Learning and Memory

Learning and Memory

Two interrelated topics

Learning requires storing information in memory.

Is awareness necessary for learning and storing information in memory?

What type and complexity of material can be learned without awareness?

Are different brain systems involved in learning with and without awareness?

Awareness of What?

Perception without awareness

- no awareness of stimulus

Learning/memory without awareness

- no awareness that learning has taken place (implicit acquisition)
- no awareness of what is learned (implicit knowledge)
- no awareness that previously acquired knowledge is being used to influence present performance (implicit retrieval)

Explicit Versus Implicit Memory

Explicit (Declarative)	Implicit (Procedural)
facts and experiences	skills and habits, priming, classical conditioning
knowledge can be verbalized (conscious)	knowledge is inaccessible (unconscious)
tested by recall, recognition, cued recall (as in school)	evidenced via altered dispositions, preferences, judgements, behavior
one trial learning	often acquired gradually over multiple trials
requires effort and intention	acquired incidentally (without intention, attention, or awareness)
flexible knowledge, available to multiple response systems	inflexible knowledge, limited to response systems participating in original learning
not durable	durable
can form conjunctions between arbitrary stimuli (e.g., paired associate learning)	cannot learn conjunctions
“specialized to detect variance, i.e., what is different or unique about the events of a particular time and place” [Eichenbaum]	“specialized for detecting invariance, i.e., for extracting what is common in stimulus environment” (i.e., regularities)
medial temporal lobe (hippocampus)	striatum (basal ganglia)

Phone Numbers, PINs, Credit Card #s, Lock Combinations

Explicit

memorize and use as needed

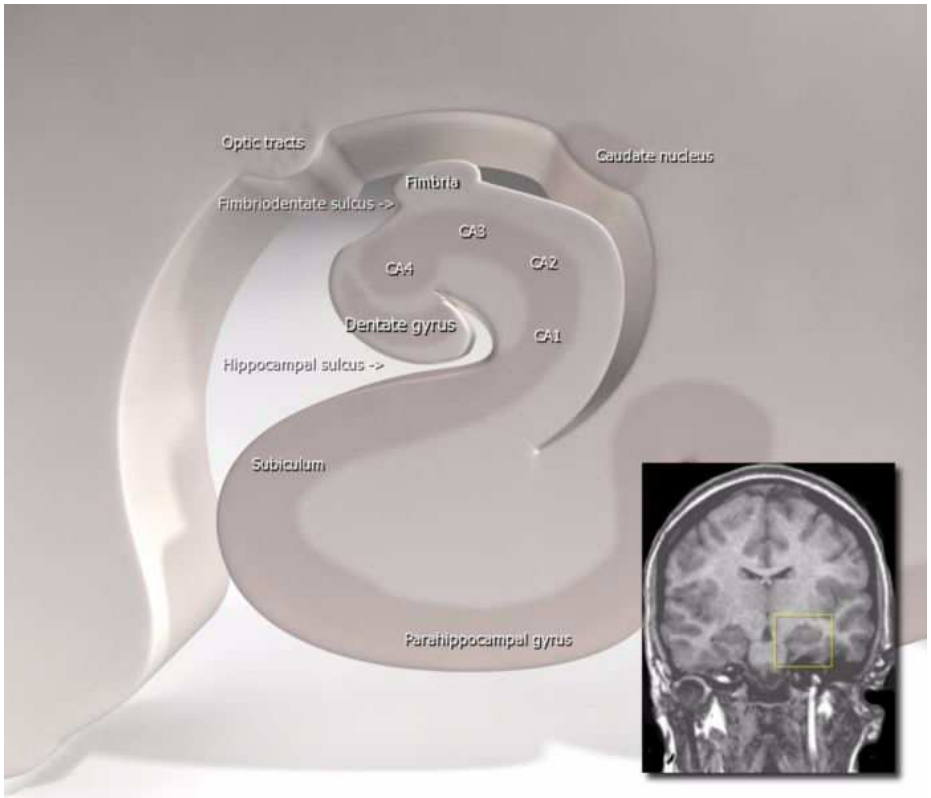
Implicit

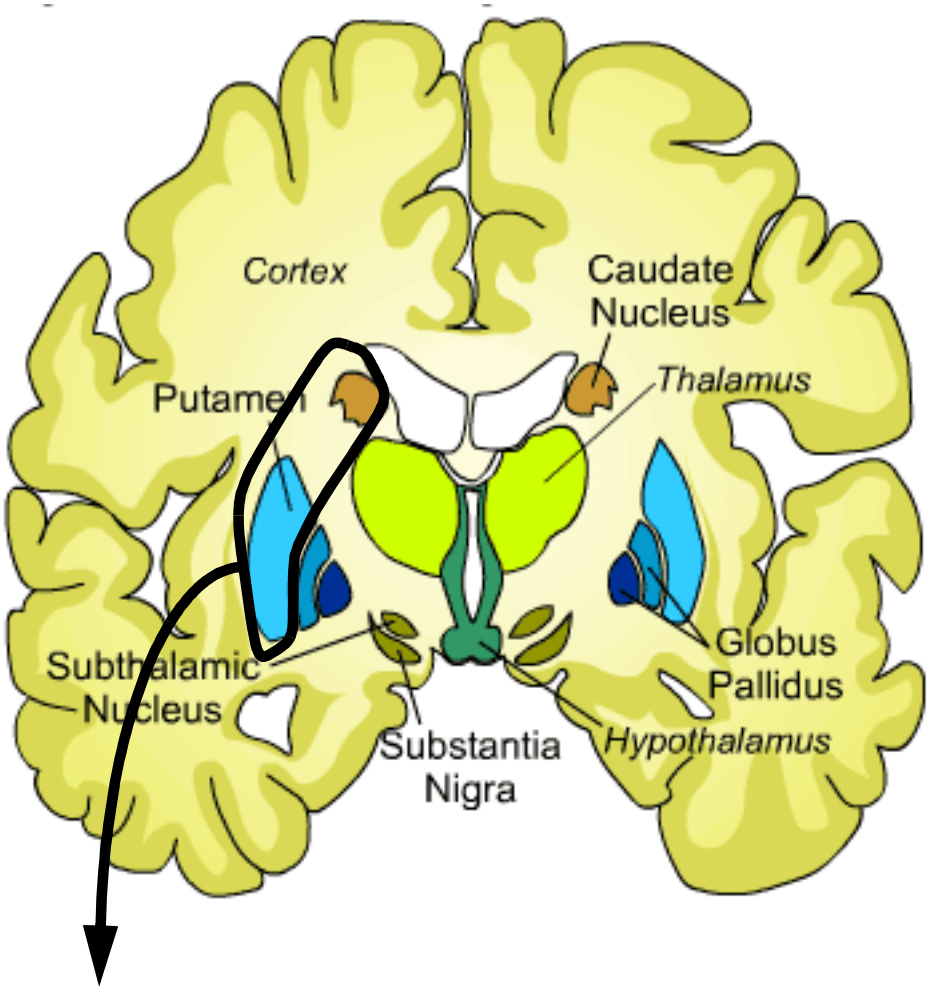
punch it in enough times, and you can punch it in again

may require the keypad to recreate

other examples: locks, PIN, credit card #

MTL and Basal Ganglia





striatum: major input station of basal ganglia system

Example of Implicit Memory: Stem Completion

1. Study list of words

table
garden
plane

2. Complete stem with any English word

gar---

e.g., garter, garden, garage

Studied word primes stem completion

i.e. subjects who studied “garden” complete “gar - - -” with garden more often than subjects who did not

Process dissociation procedure

“complete stem with word not on study list”

if more completions than expected by chance, then memory must be implicit

Example of Implicit Learning (Hefferline, 1964)

Electrodes placed over body

Annoying fan in room

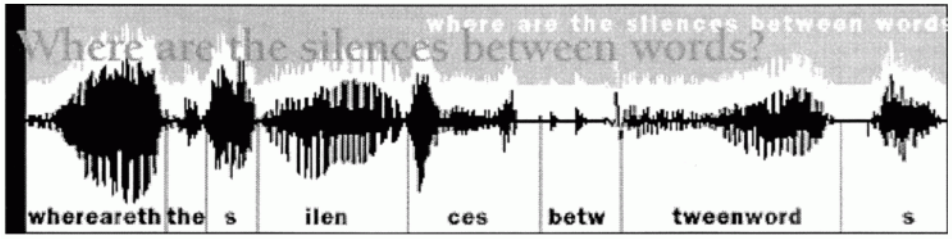
One electrode controls fan

When subject left alone in room, subject learned to tense muscle to shut off fan.

Subject was unaware of their control over fan.

Another Example of Implicit Learning: Speech Segmentation / Language Learning

Although we hear silence between words, it is not present in speech signal.



Perhaps language learners exploit *statistical regularities* to segment speech

e.g., “prettybaby”: pre->ty more often than ty->ba

Saffran, Aslin, & Newport (1996)

8 mo old infants, 2 minutes of exposure to continous stream of four three-syllable nonsense words in random order

e.g., bidakupadotigolabubidaku

P(da | bi) = 1; P(pa | ku) = 1/3

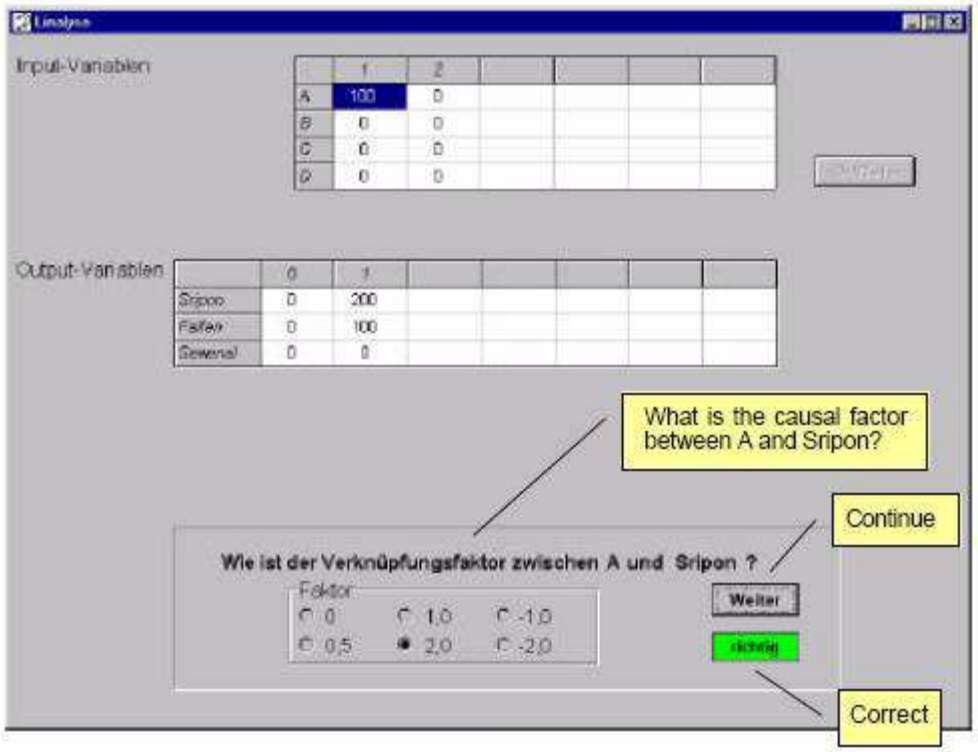
During test, infants show habituation to familiar words vs. novel words

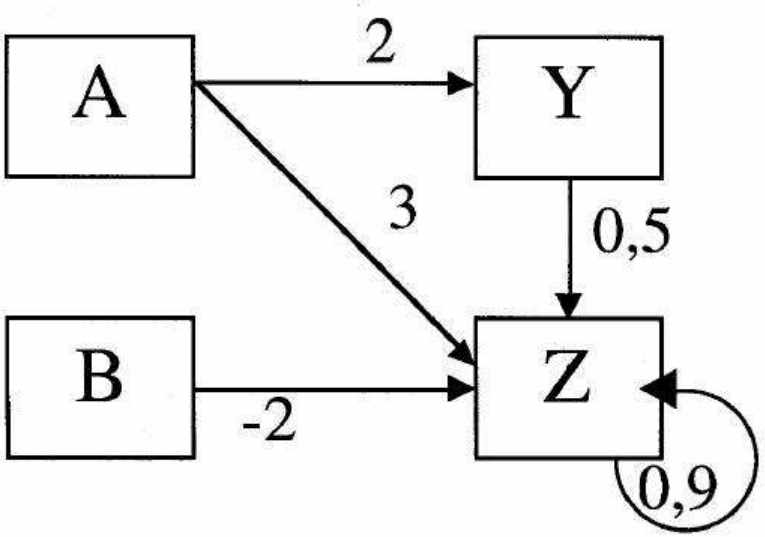
Doesn’t this have to be implicit?

Experiment	Mean listening times (s)	
	Familiar items	Novel items
1	7.97 (SE = 0.41)	8.85 (SE = 0.45)
2	6.77 (SE = 0.44)	7.60 (SE = 0.42)

Implicit Learning Tasks

Dynamic System Control

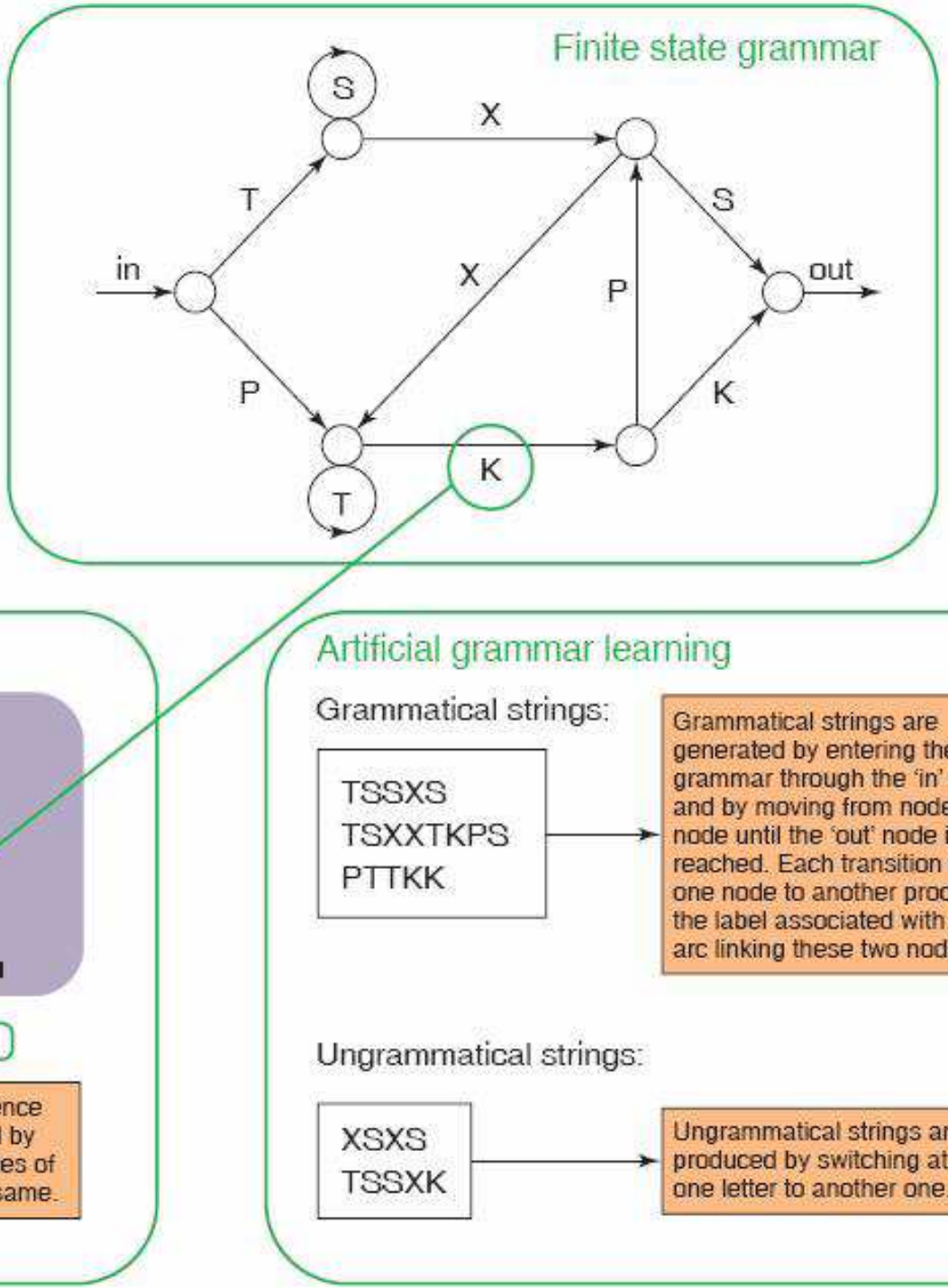




Sequence Learning

Artificial Grammar Learning

Fig. An example of finite state grammar. Strings of symbols are generated by entering the grammar through the 'in' node and by moving from node to node until the 'out' node is reached. Each transition from one node to another produces the label associated with the arc linking these two nodes. The sequences of labels so produced can be presented as strings of letters, graphic symbols, color patches or tones in artificial grammar learning experiments, or as sequences of visual events or tones in the context of sequence learning experiments. (Modified from Ref. a.)



Properties of Implicit Learning

Occurs with incidental, not intentional, learning

With SL and AGL tasks and probabilistic sequences, instructions to discover rules don't help.

WIth DSC task, explanations about nature of system help subject to answer questions, but not control.

Attention not necessary

learning occurs under divided attention, albeit weaker.

No transfer — knowledge inflexible

specificity of learning (Healy & Bourne)

Long lasting — little interference

durability of learning (Healy & Bourne)

Originally viewed as a reflection of a "smart unconscious", IL now seen as "merely a side effect of ongoing processing".

Measures for Assessing Awareness

Verbal report

Subjects surprised by structure in material, or unable to verbalize structure

Problem: Subjects may fail to report knowledge verbally due to low confidence, not lack of awareness.

Forced choice

E.g., old/new judgements on fragments of strings in grammar learning

This *implicit* measure is correlated with *explicit* measures (e.g., indicate which letters make a string ungrammatical) -> learning requires awareness

Problem: Criterion too strict; any information you can act on is conscious!

Metaknowledge

E.g., confidence judgements

Zero-correlation criterion: Subjects are above chance in performance, but accuracy is unrelated to confidence judgements

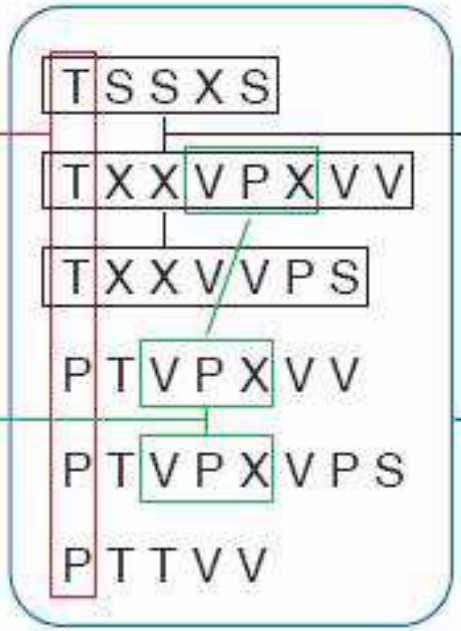
Problem: hasn't been used/demonstrated in memory tasks

Knowledge Representation in Implicit Learning

Rule abstraction approaches produce symbolic knowledge of the material in the form of production rules, discrimination trees, or classifiers:

"IF the string begins with T or P THEN the string is grammatical"

Exemplar-based approaches assume that whole instances are memorized during training. New exemplars can then be classified according to their similarity with either specific items or with the entire memorized database.



Fragment-based and chunking approaches exploit the redundancy of the training material by decomposing it into short chunks such as bigrams or trigrams. The resulting database can be organized hierarchically or not. New exemplars are classified according to how many chunks they share with the training material.

Distributional and statistical approaches (including neural network models), develop superpositional representations of the statistical constraints present in the material based on associative learning mechanisms.

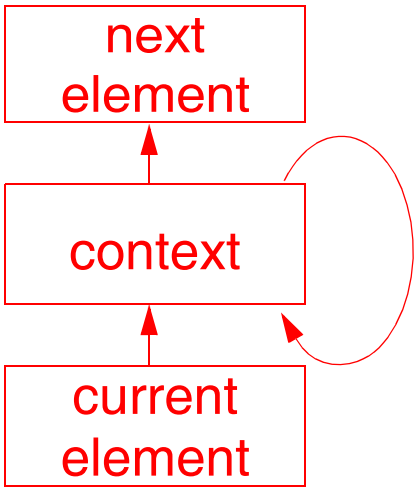
Two Models of Implicit Learning

Neural Network Sequence Prediction

Cleeremans, Servan-Schreiber, & McClelland (1991)

statistical approach

P(element n | element n–1, element n–2, element n–3 ...)



Competitive Chunking Model

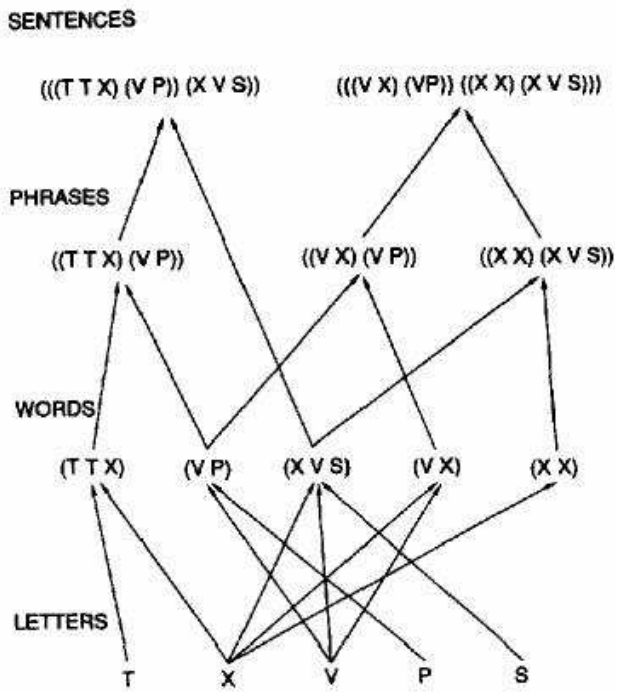
Servan-Schreiber & Anderson (1990)

fragment based approach

chunk = string of one or more letters

build new chunks by combining existing chunks

use chunks for prediction



Implicit and Explicit Learning: Distinct Mechanims?

Amnesics

Usually damage to medial temporal region

Show near-normal implicit learning, but no explicit learning

Brain imaging

Additional brain areas activated with explicit learning (awareness)

Some brain areas activated when sequence regularities are changed, even though subjects are not aware of the change (left premotor, left anterior cingulate, right ventral striatum)

Modulation of Competing Memory Systems by Distraction (Foerde, Knowlton, & Poldrack, 2006)

Headline

Study Finds TV Really Is A Learning Distraction

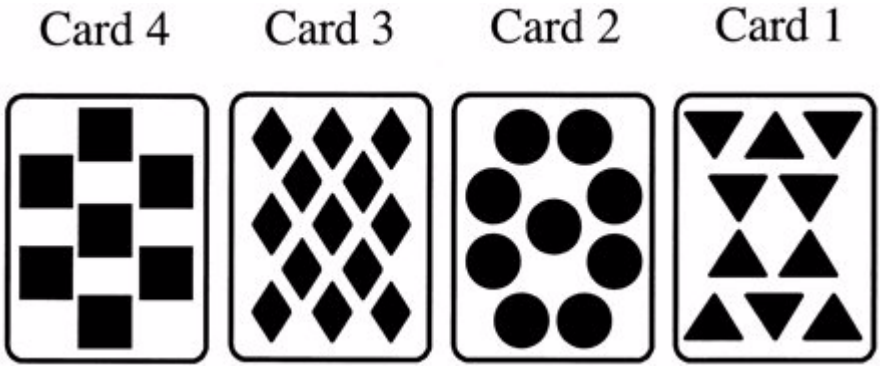
(AP) WASHINGTON

Your parents were right, don't study with the TV on.

Multitasking may be a necessity in today's fast-paced world, but new research shows distractions affect the way people learn, making the knowledge they gain harder to use later on...

Weather Prediction Task

Given some subset of “tarot cards”, predict if it will rain.



	P (Sun|cue present)	P (Rain|cue present)
Cue 4 (squares)	.756	.244
Cue 3 (diamonds)	.575	.425
Cue 2 (circles)	.425	.575
Cue 1 (triangles)	.244	.756

Pattern	Cue 4	Cue 3	Cue 2	Cue 1	P (pattern)	P (rain| pattern)
A	0	0	0	1	0.14	0.143
B	0	0	1	0	0.08	0.375
C	0	0	1	1	0.09	0.111
D	0	1	0	0	0.08	0.625
E	0	1	0	1	0.06	0.167
F	0	1	1	0	0.06	0.5
G	0	1	1	1	0.04	0.25
H	1	0	0	0	0.14	0.857
I	1	0	0	1	0.06	0.5
J	1	0	1	0	0.06	0.833
K	1	0	1	1	0.03	0.333
L	1	1	0	0	0.09	0.889
M	1	1	0	1	0.03	0.667
N	1	1	1	0	0.04	0.75

For each pattern, each card could be present (1) or absent (0). The all-present (1111) and all-absent (0000) patterns were never used. The overall probability of rain, given by summing P (Pattern) *P (rain|pattern) for all patterns, is 50%.

Weather Prediction Task

Probabilistic outcomes, and complexity of contingencies make it difficult to learn explicit rules.

Striatum contributes to performance.

Learning is impaired in patients with basal ganglion disorders.

MTL also contributes to performance.

Subjects can report declarative task knowledge (e.g., “triangles mean rain”), which can be used flexibly or abstractly.

Amnesics can perform task but are impaired at acquiring declarative task knowledge (don’t generalize to other variants of task?).

How does distraction by a secondary task affect the contributions of MTL and striatal memory systems?

Learning of facts (explicit learning) is sensitive to presence of a distracting task that does engage attention or working memory.

Learning of habits (implicit learning) is associated with automaticity, and should not require attention or working memory.

Secondary task

high and low pitched tones played through headphones

Subjects asked to count only the high pitched tones.

Behavioral Results

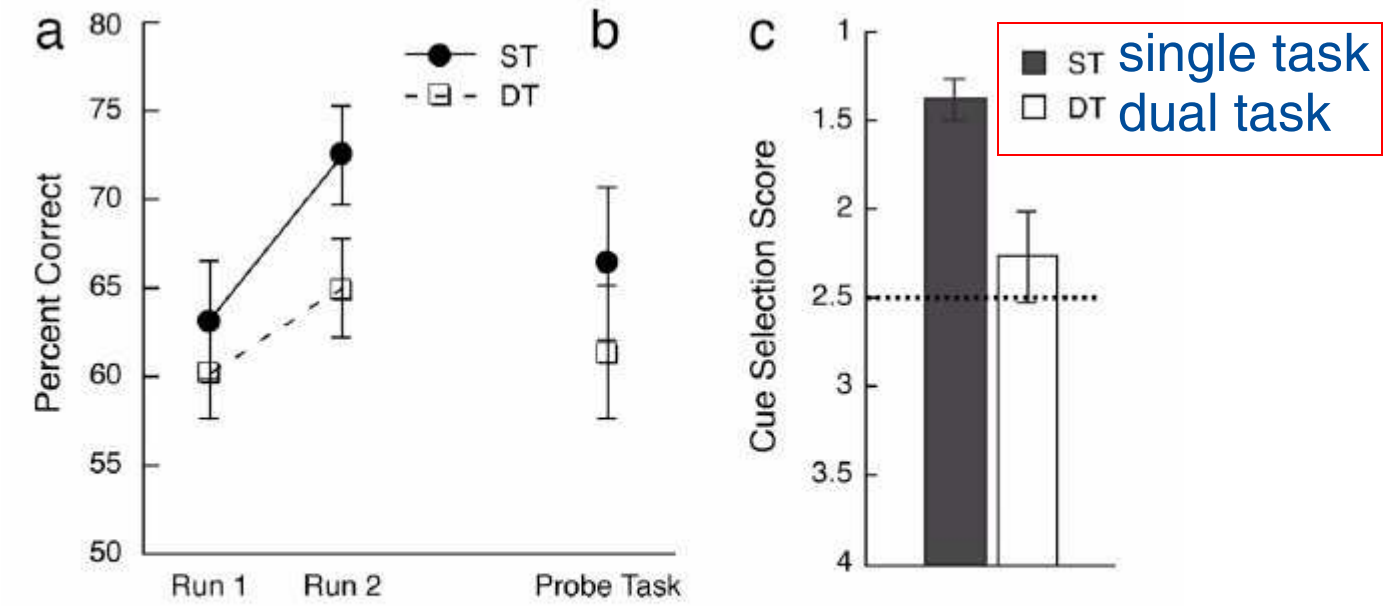


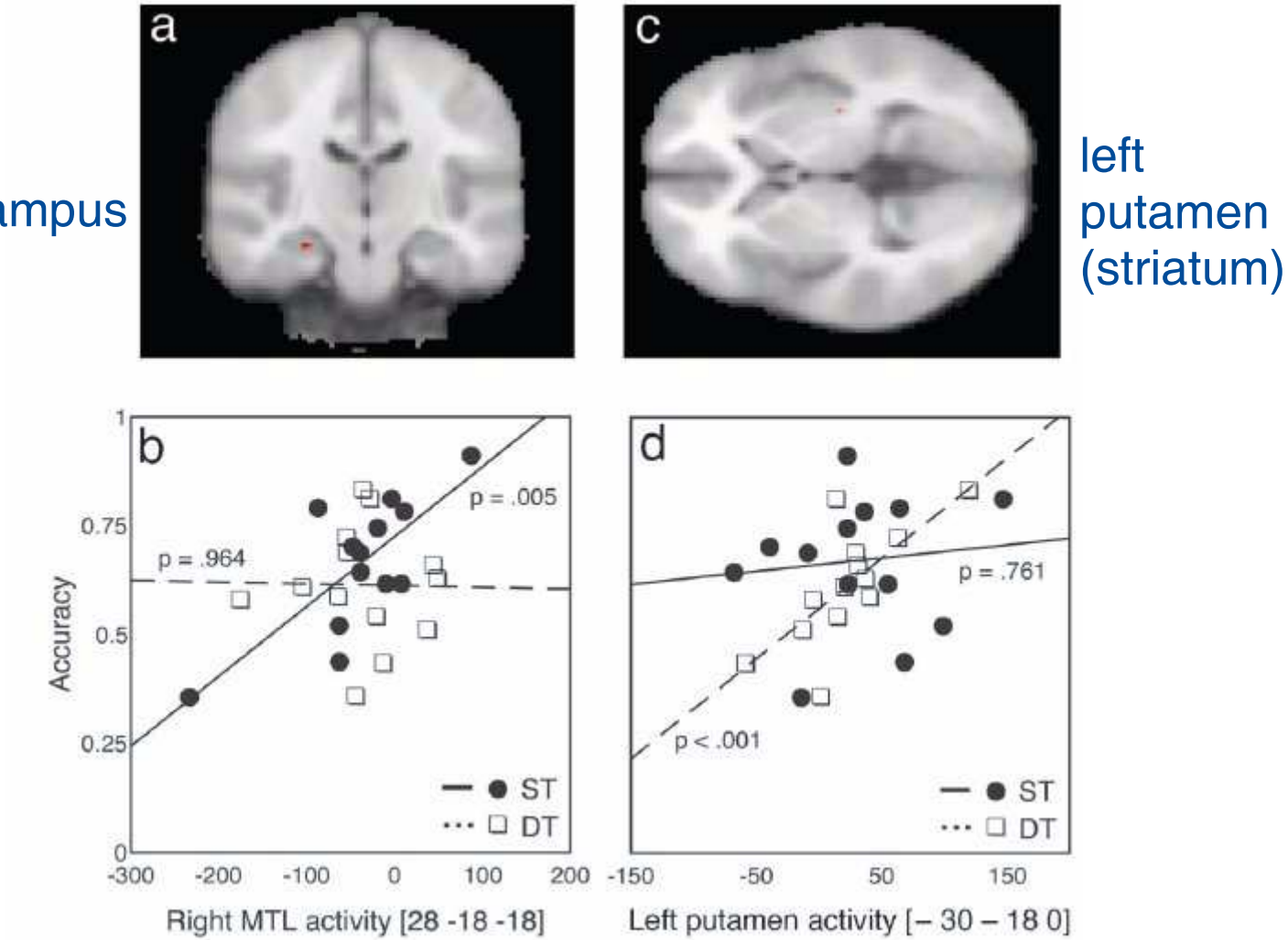
Fig. 2. Behavioral results. The percentages of correct responses are shown. (*a*) PCT performance during training runs 1 and 2 for ST and DT. (*b*) PCT performance during the probe test. (*c*) Cue-selection scores. Scores ranged from 1 to 4 (chance = 2.5). Error bars are standard errors.

***No* statistically reliable effect of secondary task on accuracy.**

However, ability to report cues (cards) that are predictive of rain is at chance with secondary task.

Brain Activity Correlates With Performance

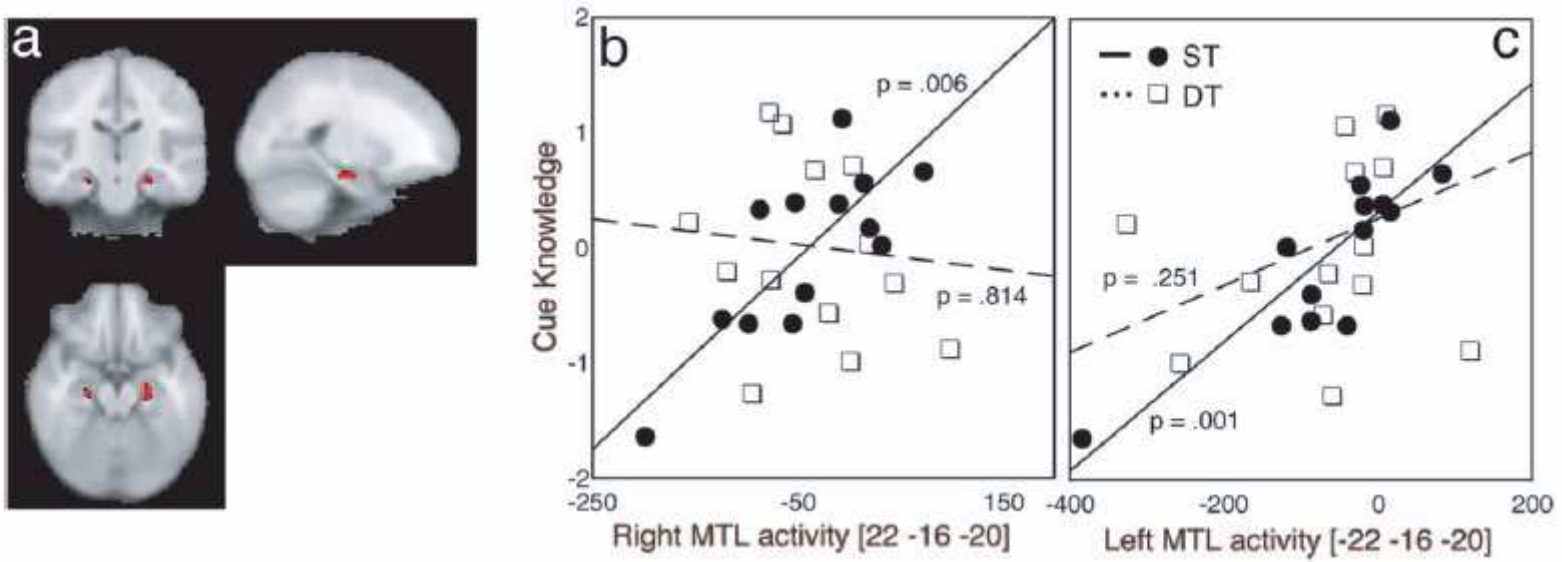
right hippocampus (MTL)



left putamen (striatum)

Further tests show that distraction during learning modulated the degree to which the MTL or striatum was involved in later task performance.

MTL Activity Correlates with Declarative Knowledge



Summary

The probabilistic task can be learned to equivalent levels either by the MTL or striatal systems.

Distraction by a secondary task modulates the relative engagement of these two memory systems.

Implicit (habit) learning

Relatively insensitive to attentional and working memory resources

Explicit (declarative) learning

Responsible for knowledge of cues, and therefore, generalization.

Moral

If you want to learn material robustly (i.e., generalize to new situations), don't be distracted.

Next Class

“Telling more than you can know: Verbal reports on mental processes”

***Many* experiments are described, mostly social psychology and higher-level cognition.**

Pay attention to section headings to see structure of paper.