Age, Working Memory, and On-Line Syntactic Processing in Sentence Comprehension

Gloria S. Waters, David Caplan,
2001
Introduction

Participants

Pretests

Experiment memory and plausibility judgment

Result Experiment memory and plausibility judgment

Experiment Auditory Moving Window

Result Experiment Auditory Moving Window

Summary

Discussion
Introduction

Motivation:

- old people in society
- computational linguistic project for young and old

NEED for adaption?
Participants:

- 127: 58 men, 69 women
- 5 age-groups:
  1.) 18-30 years, n=24
  2.) 50-59 years, n=29
  3.) 60-69 years, n=27
  4.) 70-79 years, n=25
  5.) 80+ years, n=22
- paid for participation
<table>
<thead>
<tr>
<th><strong>Pretest</strong></th>
<th>18-30</th>
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<th>60-69</th>
<th>70-79</th>
<th>80+</th>
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</thead>
<tbody>
<tr>
<td>Mini-Mental State Examination</td>
<td>-</td>
<td>higher</td>
<td>higher</td>
<td>lower</td>
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<td>Logical Memory I</td>
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<td>higher</td>
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<td>Logical Memory II</td>
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<td>WAIS-R Vocabulary</td>
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<td>Nelson-Denny Vocabulary</td>
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<td>Nelson- Denny Reading Comprehension</td>
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→ older participants were not more cognitively impaired
Just imagine that you have to do the experiment now...
Your Task:

Recall the final words of sents in the right serial order.
It is more important to give CORRECT answers about ACCEPTABILITY as FAST as possible than to recall the final words in the RIGHT SERIAL ORDER!
READY?
It was the car that drove the woman.
It was the food that nourished the child.
Word Recall:

[Blank lines for the recall process]
Word Recall: woman, child
Expt memory and plausibility judgment

- Sentences syntactically simple sentences in CS form → half acceptable, half unacceptable
- Length of a series: 2, 3, 4, 5 and 6
- Testing began with Span Size 2:

<table>
<thead>
<tr>
<th>5* series n=2</th>
<th>5* series n=3</th>
<th>5* series n=4</th>
<th>5* series n=5</th>
<th>5* series n=6</th>
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<td>Sent6</td>
</tr>
</tbody>
</table>

3 correct of 5 trials 3 correct of 5 trials ....
Figure 1. Mean span on the sentence-final word recall component of the sentence span task.
Working Memory Span

- WM Span = largest set size of participant
  (word recall in right serial order on at least 3 of 5 trials
  + 0.5 words recall on 2 of 5 trials in next Span Size)

- 18-30 year-olds had significantly higher span than

![Figure 1. Mean span on the sentence-final word recall component of the sentence span task.](image)
Figure 2. Mean reaction time (RT) on the sentence acceptability component of the sentence span task.
Working Memory Span

- RT = time participant needs to decide about plausibility
- All were extremely accurate on the sentence acceptability

Figure 2. Mean reaction time (RT) on the sentence acceptability component of the sentence span task.
Result Working Memory Span

→ Older Partizipants have reduced WM spans compared to younger

• Old group: 60, 70, 80 yo
  → did not differ from another

• Old group did differ from 18yo
Just imagine that you have to do the experiment now...
Your Task:

Segment → next → Segment → next → …

unacceptable/ acceptable

→ Pace your way through the sentence as FAST as possible

→ Decide about acceptability
READY?
Expt Auditory Moving Window

- 104 acceptable
  - 26 CS
  - 26 CO
  - 26 OS
  - 26 SO
- 104 unacceptable

- Male speaker with normal intonation and prosody
- Sentences with verbs that require either animate objects or animate subjects
- Acceptability judgments did not require detailed semantic knowledge
- If participant pressed the button before the end of a segment
  → stop & skip to the next segment
On-line Measure of Sentence-Processing Efficiency
On-line Measure of Sentence-Processing Efficiency

LT = subtracting segment's tag-to-tag duration from response time
On-line Measure of Sentence-Processing Efficiency

LT = subtracting segment's tag-to-tag duration from response time

- Shorter LT for 18-30 yo
- Longer LT for 80+ yo
On-line Measure of Sentence-Processing Efficiency

- Shorter LT for 18-30 yo
- Longer LT for 80+ yo
- Longer LT for SO than OS (at V1, V2 and NP3)
  → SO more complex than OS

LT = subtracting segment's tag-to-tag duration from response time
On-line Measure of Sentence-Processing Efficiency

- longer LT for the 80 yo than for the 18 yo
- longer LT for the 50 yo than for the 18 yo
On-line Measure of Sentence-Processing Efficiency

- Longer LT for CO than for CS
- LT were longer on NP2 in CS than in CO sentences
- LT longer on V in CO than in CS sentences (V longer than NP2) → CO more complicated

- Longer LT for the 50 yo than for the 18 yo
- Longer LT for the 50 yo than for the 18 yo

Mean Listening Time (ms)

<table>
<thead>
<tr>
<th>Phrase</th>
<th>Intro</th>
<th>NP1</th>
<th>NP2</th>
<th>V</th>
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Age:
- 18-30
- 50-59
- 60-69
- 70-79
- 80+
Result On-line Measure of Sentence-Processing Efficiency

- Increases in LT on complex parts of sentences
  - CS-CO: V
    → longer LT for the 80+ yo than for the 18-30 yo
    → longer LT for the 50-59 yo than for the 18-30 yo
  - SO-OS: V1, V2, NP3
    → not because of age

⇒ No systematic difference between on-line sentence-processing efficiency and age
Off-line Measure of Sentence-Processing Efficiency

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How much time one need to decide about Acceptability in ms

RT faster for CS then for CO

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Off-line Measure of Sentence-Processing Efficiency

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- 18 yo were faster than 70 yo and 80 yo
- 50 yo were faster than 80 yo
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How much time one need to decide about Acceptability in ms

- RT faster for CS then for CO
- RT faster for OS than for SO (only 70,80 year old)

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- 18 yo were faster than 70 yo and 80 yo
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Off-line Measure of Sentence-Processing Efficiency

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- RT faster for CS then for CO
- RT faster for OS than for SO (only 70,80 year old)
- 18 yo were faster than 70 yo and 80 yo
- 50 yo were faster than 80 yo
- 18 yo, 50yo were faster than 70 yo, 80 yo
Off-line Measure of Sentence-Processing Efficiency

- A' = accuracy measure: How many judgments were correct
- Higher A's for CS than for CO
  → CS-CO: 18 yo higher A's than 50yo and 80yo
- A's higher for OS than for SO
  → OS-SO: 18yo higher A's than for rest
  → + SO: 50,60yo higher A's than 80yo
Result Off-line Measure of Sentence-Processing Efficiency

- see where people have problem to give an acceptability judgment for the more complex sentence type
  - CS easier to process than CO
  - OS easier to process than SO
  - OS-SO are more complex than CS-CO, because they contain more prepositions
- significant correlation between age and A' in making acceptability judgment at the end of CS, OS and SO and with RT at the end of CO

=> age is associated with off-line measures
Summary

• WM = Working Memory
  → Older people have reduced WM spans compared to younger

• On-line measure: Local increase of part of the sentences
  → age is not associated with on-line measures

• Off-line measures: Judgment of input
  → age is associated with off-line measure
Thanks for your attention!
Discussion:

- How do you think machines should be adapted for older people?
- How do you think are older people effected by the offline measure?
- How could they train their WM?
Off-line Measure of Sentence-Processing Efficiency

A' = accuracy measure: How many judgments were correct

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<td>0.986 (0.018)</td>
<td>0.938 (0.085)</td>
<td>0.982 (0.025)</td>
<td>0.951 (0.053)</td>
</tr>
<tr>
<td>50–59</td>
<td>0.912 (0.086)</td>
<td>0.887 (0.103)</td>
<td>0.940 (0.061)</td>
<td>0.892 (0.087)</td>
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<tr>
<td>60–69</td>
<td>0.937 (0.060)</td>
<td>0.878 (0.171)</td>
<td>0.934 (0.067)</td>
<td>0.879 (0.084)</td>
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<tr>
<td>70–79</td>
<td>0.916 (0.062)</td>
<td>0.906 (0.069)</td>
<td>0.923 (0.060)</td>
<td>0.848 (0.058)</td>
</tr>
<tr>
<td>80+</td>
<td>0.895 (0.062)</td>
<td>0.867 (0.080)</td>
<td>0.918 (0.086)</td>
<td>0.825 (0.084)</td>
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How much time one need to decide about Acceptability

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*Note.* Standard deviations are shown in parentheses. CS = cleft subject; CO = cleft object; OS = object–subject; SO = subject–object.
# Acceptability Judgment Mean Reaction Times (in Milliseconds)

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### Acceptability Judgment Mean A’ Scores

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Relationship Between Sentence Processing and Age and Working Memory
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No significant correlation between age & online measures
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→ Judgments about SO is partially due WM
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