Memory by Temporal Sampling

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Aim of Talk

Free recall in humans

Existing temporal distinctiveness models of memory treat the temporal locations of items as point sources

Extend temporal distinctiveness approaches to reflect the fact that items in a to-be-remembered list have *temporal extension*

Apply to some key free recall data including:

- Effects of retention interval on serial position curve
- Effects of rehearsal on serial position curve
- "Total Time" effects

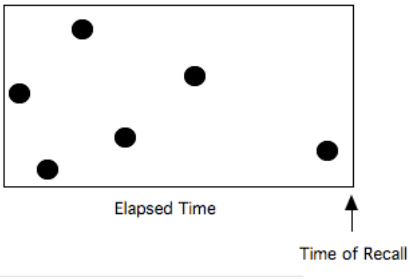
Starting point

SIMPLE model of memory (Brown, Neath, & Chater, 2002)

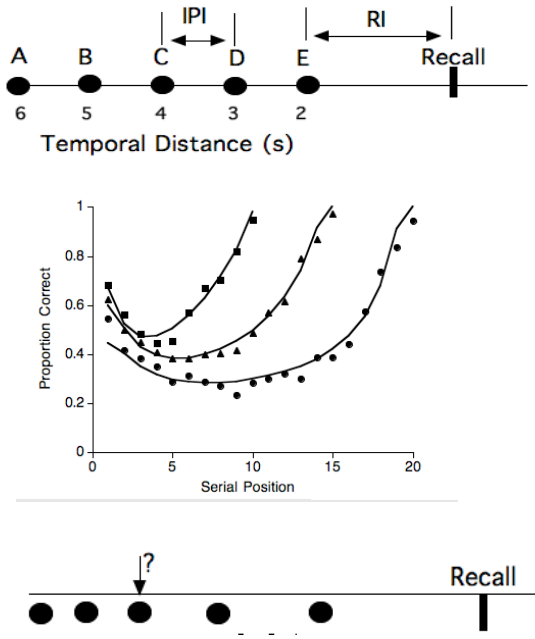
- Items are located within a multi-dimensional space (as in exemplar models)
- Items close to one another will be more difficult to discriminate from one another and hence less retrievable

A key dimension is **temporal distance** (how long ago an item occurred, as seen from the time of retrieval)

Here we discuss just this temporal dimension



Recency Matters



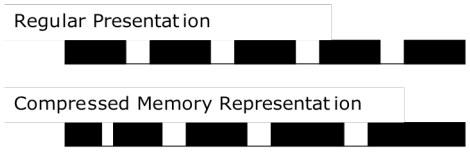
A simplification (in SIMPLE)

SIMPLE does well on a range of data, e.g.:

- serial position curves,
- proactive interference effects
- effects of passage of time

But:

- It assumes that items occupy point locations in multidimensional space (including along the temporal distance dimension)
- In fact: item presentations are temporally extended



Why it might matter

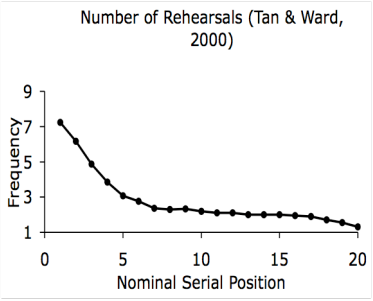
Rehearsal in free recall

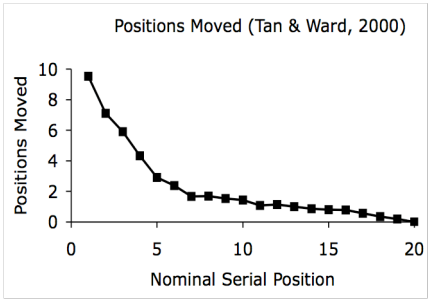
- In the gaps between item presentations, participants rehearse the items
- **A** a a a **B** a b a **C** a b c **D** a b c .....
- Rehearsal seems to be important in explaining primacy effects (Rundus, 1971; Tan & Ward, 2000)
- But rehearsal may cause the memory traces to become less temporally distinctive

"Total time" effects (Murdock, 1960; Waugh, 1967)

- When total list time is held constant, the probability of retrieving a repeated item will depend on the proportion of the total list time for which that item is presented
- No natural way to explain with point-source model

Effects of Rehearsal (overt rehearsal procedure)





Items that are presented early in the list (a) receive more rehearsals, and (b) are "carried forward" further

Primacy and Rehearsal

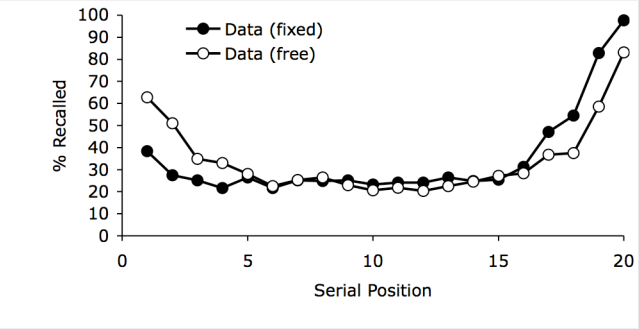
Data from Tan & Ward (2000; overt rehearsal)

Compare *fixed* rehearsal

- **A** a a a **B** b b b **C** c c c **D** d d d .....

with *free* rehearsal

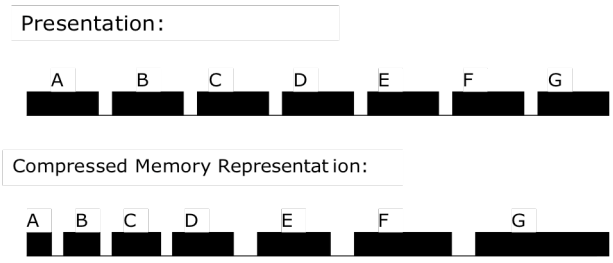
- **A** a a a **B** a b a **C** a b c **D** a b c .....



Extending the Model

Incorporate the idea that items have temporal extension

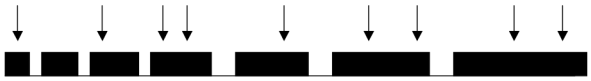
- Preserve the compressed time-line (cf. telephone pole analogy)
- Items occupy sections of the time-line
- Power-law transformation of temporal distances to achieve the compression (first free parameter)



Sampling the Time Line

Retrieval:

- The time-line is sampled many times at random locations



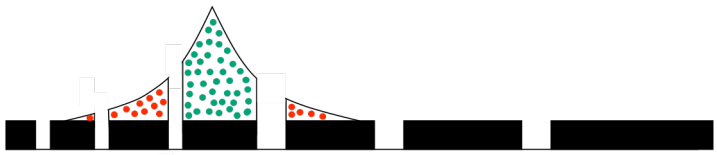
Each cue is evidence for only the item whose memory representation it lands on

- Recent items will receive more retrieval cues on average (especially if they are sampled soon after presentation, when temporal distance remains short)

Sampling the Time Line (2)

Each cue is evidence for only the item whose memory representation it lands on

However each cue will tend to activate nearby items (exponential gradient; second free parameter)



The evidence for an item given a cue depends on the extent to which the cue activates *only that item*

- e.g.: (green area) / (green area + red area)

Finally: Probability of recall will depend on the amount of evidence accumulated for each item (third parameter: proportionality constant)

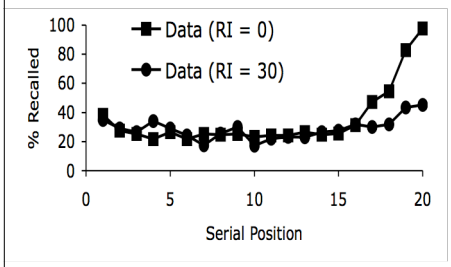
Immediate vs Delayed Free Recall (Fixed Rehearsal)

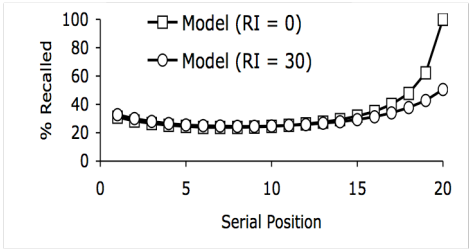
Data from Tan & Ward (2000; overt rehearsal)

Use fixed rehearsal; immediate or delayed FR

- **A** a a a **B** b b b **C** c c c **D** d d d .....

Time-line structure in model exactly as in experiment





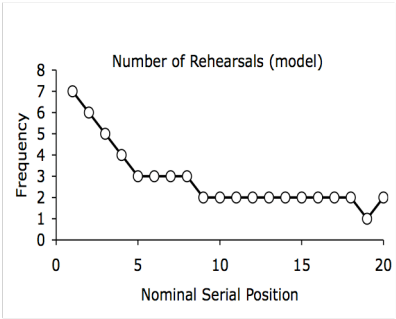
Impose a Rehearsal Strategy

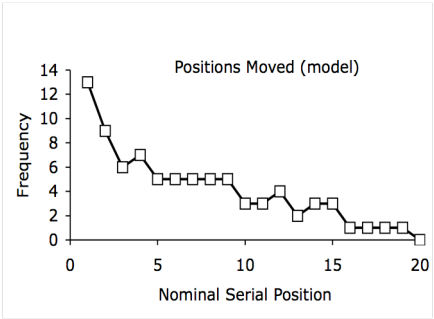
In the gaps between item presentations, participants rehearse the items

- **A** a a a **B** a b a **C** a b c **D** a b c .....

Impose a rehearsal structure on the model:

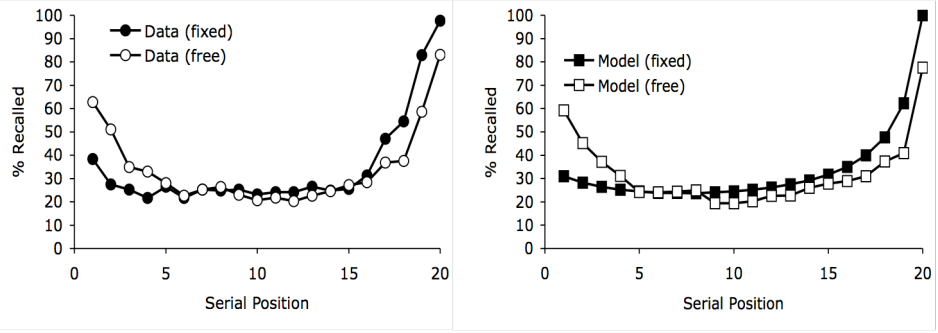
- (same rehearsal as observed experimentally)





Fixed vs Free Rehearsal

All parameters held constant: Impose rehearsal schedule on model. Each rehearsal of an item is like a new presentation of the item

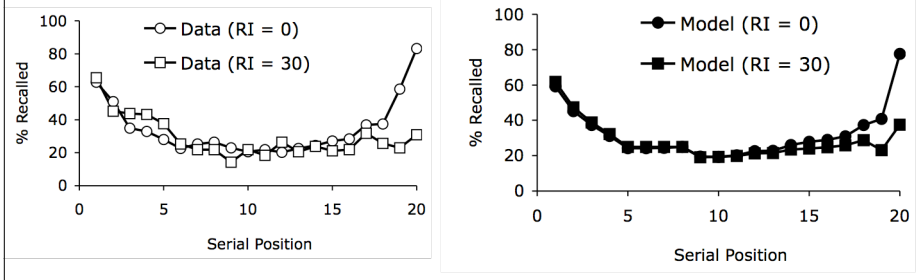


- Primacy items are advantaged through recency of last rehearsal, and number of rehearsals
- Primacy items receive more rehearsals and hence occupy more of the time-line

Effect of Delay

Keep all parameters the same; use same rehearsal schedule

Add fixed retention interval of 30 s



Primacy effects remain after delay in both model and data

Reflects high proportion of time-line occupied by primacy items

Total Time Hypothesis (Data)

Waugh (1967; see also Murdock, 1960; Roberts, 1972)

Free recall; hold total list presentation time constant (at 120 sec)

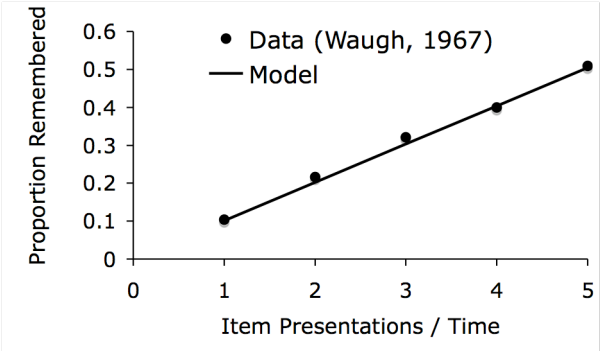
- 120 words each presented X 1
- 60 words each presented X 2
- 40 words each presented X 3
- 30 words each presented X 4
- 24 words each presented X 5

Key Result:

- The probability of recalling an item is proportional to its total presentation time
- (the same number of unique words are recalled in each condition)

Total Time Hypothesis (Model)

Parameters the same as before except for a constant



The temporal sampling model behaves in accordance with the total time rule

(serial position effects occur, but these average out in both data and model)

Summary and Conclusion

Current temporal distinctiveness models make the simplifying assumption that items' temporal locations can be treated as point sources

The temporal sampling model extends temporal distinctiveness models to represent the proportion of a compressed time-line occupied by an item

Offers potential account of rehearsal effects and serial position effects in serial recall

Extensions:

- Generate the rehearsals (akin to recall after each item)
- Output order effects