to procedural memory

Declarative stage:

- Existing productions are chained together
- Relevant information is held in working memory

Procedural stage:

- Multiple productions are chained into single productions with declarative knowledge built in
 - decreases working memory requirements
- New compiled productions are strengthened

Goal: Type the word “hot”

Variables: L1=h, L2=o, L3=t

Productions:

- If the goal is to type a word & the 1st letter of the word is L1,
 - Then type L1
- If the goal is to type a word & the 2nd letter of the word is L2,
 - Then type L2
- If the goal is to type a word & the 3rd letter of the word is L3,
 - Then type L3

After practice, composition and proceduralization lead to the following production:

- If the goal is to type “hot”, type “h”, “o”, and “t”

Strengths:

- Makes detailed behavioral predictions
- Predicts power function speedup

Weaknesses:

- Has primarily been applied to verbal cognitive tasks
- Not clear that declarative-to-procedural transition is a valid descriptor of all types of skill acquisition

Instance/exemplar-based memory

- Each episode results in a memory trace containing the contents of attention
- Each instance retrieves all similar traces from memory

Race between memory and algorithm

- Performance initially driven by algorithm (or analogy)
- Memory retrieval time decreases as power function of number of instances stored in memory
 - Memory retrieval soon comes to dominate performance
 - Even when average memory retrieval time is longer than algorithm time

Strengths:

- Predicts changing shape of response time distributions with learning

Weaknesses:

- Current incarnation only models response times
- Does not make behavioral predictions

Skill learning is tested in a number of domains

- Motor skill
- Perceptual skill
- Cognitive skill

Novel perceptual-motor mappings

- Mirror-tracing
- Prism adaptation

Novel movement patterns / sequences

- Rotary pursuit
- Motor sequence learning

Motor skill learning is usually intact in amnesia

- Rotary pursuit
- Mirror-tracing

- Motor sequence learning

But motor skill learning is sometimes impaired in amnesia

- Maze learning
- Higher-order motor sequence learning
- Exceptions may require higher-order relational or spatial learning

Other forms are spared:

- Mirror-tracing

BG may play particular role in open-loop motor skills

Imaging shows increasing putamen activity with motor skill acquisition

Neuropsychology:

- cerebellar lesions sometimes impair motor learning
- pattern tracing (Sanes, Dimitrov, & Hallett, 1990)

Imaging:

- decreased cerebellar activation with acquisition of very simple motor tasks
- cerebellar activation related to errors on motor tasks

Neurophysiology:

- Increased # of synapses in cerebellar cortex accompanies motor skill learning in rats (Greenough et al.)

Neuropsychology:

- Little evidence about role of cortex in memory for motor skills
- SMA lesions impair SRT and tracking
- Evaluation of role of motor cortex is difficult
 - Motor control impairments following cortical lesions
 - Cortical lesions are often large

Neuroanatomy:

- Size of motor cortex is correlated with long-term motor skill acquisition (Amunts et al., 1997)

Neurophysiology:

- changes in cortical maps with skill learning
- areal expansion for trained movements

Novel perceptual recognition skills

- Mirror-reading

- Low-level visual discrimination (e.g., vernier discrimination)
- Object discrimination (e.g., Greebles)

Intact mirror-reading
in amnesia

Neuropsychology:

- HD patients mildly impaired at mirror-reading skill
- PD patients are variably impaired
 - Some studies find severe impairment
 - Others find no impairment

Neuroimaging:

- Imaging shows learning-related changes in caudate

Frontal, occipital, and cerebellar lesions do not impair mirror-reading

Categorization learning

- Probabilistic classification
 - Weather prediction task

Strategic game learning

- Tower of Hanoi
 - Learned using recursive subgoaling strategy

Tower of Hanoi

- Amnesic patients are sometimes normal
- Other studies have found impaired learning

Probabilistic Classification

- Amnesics show normal early learning
- Seem to show impaired later learning

Tower of Hanoi

- Learning intact following cerebellar lesions
- Learning impaired in HD and PD

- Learning impaired following frontal lesions

Probabilistic classification learning

- Learning impaired in PD and HD
- Imaging shows activation of caudate nucleus which decreases with learning
- Learning intact following frontal lesions

Skill learning is (mostly) independent of MTL

Basal ganglia are involved in a wide range of skills

Different cortical regions important depending upon nature of skill

Cerebellum important for motor skills

Two ways that the brain changes during skill learning

- Tuning of existing processes/representations
 - Existing representations are dynamically altered
- Switching to new processes/representations
 - Task is performed in a completely different manner
 - May reflect race/competition between multiple processes