Models of Free Recall

PSYC201: Cognitive Psychology

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Week 8

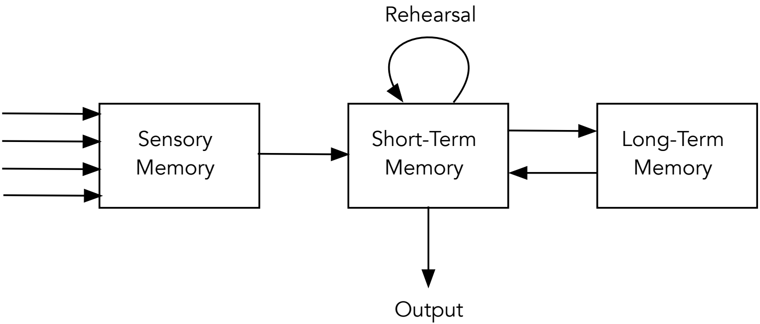
Learning Objectives

- Dual-Store Memory Search Models
  - STS and LTS
  - storage
  - retrieval
  - stopping
  - semantic associations
- Testing Dual-Store Models
  - serial-position effects
  - temporal and semantic clustering
  - category clustering
  - prior-list and extralist intrusions
- Challenges To Dual-Store Models

Dual-Store Memory Search Models

- **Dual-store models** assume separate but interacting short-term and long-term memory stores
- Popularised in the 1970s because of analogy to computer systems
- Consistent with findings from anterograde amnesia patients (Baddeley & Warrington, 1970)
- Interpreted as damage to pathway from short-term to long-term memory

The Modal Model (Atkinson & Shiffrin, 1968)



- The model has been refined over the years
- The modern version of the model is known as SAM, which stands for *<u>S</u>earch of <u>A</u>ssociative <u>M</u>emory* (Raijmakers & Shiffrin, 1980)

SAM: STS and LTS

- Two types of store: **short-term store (STS)** and **long-term store (LTS)**
- STS is a limited capacity memory "buffer"
- Items in STS are:
  1. easily recalled, and
  2. their associations in LTS can be strengthened
- LTS consist of two components:
  1. a matrix that stores associations among items, and between items and list context (*episodic matrix*)
  2. a matrix that stores pre-existing semantic associations among items (*semantic matrix*)

SAM: Storage

- Items enter STS as they are presented
- Items are rehearsed while in STS, which increases strength of associations in LTS
- STS has limited capacity of $\approx$ 4 items
- Once full, a newly encoded item will displace an item already in STS
- For example, if *house shoe tree car* are in STS, then one item must be displaced to make way for *dog*
- Longer an item has been in STS, the more likely it will be displaced (e.g., *house* is most likely to make way for *dog*)

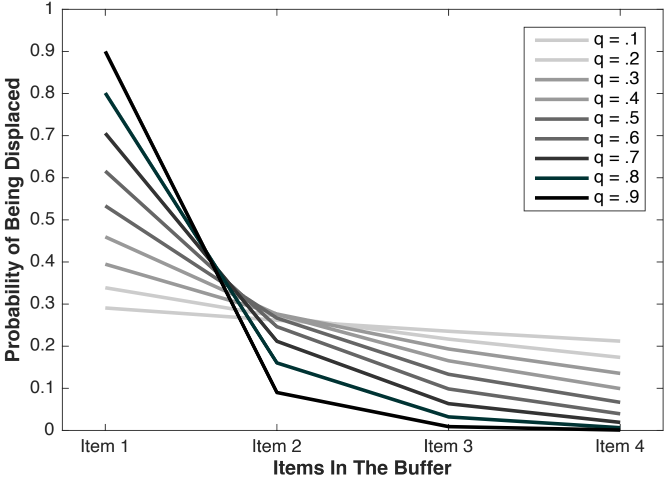
SAM: Storage

- Displacement occurs probabilistically, so sometimes a more recently encoded item will be displaced
- The probability that the *i*th item will be displaced from the buffer is given by:

$$p(i) = \frac{q(1-q)^{i-1}}{1-(1-q)^{r}},$$

- q is a parameter of the model that determines the degree of bias favouring displacement of older items
- r is the number of items in the buffer

SAM: Storage


Probability of Being Displaced
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Item 1
Item 2
Item 3
Item 4
Items In The Buffer
q = .1
q = .2
q = .3
q = .4
q = .5
q = .6
q = .7
q = .8
q = .9

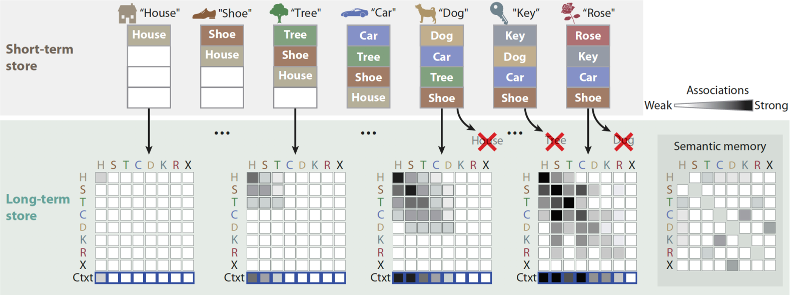
SAM: Storage

- Time spent in STS depends on presentation rate and buffer size (a parameter of the model)

SAM: Storage

- Rehearsal in STS modifies strength of associations in LTS
- Increases strength of association between each item in STS and the list context
- Also increases strength of the *forward* and *backward* association in LTS between any two items that simultaneously occupy STS
- Amount by which associations are increased determined by parameters of the model (SAM uses separate learning parameters for forward and backward associations)

SAM: Storage



- Each word enters STS, which holds up to four items
- Once full, new words displace older ones (indicated by X-ed out words)
- While in STS, associations among words strengthen in LTS, as shown in matrices with shaded boxes
- Shading of cells represents strength of a given association: between list items, or between list items and context
- Semantic memory contains semantic associations among list items

SAM: Retrieval From STS and Search of LTS

- In SAM, retrieval during immediate free recall consists of two stages:
  1. items in STS are output first
  2. items are retrieved from LTS
- Retrieval from LTS divided into two phases: first an item is *sampled*, then it may or may not be *recalled*
- Search begins by using list context as a retrieval cue
- Probability of an item being sampled depends on strength of its association with context (“dartboard” analogy)

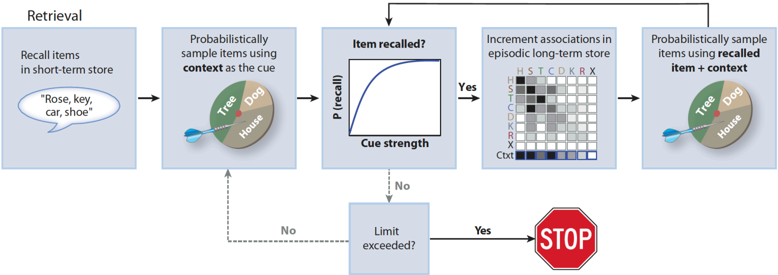
SAM: Retrieval From STS and Search of LTS

- A sampled item is further evaluated to determine if it is recalled
- To be recalled, the strength of the sampled item in memory must exceed a threshold
- If the item is recalled, the strength of its association with the list context is increased in episodic LTS
- The item, plus the list context, is then used to cue recall of another list item
- If an item is retrieved, its association with the last recalled item is increased in episodic LTS as is its association with the list context

SAM: Retrieval From STS and Search of LTS

- When both cues are used (item + context), sampling and recall involves associations in episodic and semantic matrices
- Consider two non-recalled items (*apple* and *lorry*) that have equivalent associations to the just recalled item (*orange*) and the list context in the episodic matrix
- If the association between *orange* and *apple* is higher than between *orange* and *lorry* in the semantic matrix, *apple* is more likely to be sampled
- An item previously recalled cannot be recalled again
- There is a total limit on the number of recall attempts that can be made before search terminates

SAM: Retrieval From STS and Search of LTS



- Retrieval begins with recall of items in STS
- Continues with search of LTS cued by context and previously recalled items
- Recalling an item from LTS involves first sampling candidate items for potential recall and then determining whether the candidate item is recalled
- Recall ends after a certain number of retrieval failures

Testing Dual-Store Models

- Serial-position effects
- Temporal and semantic clustering
- Category clustering
- Intrusions

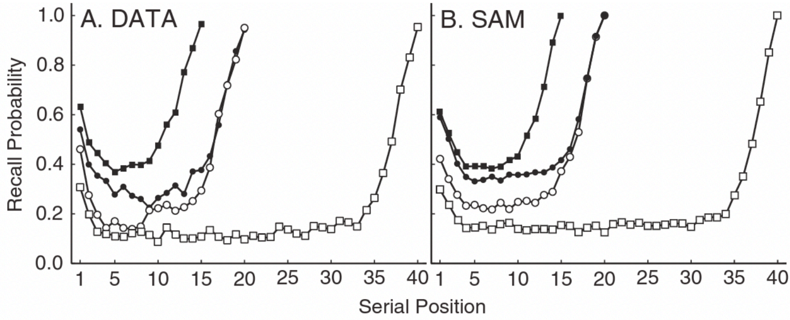
Serial Position Effects

- According to SAM, recency effects in immediate free recall reflect retrieval from STS
- Items at end of list are most likely to be in STS at time of test
- SAM can explain loss of recency following a distractor-filled delay as distractors displace study items in STS
- Fixed capacity of STS means SAM can explain insensitivity of recency effect to list length and presentation rate

Serial Position Effects

- Pre-recency items spend more time in the STS having their strengths increased in episodic LTS
- This explains the primacy effect
- Slower presentation rates enhance the primacy effect
- Items spend more time in STS before they are displaced
- Leads to stronger item-to-item and item-to-context associations in episodic LTS

Serial Position Effects

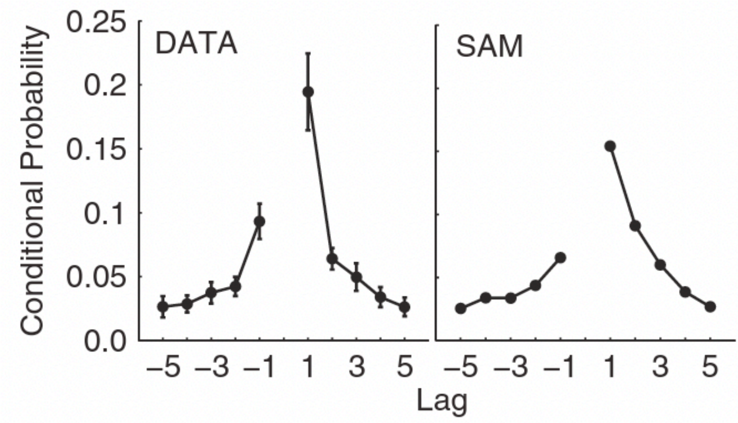


- Filled squares and circles represent lists of 15 items and 20 items presented at a 2-sec/item rate
- Open circles and squares represent list of 20 items and 40 items presented at a 1-sec/item rate

Temporal Clustering

- SAM accounts for participants' tendency to make recall transitions to neighbouring list items (the contiguity effect)
- Neighbouring items are most likely to spend time together in STS
- The associations between those items in episodic LTS will be strengthened
- The forward bias in the contiguity effect arises as forward associations are increased more than backward associations

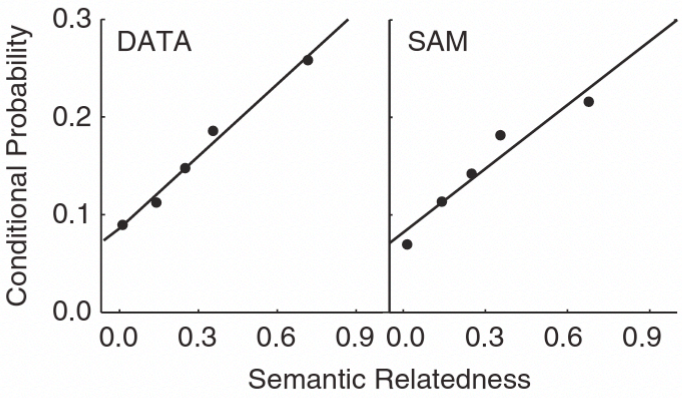
Temporal Clustering



Semantic Clustering

- SAM accounts for participants' tendency to make recall transitions to semantically related items (semantic proximity effect)
- This effect arises because semantic similarities are used to cue retrieval

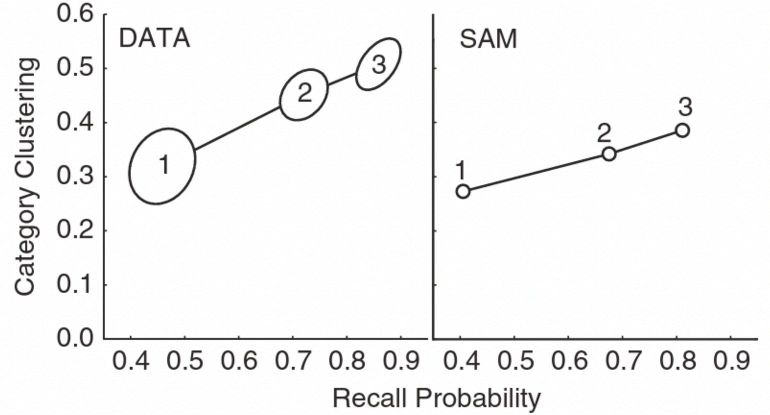
Semantic Clustering



Category Clustering

- Participants tend to recall categorically related words in clusters (category clustering)
- Kahana and Wingfield (2000) had participants study lists of 20 words, each comprised of four exemplars drawn from five natural categories
- Participants studied and recalled lists several times (in different random order) until they achieved perfect recall
- **Ratio of repetition** = number of within-category recall transitions / total number of recall transitions
- **Category clustering** = ratio of repetition – ratio expected if items recalled in random order

Category Clustering



- Clustering is plotted as a function of recall probability for the first three trials of a multi-trial free-recall experiment

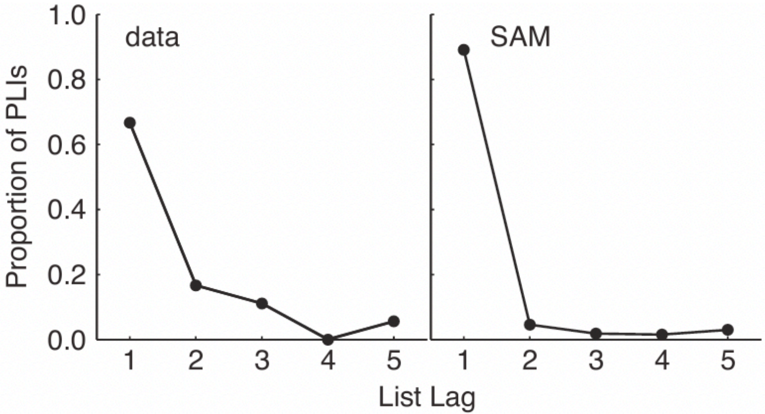
Category Clustering

- Two mechanisms are responsible for ability of SAM to cluster responses categorically:
  1. pairs of words would be recalled together due to semantic relatedness
  2. after initial recall, these pairs become increasingly likely to be recalled together on subsequent trials due to strengthening of episodic associations at retrieval

Prior-list and Extralist Intrusions

- When participants commit prior-list intrusions (PLIs), those intrusions tend to be items that appeared on recent lists (PLI-recency effect)
- SAM can reproduce this basic trend
- It can also reproduce the distribution of correct responses, PLIs and extralist intrusions (ELIs)

Prior-list Intrusion Recency Effect



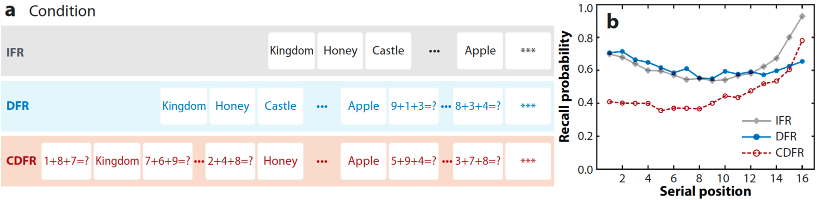
Prior-list and Extralist Intrusions

	Correct	PLI	ELI
DATA	5.0 (±0.5)	0.5 (±0.2)	0.2 (±0.1)
SAM	4.7	0.53	0.18

Prior-list and Extralist Intrusions

- In SAM, context changes gradually between lists
- SAM accounts for PLIs and the PLI-recency effect because the list context for list L will be most similar to list $L - 1$
- ELIs are generated by strong semantic associations between items

Challenges To Dual-Store Models: Long-Term Recency



- IFR = immediate free recall; DFR = delayed free recall; CDFR = continual-distractor free recall

Challenges To Dual-Store Models: Long-Term Recency

- Dual-store models assume recency reflects retrieval from STS
- But in CDFR any items in STS would have been displaced by distractors
- Long-term recency is thus a major challenge to such models
- Some theorists have suggested separate mechanisms are responsible for short and long-term recency (Davelaar et al., 2005)

Summary

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- Challenges To Dual-Store Models

Recommended Reading

Kahana, M. J. (2017). Memory search. In J. H. Byrne (Ed.), *Learning and Memory: A Comprehensive Reference, 2nd Edition* (Second Edition Ed, vol. 2, p. 181-200). Oxford: Academic Press. `http://memory.psych.upenn.edu/files/pubs/Kaha17.pdf`

References

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. *Psychology of Learning and Motivation, 2(4),* 89-195.

Baddeley, A. D., & Warrington, E. K. (1970). Amnesia and the distinction between long-and short-term memory. *Journal of Verbal Learning and Verbal Behavior, 9(2),*176-189.

Davelaar, E. J., Goshen-Gottstein, Y., Ashkenazi, A., Haarmann, H. J., & Usher, M. (2005). The demise of short-term memory revisited: empirical and computational investigations of recency effects. *Psychological Review, 112,* 3-42.

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Kahana, M. J., & Wingfield, A. (2000). A functional relation between learning and organization in free recall. *Psychonomic Bulletin & Review, 7(3),* 516-521.

Raaijmakers, J. G., & Shiffrin, R. M. (1980). SAM: A theory of probabilistic search of associative memory. *The Psychology of Learning and Motivation: Advances in Research and Theory, 14,* 207-262.