An ACT-R/PM Model of the Articulatory Loop

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Overview

- Data Set
- Previous computational models of serial recall
- ACT-R/PM's implementation of the articulatory loop
  - Features of the model
  - Parameters
- Discussion of the model
  - Behavior of the model
  - Fit to the data
  - Future improvements/uses

Experiment of Baddeley et al (1975)

- Experiment number 1
  - Serial memory task
  - 2 variables
    - Word length (syllables)
    - List length (in words)
  - Random lists, of 4-8 items, were made from pools of short or long words.
  - Dependent measure was the correct recall of the entire list.

Word List

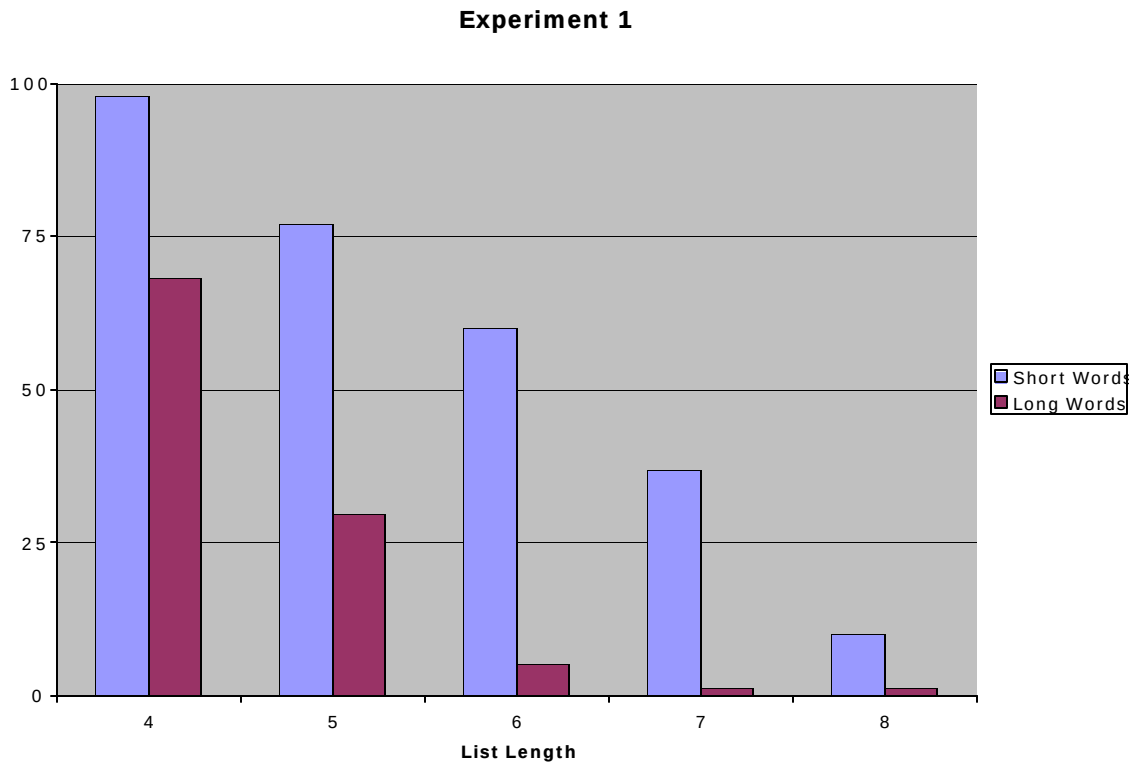
Word List

Short Words	Long Words
sum	associ ation
Harm	representative
wit	opportunity
bond	organization
yield	considerable
worst	immediately
twice	university
Hate	individual

(figure 1 stimulus list)

- Exact times of articulation were not provided
- Therefore ACT-R/PM's method of calculation was used.
- The parameter **syllable-rate** was kept at its default value, .15 s

Experiment 1



- Increased word length (time of articulation) degrades performance
- Longer lists degrade performance

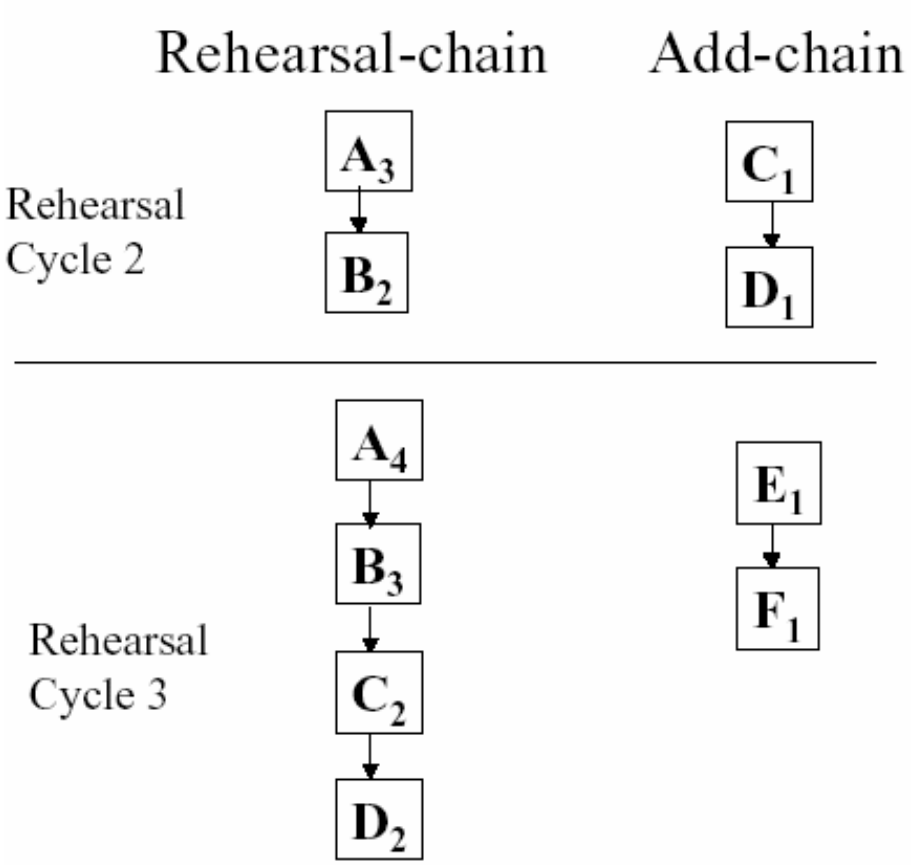
Models of Serial Recall

- Aside from the ACT-R/PM model of the articulatory loop numerous other models of serial recall exist.
- EPIC has a model of the articulatory loop and serial recall
  - It has been used to model Baddeley's experiment number 1
- ACT-R has numerous models of serial recall
  - Ex. The ACT-R model of serial recall (in Atomic Components of Thought)
  - However, none of these are truly articulatory

EPIC

- EPIC's architecture is quite different from ACT-R
- EPIC's production system is much simpler
  - All the productions that match fire
    - So there is no cognitive bottleneck
- The approach to declarative memory is also simplified
  - No graded activation
  - Chunks either exist or they don't
  - Some models (including the EPIC model of the articulatory loop) utilize decay
  - Decay time is set for chunks. After this decay time passes, the chunk disappears

Overview of the EPIC Model



During a single Rehearsal Cycle, EPIC generates a new rehearsal-chain by first rehearsing all items in the rehearsal chain.

Next, EPIC completes the new rehearsal chain by rehearsing the items in the add-chain.

Subscripts denote the "copy" of a word that is being used by this rehearsal strategy. For instance, during Rehearsal Cycle 3, "A" has been rehearsed or heard four times, while "E" has only been heard once.

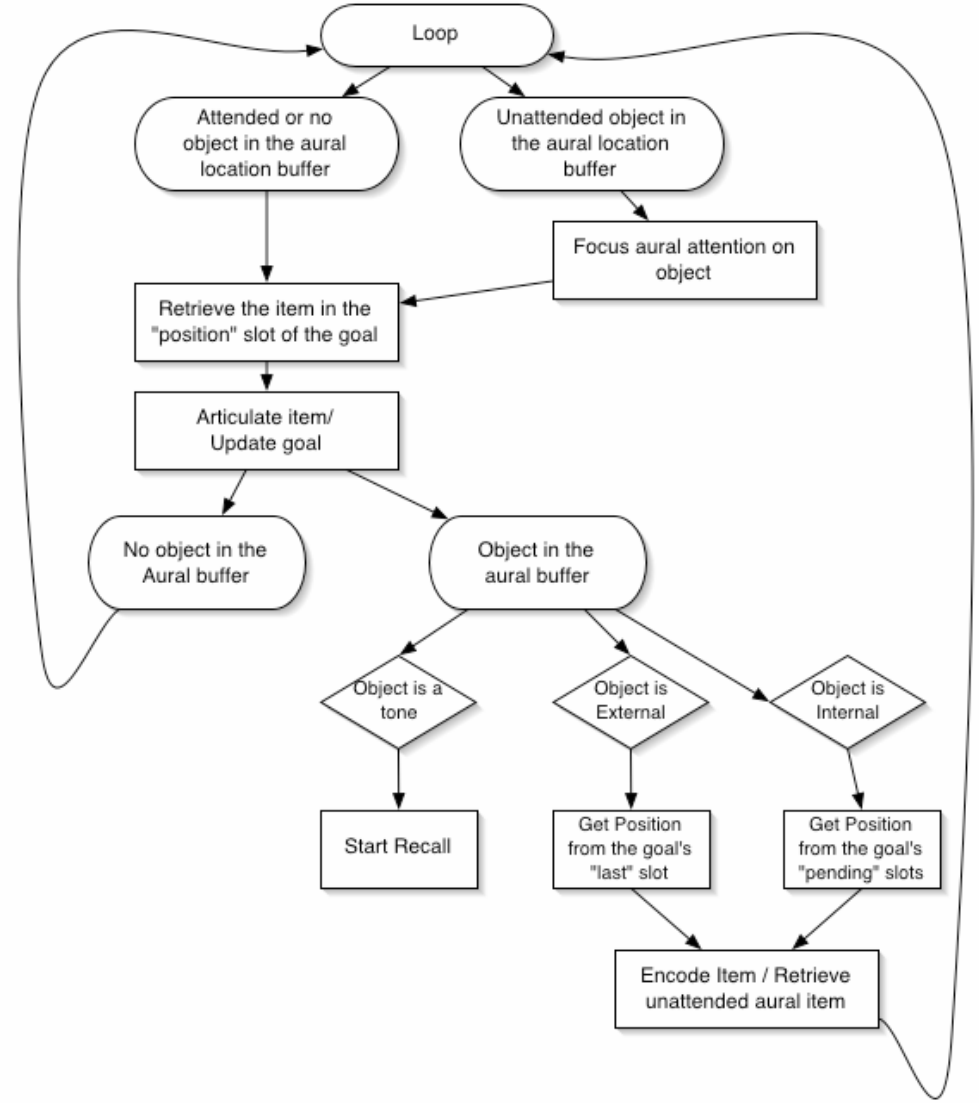
ACT-R Models of Serial Recall

- There are many differences between the ACT-R model of serial recall (Atomic Components of Thought) and the ACT-R/PM model of the articulatory loop.
  - The ACT-R model of serial recall
    - Utilizes a retrieval, not an articulatory based loop
    - Does a different Task (numerical grouped recall)
    - Is focused on more higher level effects (grouping etc.)
- Yet similarities exist
  - Chunk structure for encoded items

The ACT-R Model of the Articulatory Loop

- Emphasis on time based decay
  - Base level learning takes place through retrievals and re-encoding of chunks
- Parallelism
  - ACT-R/PM's various modules function independently
  - The model's productions are structured to take advantage of this fact
  - Ex. While the audition module is recoding an audio-event the vocal module can be subvocalizing an item
- Items are chunked positionaly
  - As opposed to EPIC's "chain" encoding
  - This is similar to the approach taken in the ACT-R model of Serial Recall

Overview of the Model



Goal Structure

Goal-1	
isa	do-loop
Position	(contains the position of item that is to be subvocalized)
Pending1	(contains a previously subvocalized item's position)
Pending2	(contains a previously subvocalized item's position)
Last	(contains the position of the last element in the list)
List	(contains the chunk signifying he current list)

Declarative Memory

- 3 Major Chunk Types
  - Item Chunks

goal123		goal124	
isa	Item	isa	Item
Position	First	position	Second
Word	Hate	Word	Sum
List	new-list	List	New-list

    - Created through a +goal>
  - “Position-fact’s”
    - Ex. after first is second
  - “Meaning” chunks (To get a string’s meaning)

Parameters

- Most of the parameters were kept at their default values.
  - The retrieval threshold was manipulated
    - Final estimation .54
  - The activation noise level was manipulated
    - Final estimation .3

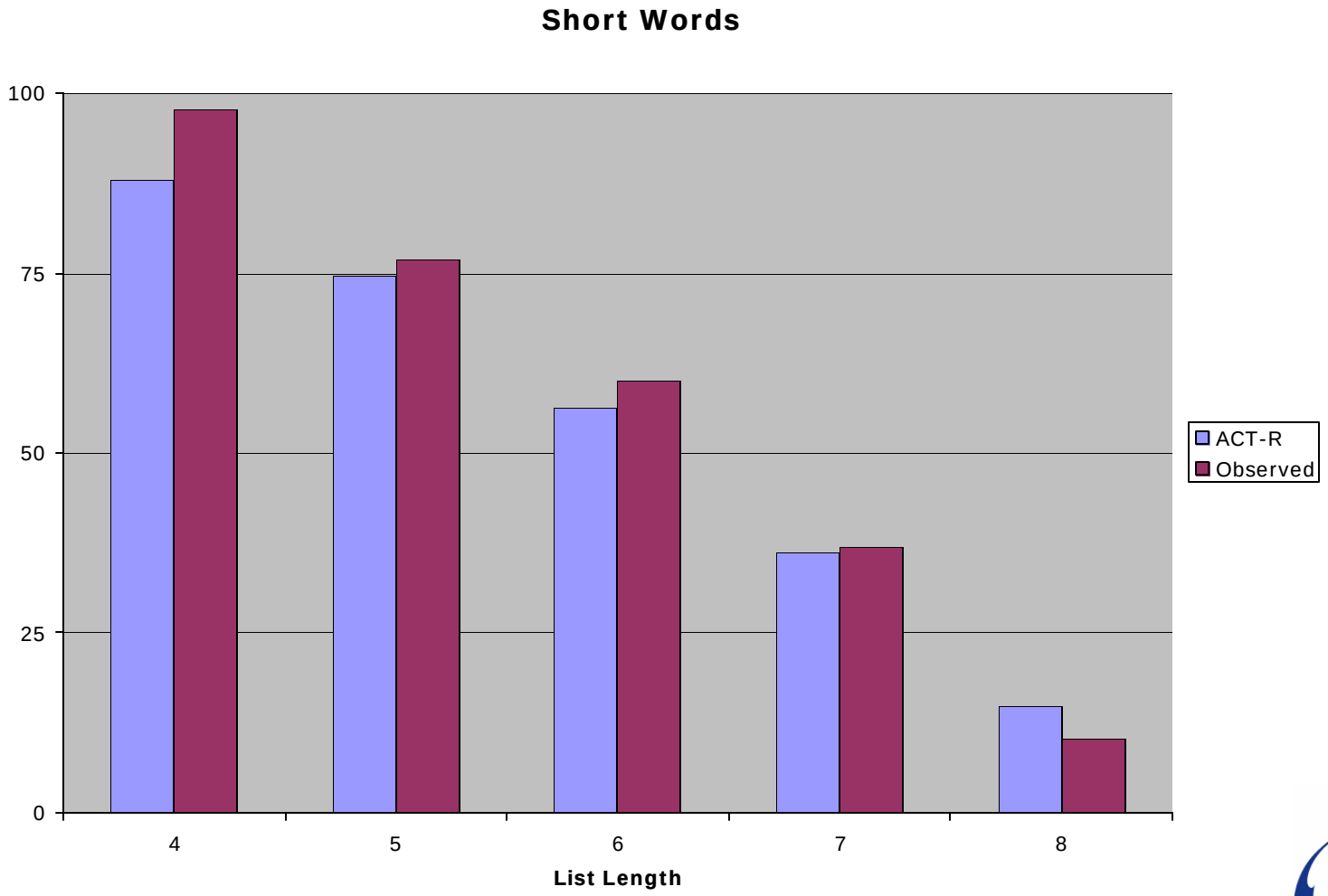
Modifications to ACT-R/PM

- Additions were made to accommodate the model
  - Subvocal speech output was added.
    - Subvocal functions similar to speak. It places a sound in the audiocon but does not produce any other output.
  - Localization of sound was added
    - This feature has been partially present, but until now was unused.
- Both of these features are now available in the perceptual motor modules.

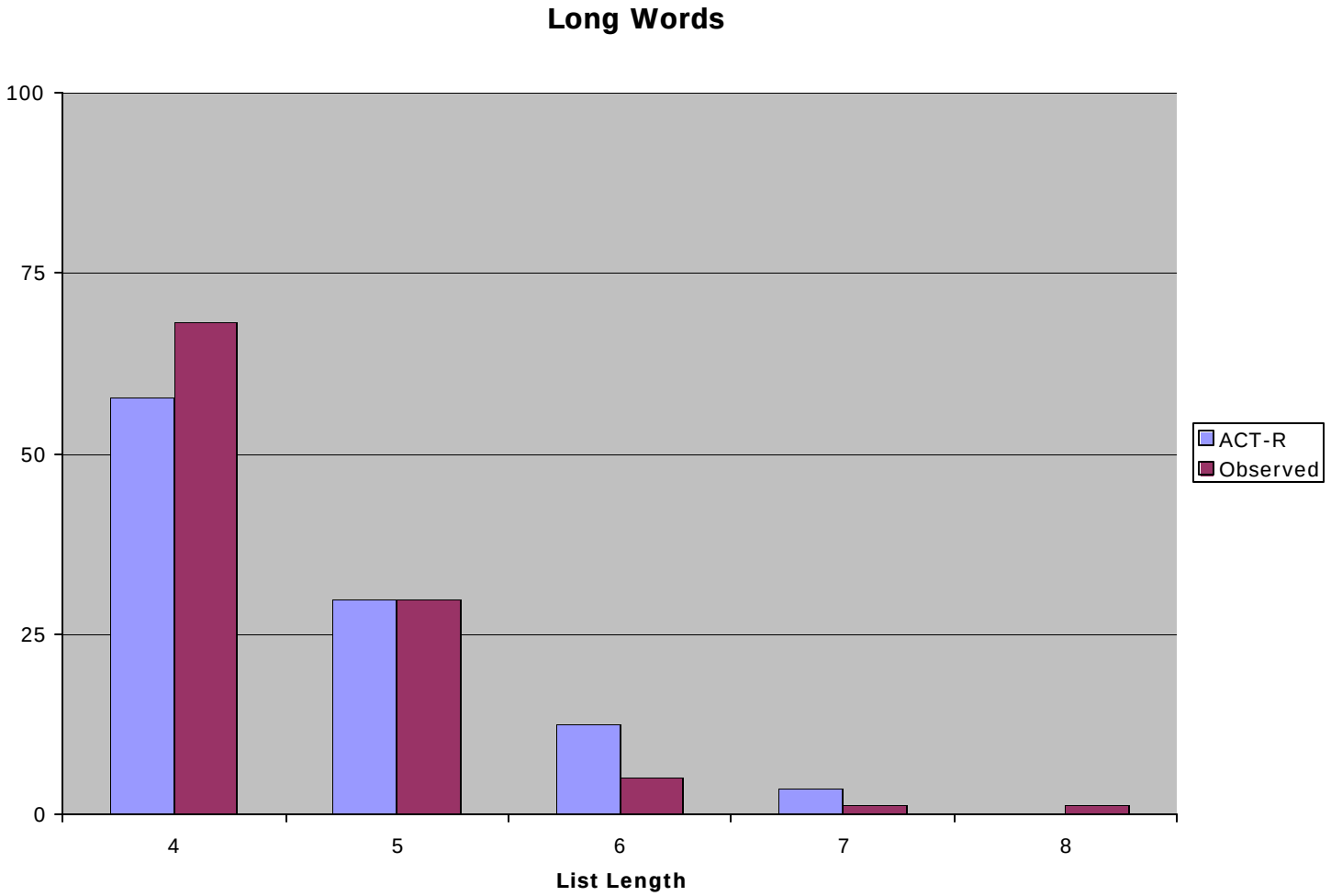
Behavior

- The model successfully demonstrated quantitative effects of list and word length
  - Items in longer lists are articulated less often, thereby degrading performance
  - Longer words take longer to articulate, also leading to a decrease in performance

Results- Short words



Results- Long words



Analysis

- The model produces the required effects, but does not give an ideal fit to the data
- Underestimates short lists, over estimates longer lists
- Thus the list length effect is not as strong as it should be
  - Reasons?
    - Estimated times of articulation
    - No partial matching
- There is also a possibility that this is a result of the experiment's design.

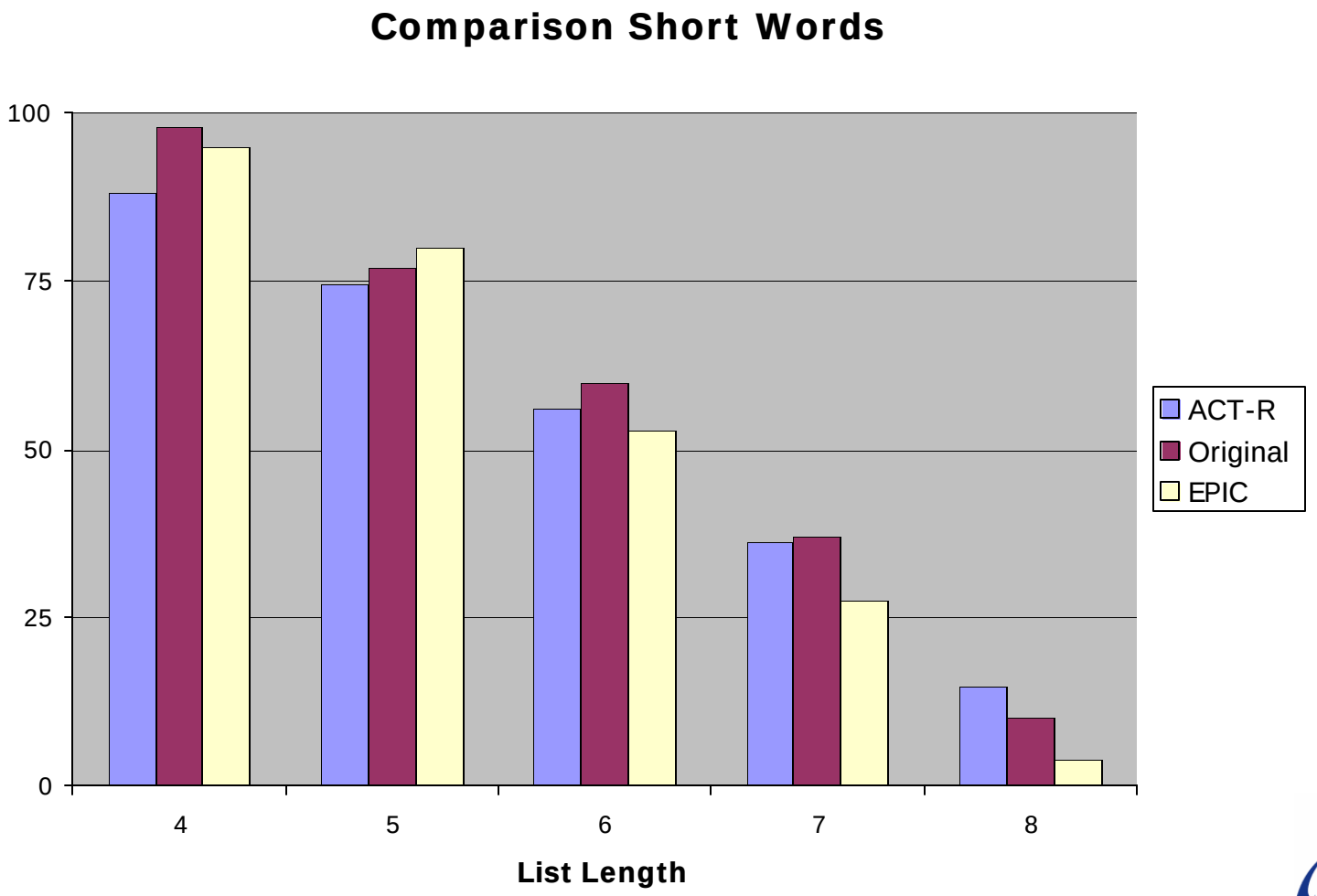
Experiment Design

- Baddeley ran the experiment in an odd way
  - Subjects were presented 8 trials of each type
  - Trials were given in an ascending order
    - So after 8 four item trials were ran, 8 five item trials would be ran.
  - However if a subject failed all 8 trials, the experiment was terminated
- This leaves two possibilities
  - The subject pool decreases as word length increases
    - This would be odd as it is a very selective
  - Or Baddeley assumed the subject would fail and recorded the data as such
    - This would cause the data to underestimate longer lists.

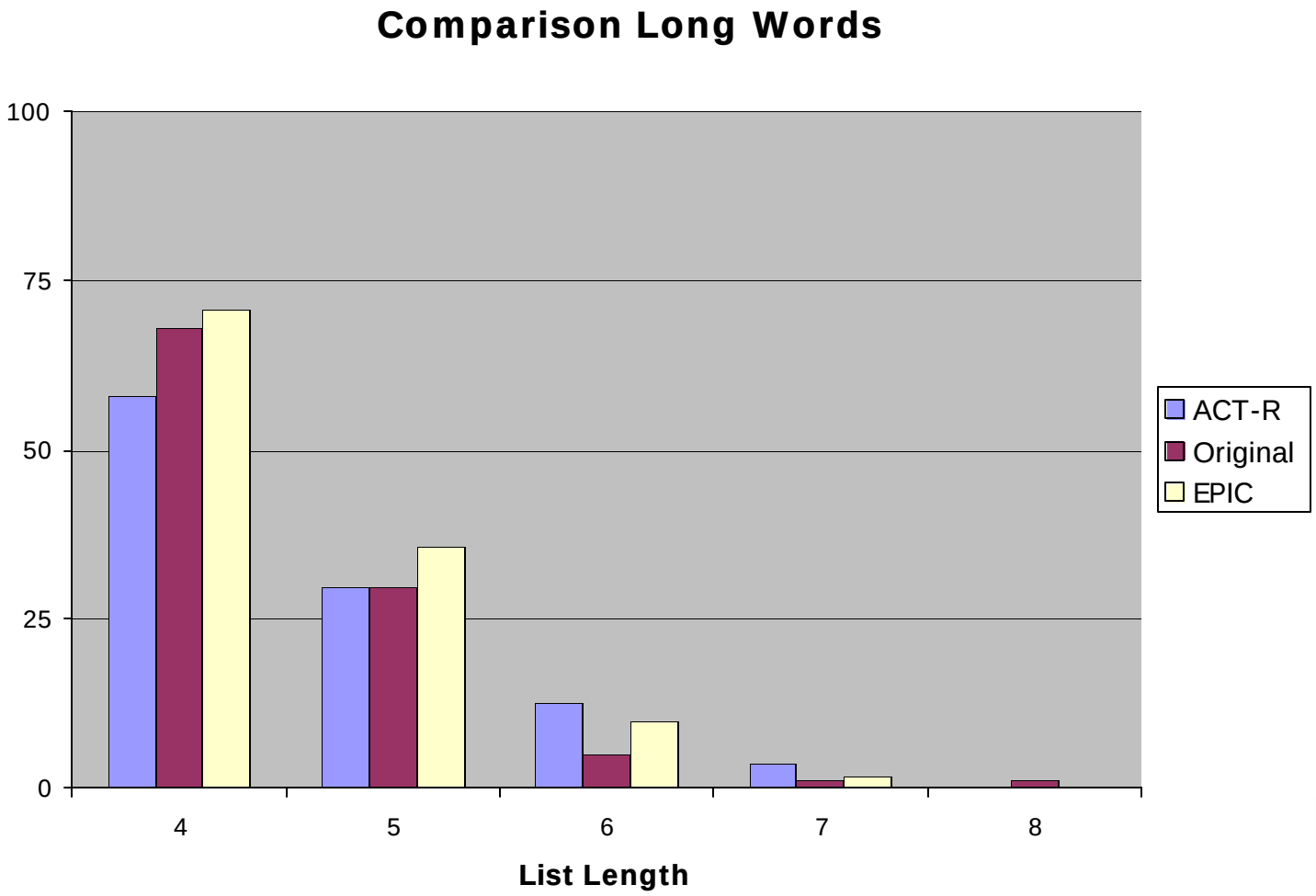
Comparison of EPIC and ACT-R/PM

- Two very different approaches
  - ACT-R/PM
    - Positional encoding
    - Graded activation
    - Baselevel learning
  - EPIC
    - “Chaining”
    - All or none activation
- Yet the models yield similar fits to the data

Comparison ACT-R/PM and EPIC



Comparison ACT-R/PM and EPIC



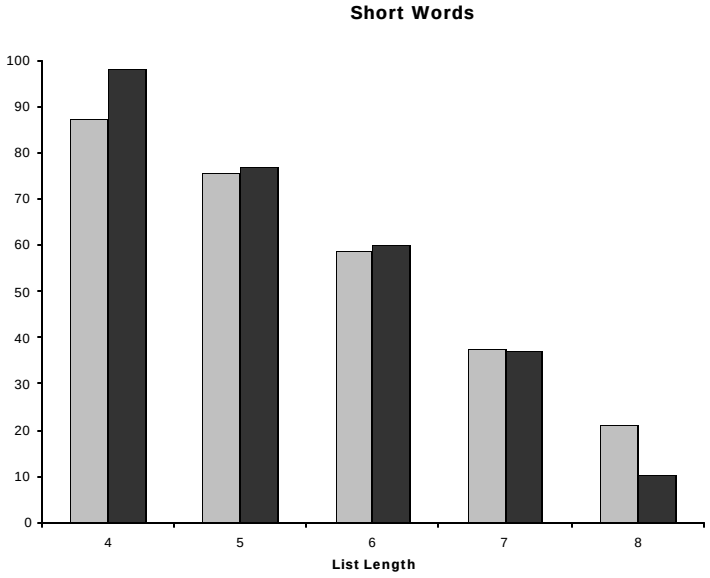
Future Development

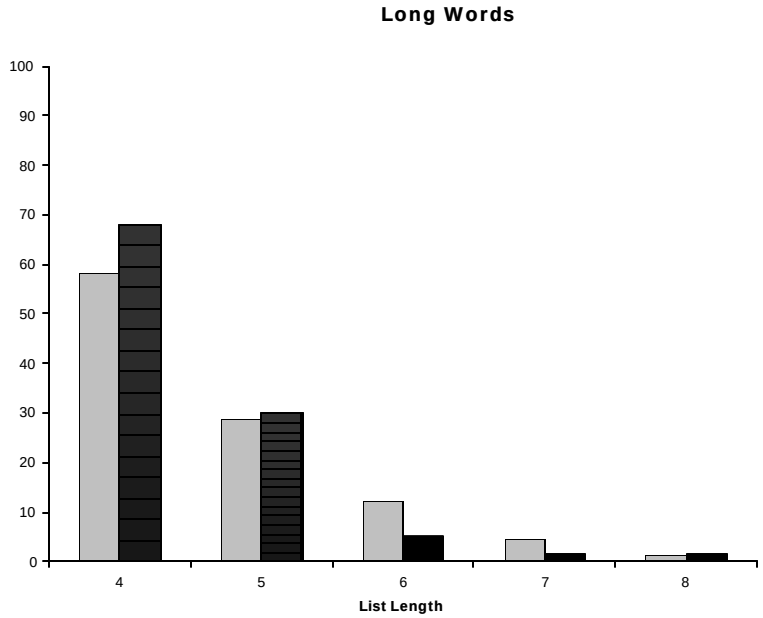
- Future Development of the model
  - Addition of Partial Matching
- Other uses
  - Modeling other memory tasks
  - More complex tasks were subvocal articulation may take place

Item Chunks

goal123		goal124	
isa	Item	isa	Item
Position	First	position	Second
Word	Hate	Word	Sum
List	new-list	List	New-list

Results


Short Words
100
90
80
70
60
50
40
30
20
10
0
4
5
6
7
8
List Length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