

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

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2001

Structure:

- Introductions
- Participants
- Pretests
- Experiment memory and plausibility judgment
- Result Experiment memory and plausibility judgment
- Experiment Auditory Moving Window
- Result Experiment Auditory Moving Window
- Summary
- Disucssion

Introduction

Motivation:

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

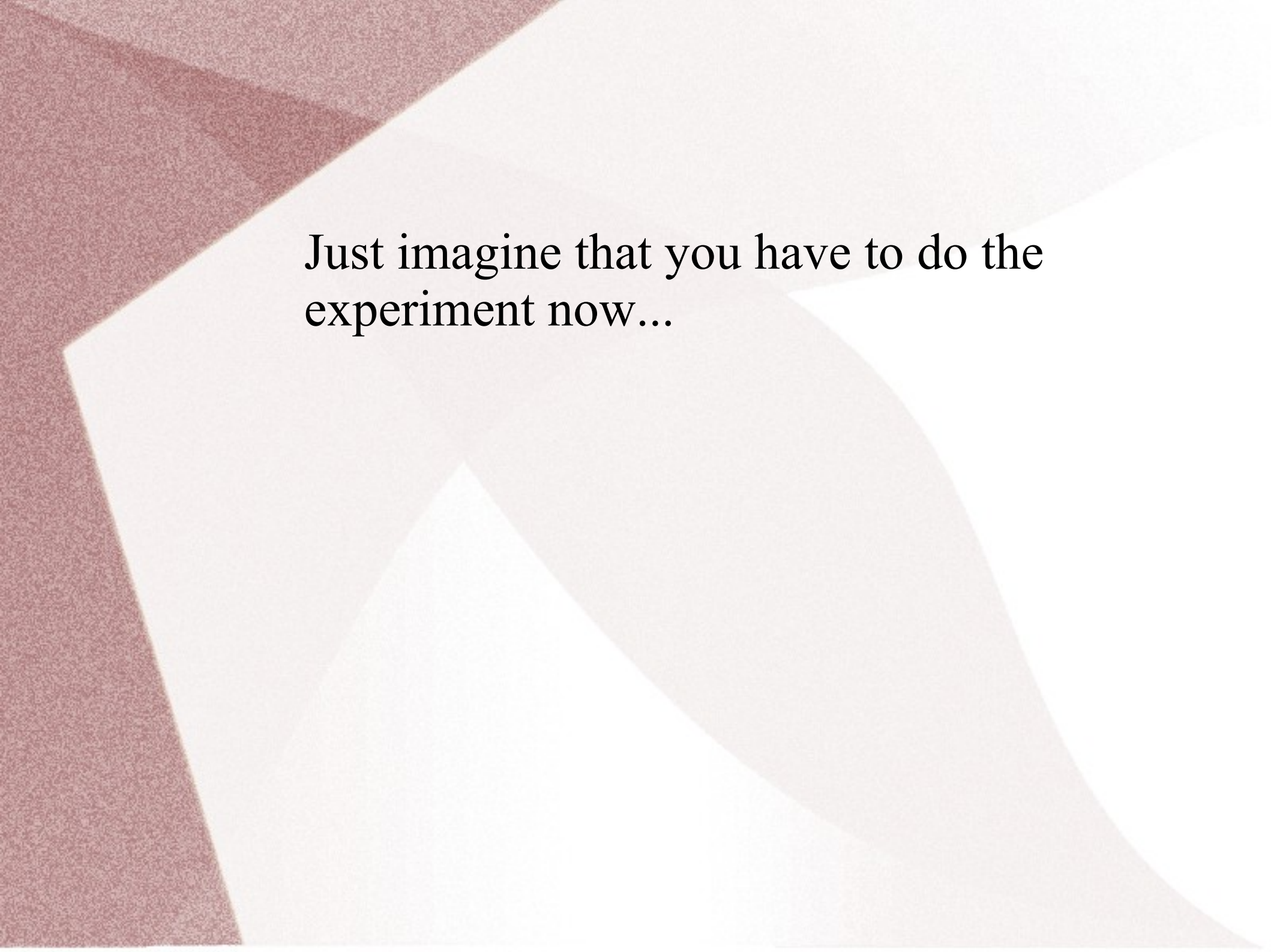
NEED for adaption?

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

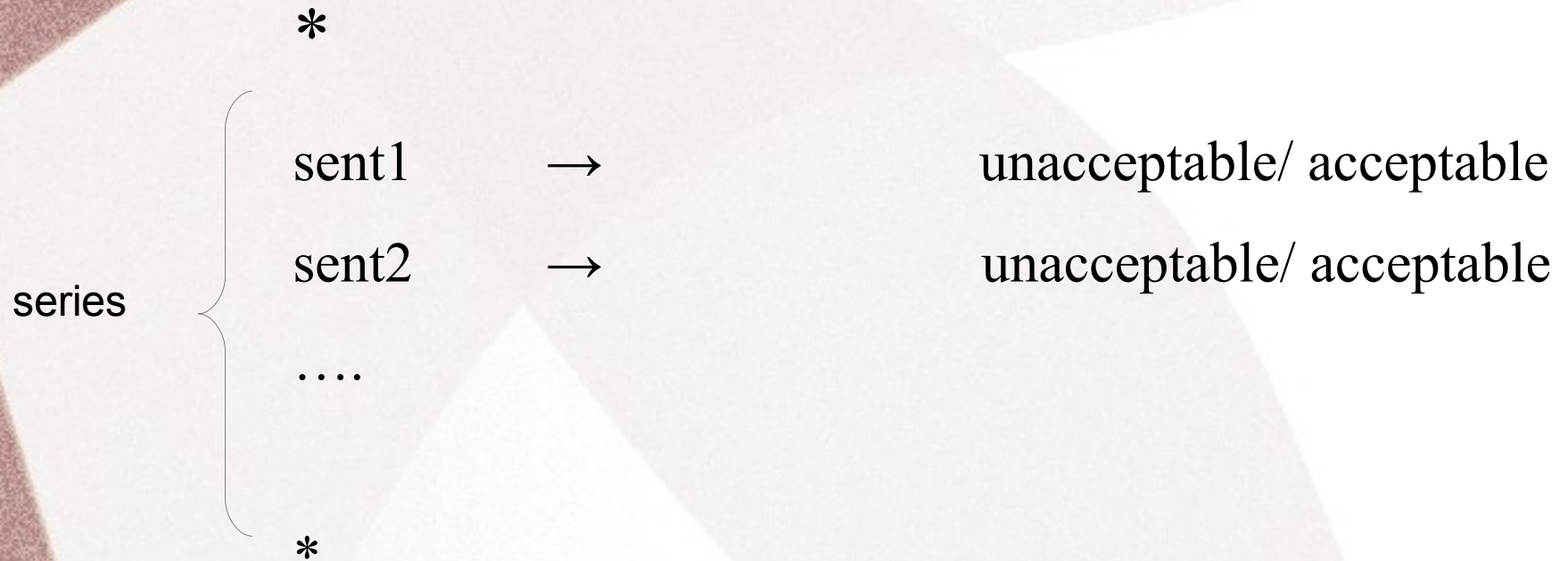
<u>Pretest</u>	18-30	50-59	60-69	70-79	80+
Mini-Mental State Examination	-	higher			lower
Logical Memory I		lower		higher	
Logical Memory II					
WAIS-R Vocabulary					
Boston Naming Test		higher			lower
Nelson-Denny Vocabulary					
Nelson- Denny Reading Comprehension					

→ 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.

unacceptable	acceptable
--------------	------------

It was the food that nourished the child.

unacceptable	acceptable
--------------	------------



*

Word Recall:

_____ , _____

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:

5* series n=2	5* series n=3	5* series n=4	5* series n=5	5* series n=6
Sent1 Sent2	Sent1 Sent2 Sent3	Sent1 Sent2 Sent3 Sent4	Sent1 Sent2 Sent3 Sent4 Sent5	Sent1 Sent2 Sent3 Sent4 Sent5 Sent6

3 correct of 5 trials 3 correct of 5 trials

Working Memory Span

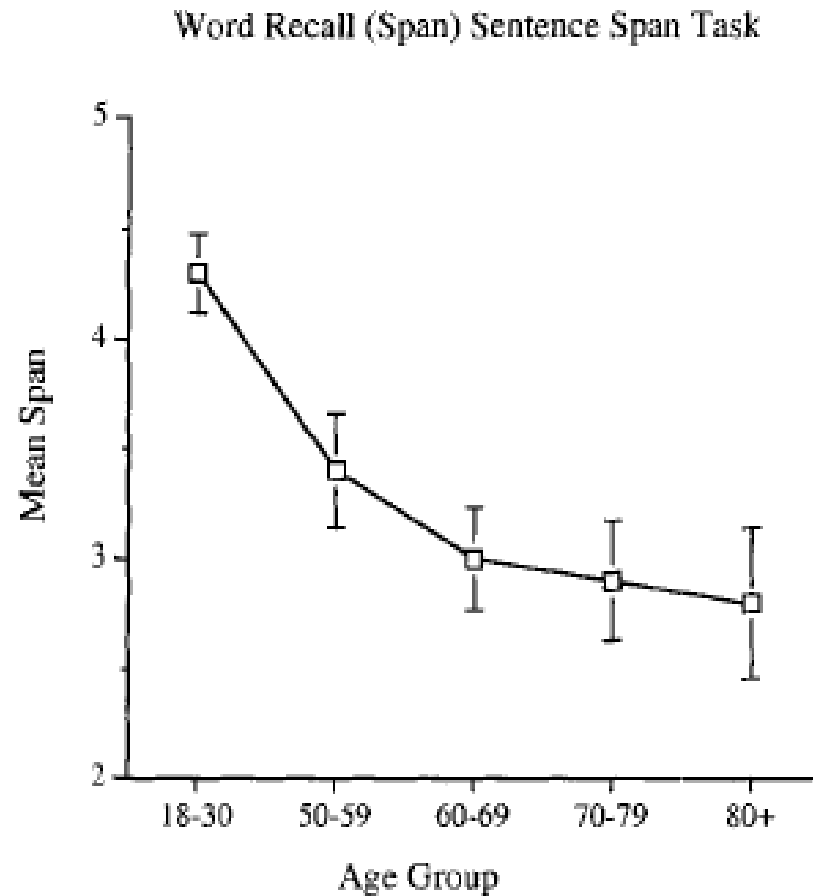


Figure 1. Mean span on the sentence-final word recall component of the sentence span task.

Working Memory Span

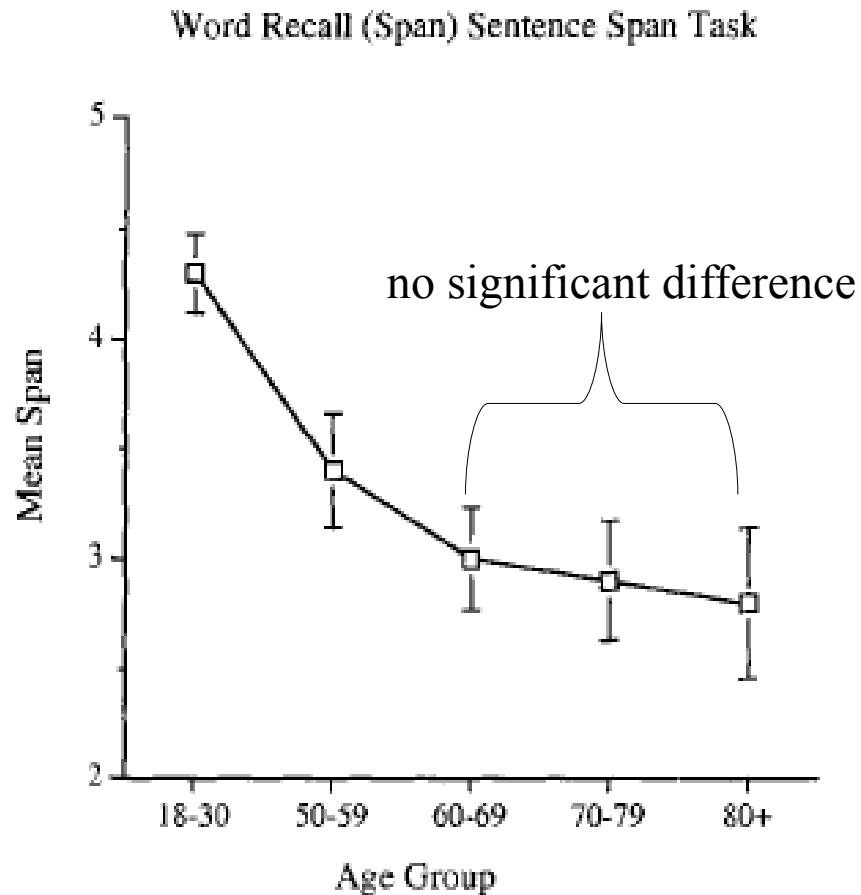


Figure 1. Mean span on the sentence-final word recall component of the sentence span task.

- 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

Working Memory Span

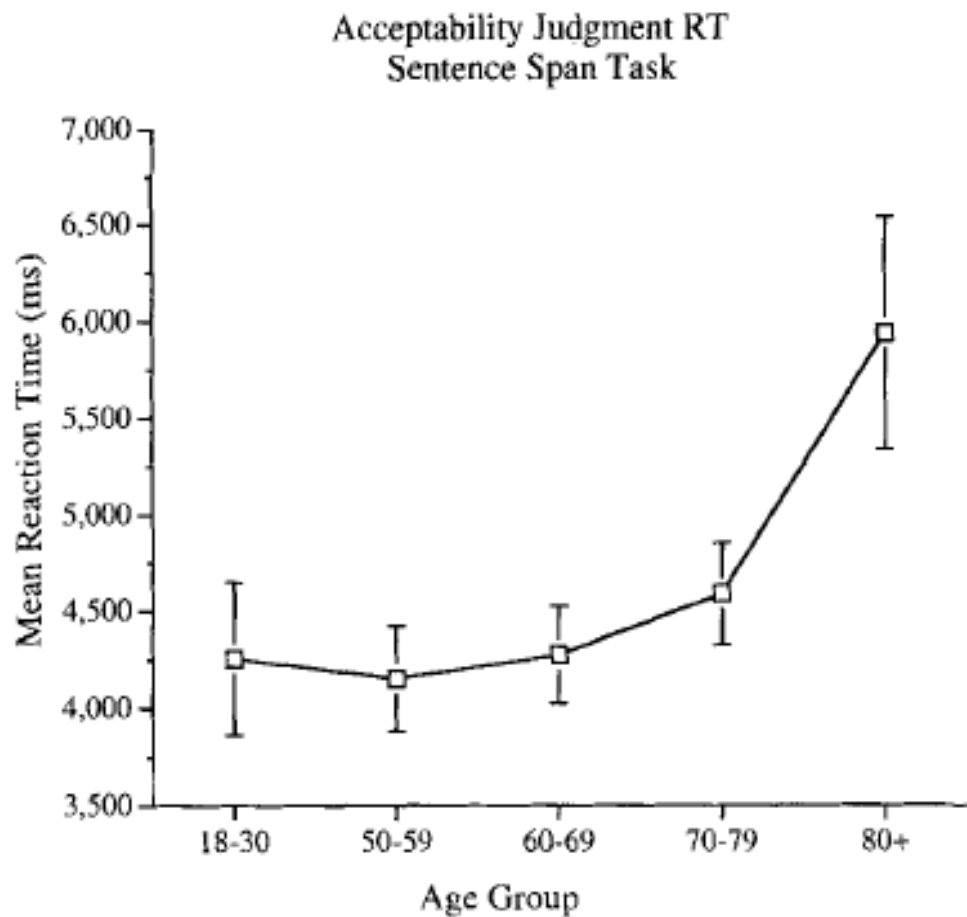
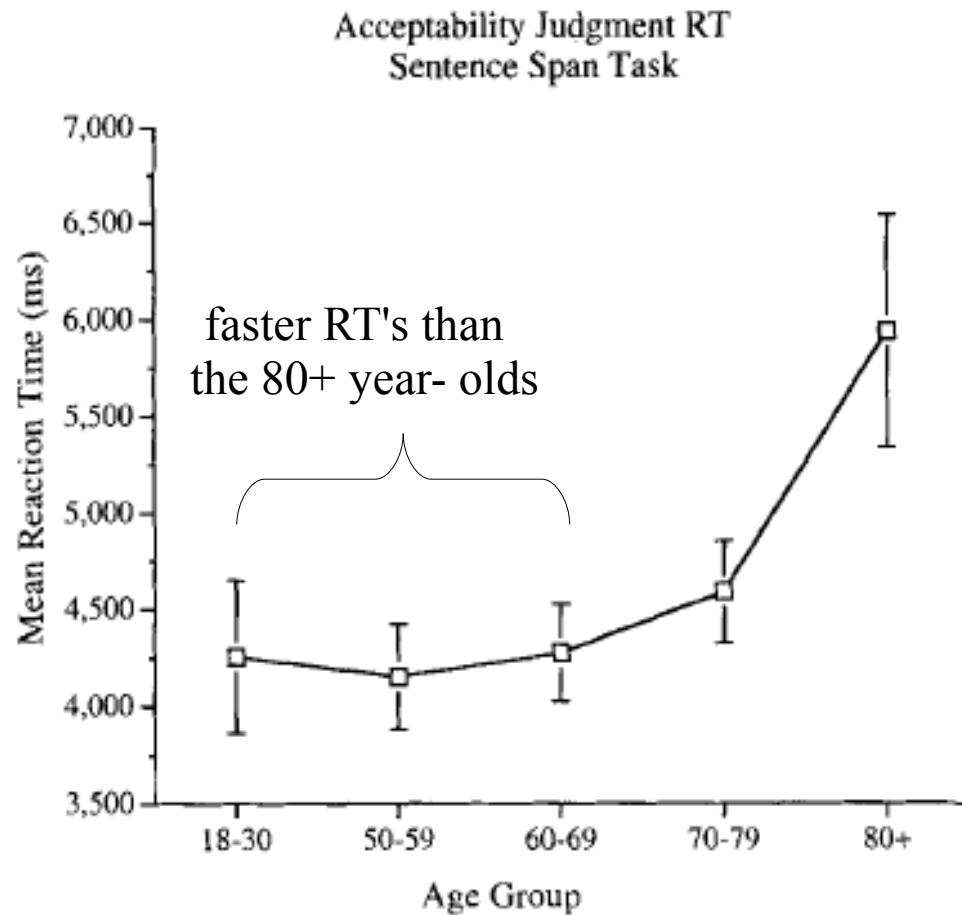


Figure 2. Mean reaction time (RT) on the sentence acceptability component of the sentence span task.

Working Memory Span



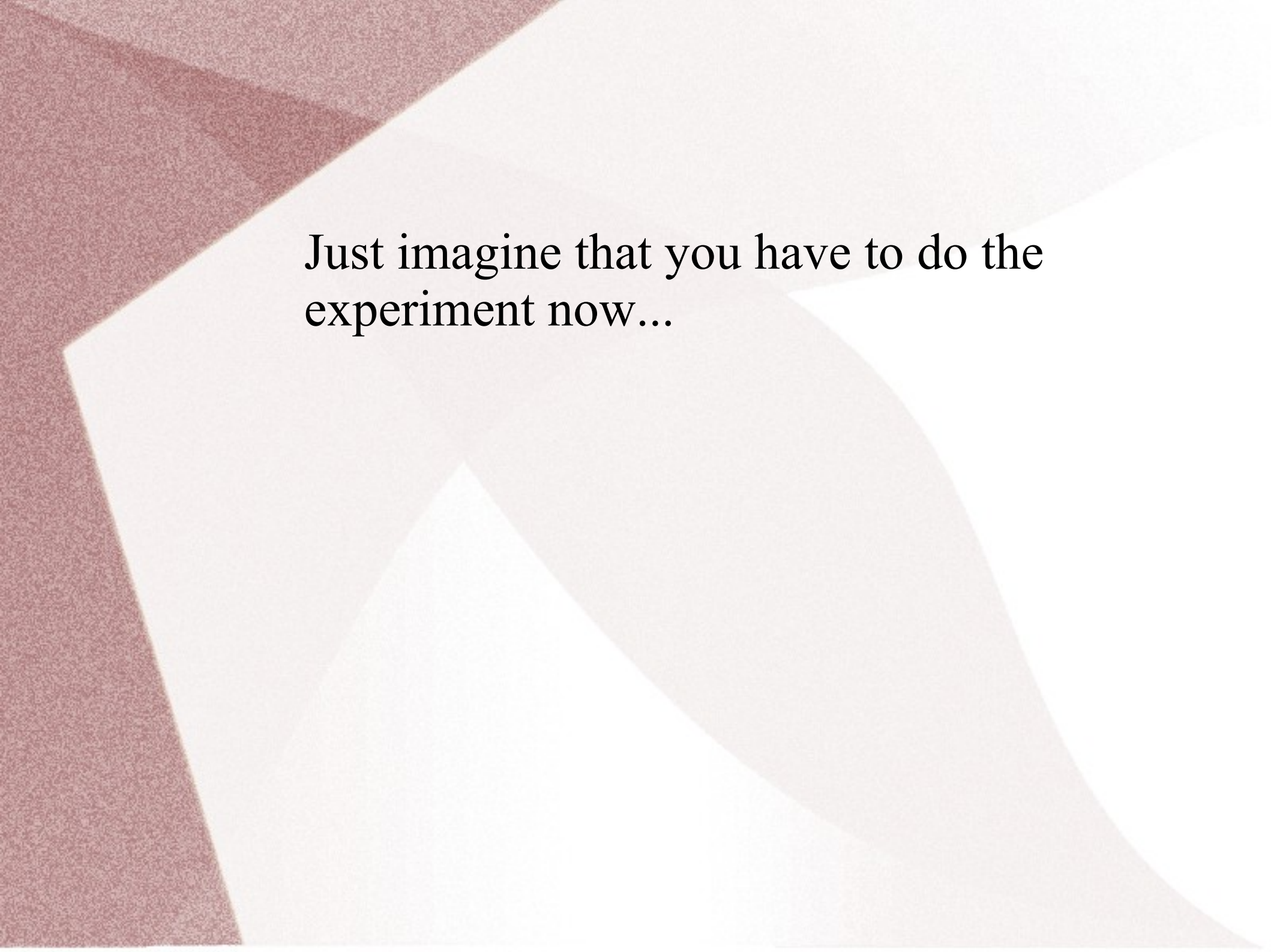
- RT= time participant needs to decide about plausibility
- All were extremely accurate on the sentence acceptability

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

Result Working Memory Span

→ Older Participants 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 → ...

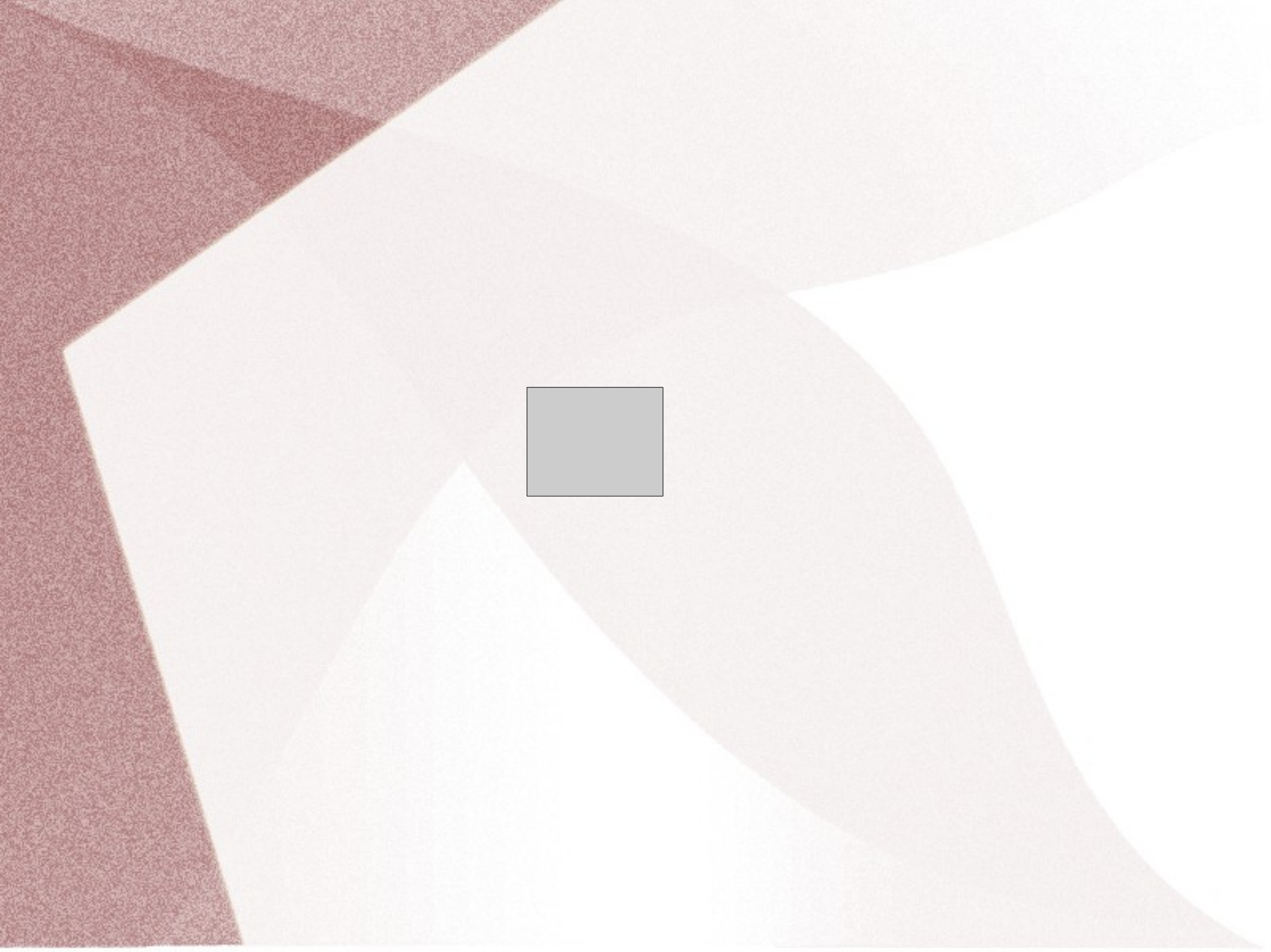
unacceptable/ acceptable

→ Pace your way through the sentence as FAST as possible

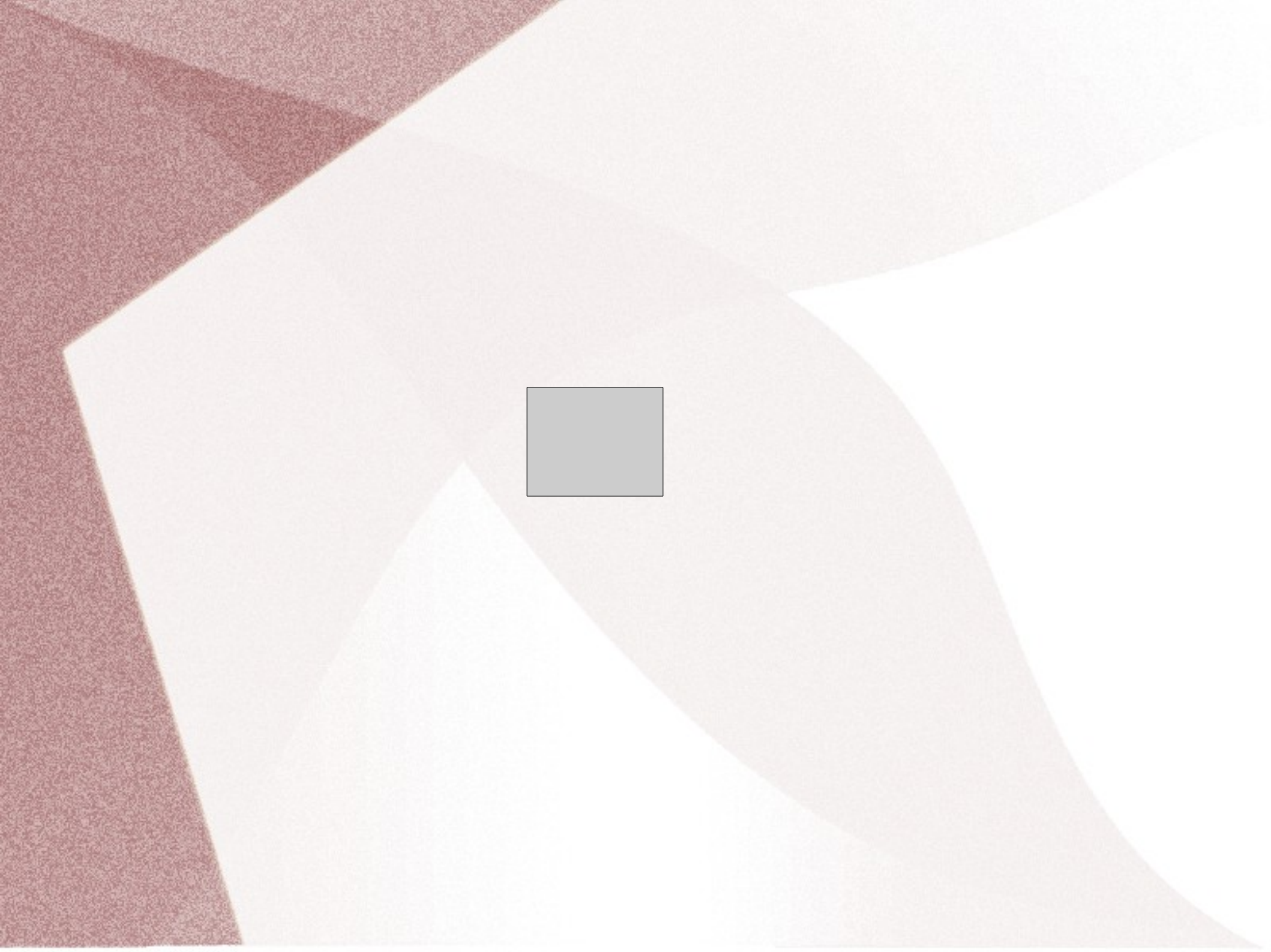
→ Decide about acceptability

READY?

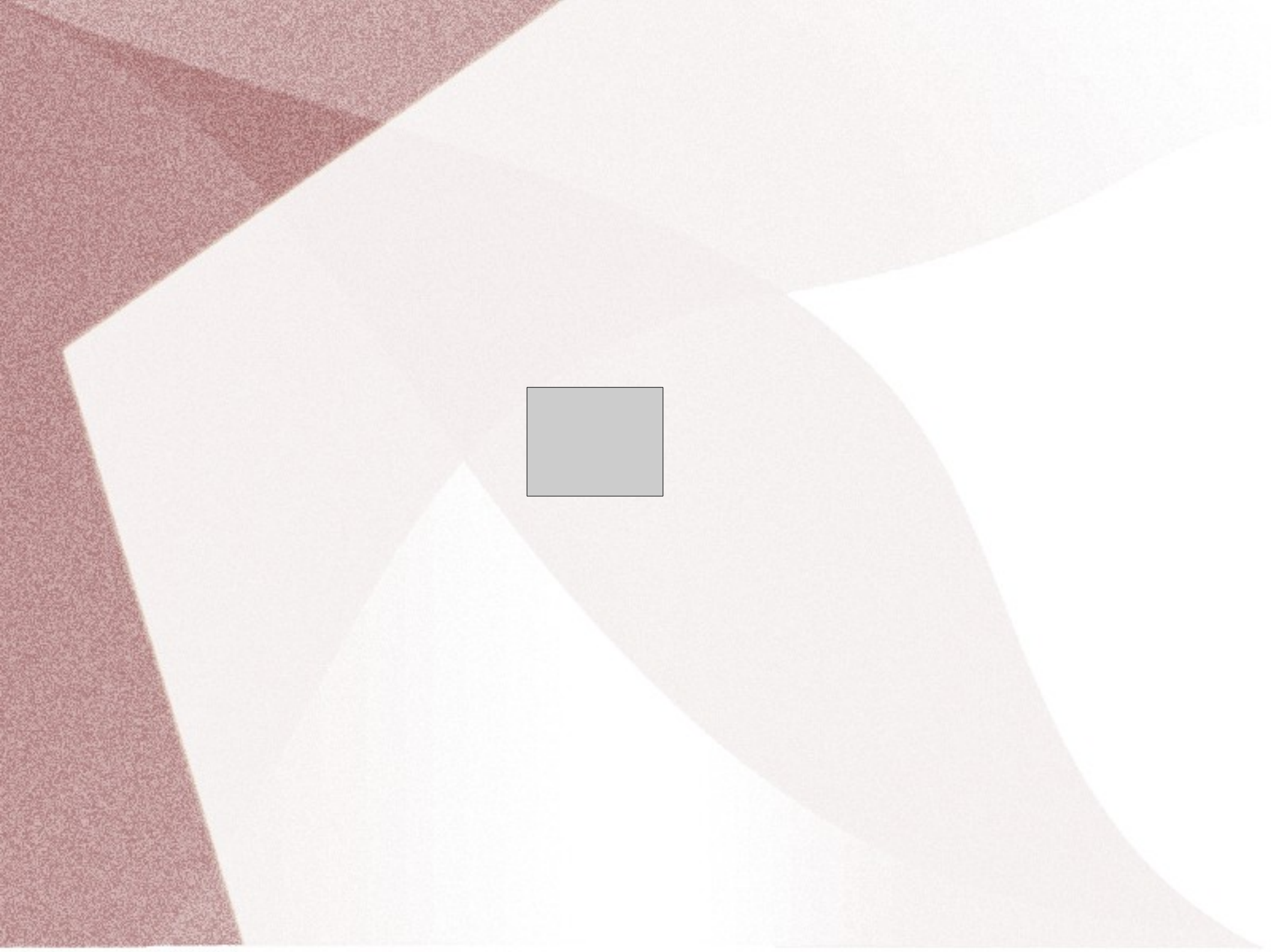
Next



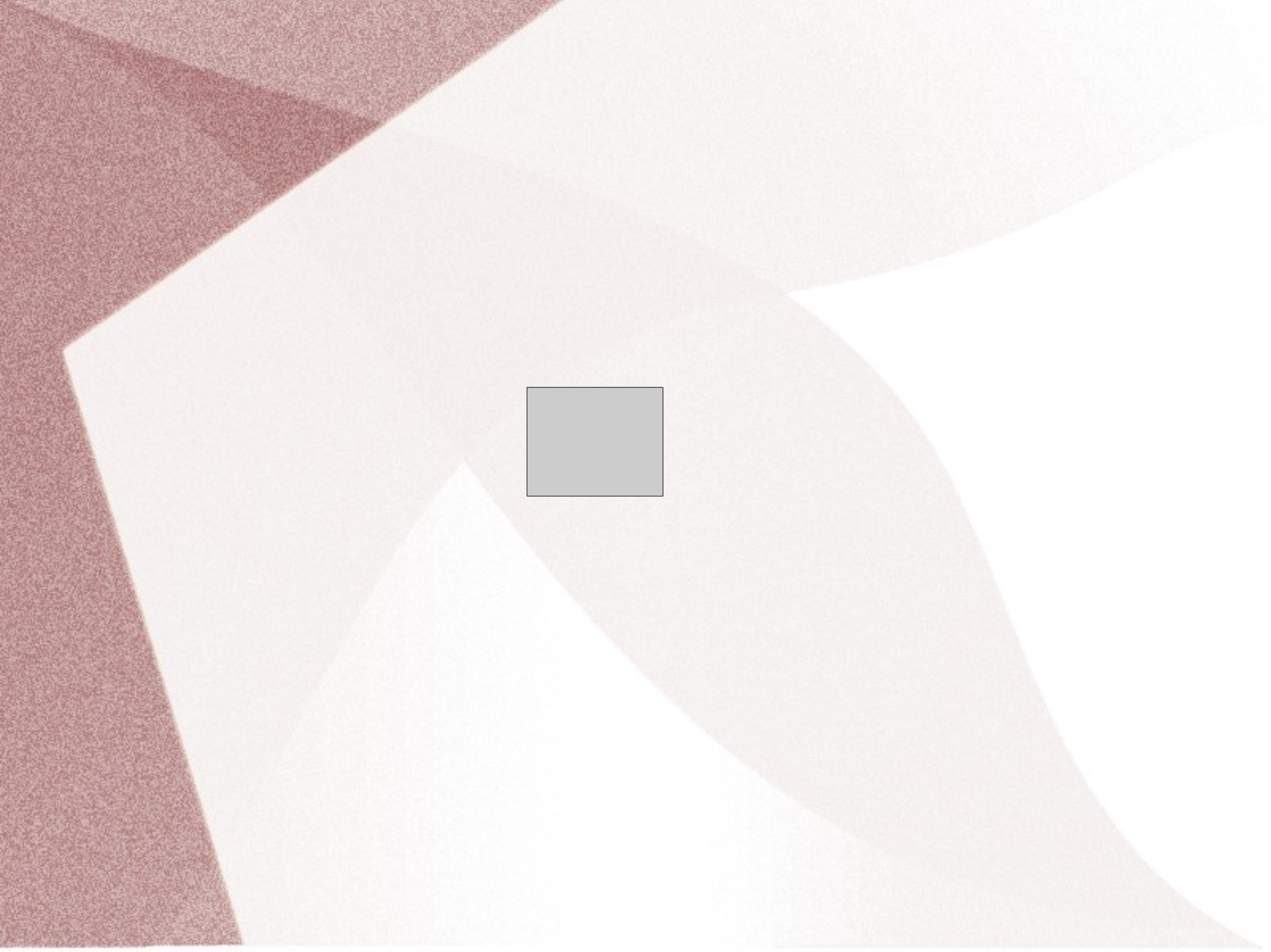
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Next



Next



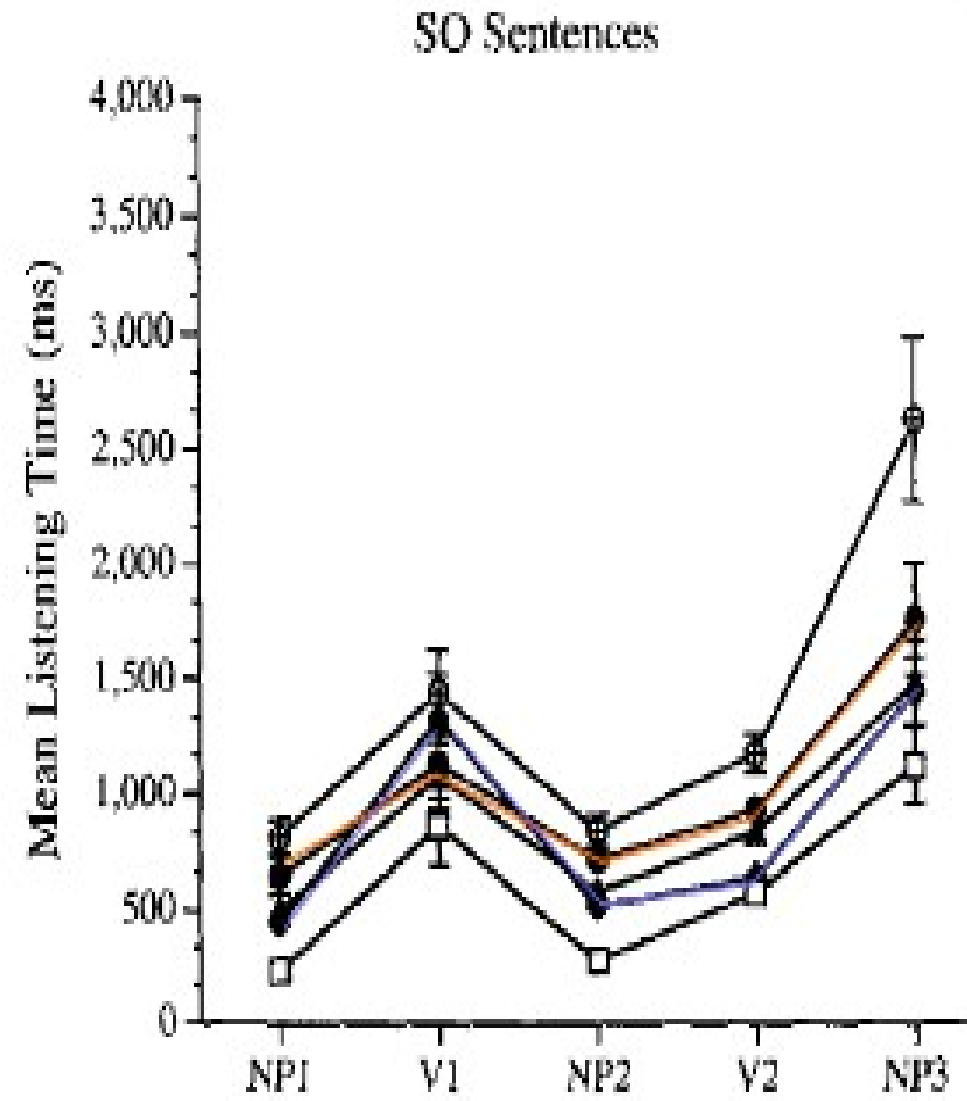
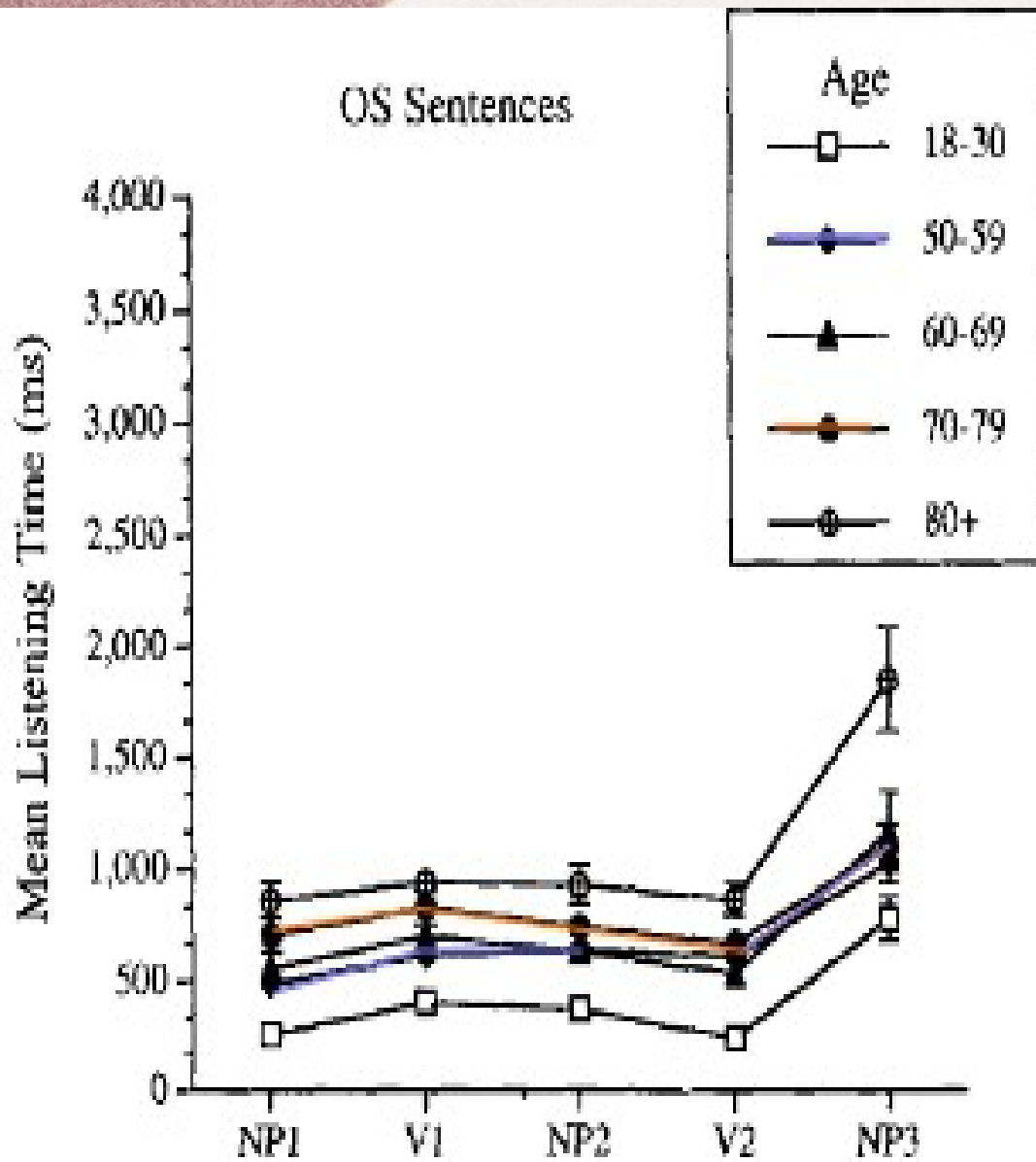
unacceptable

acceptable

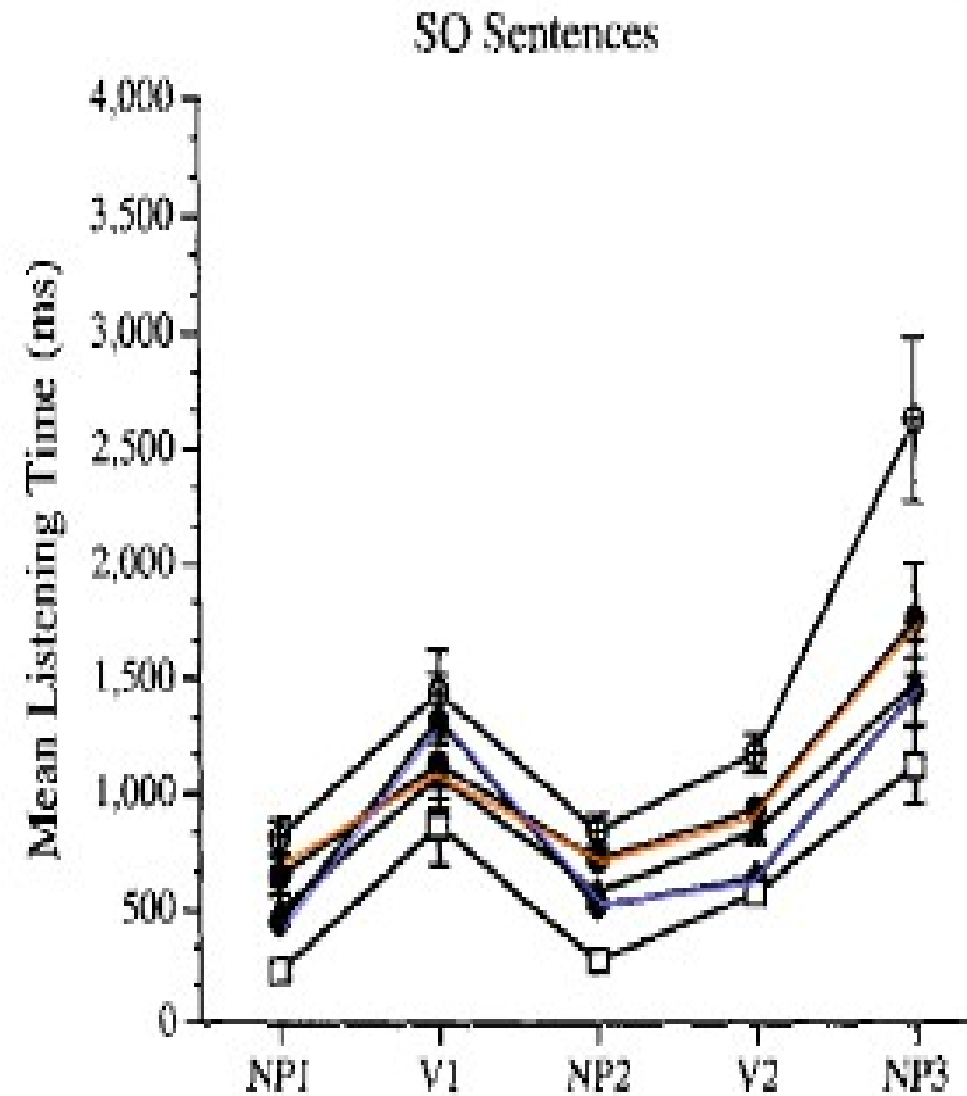
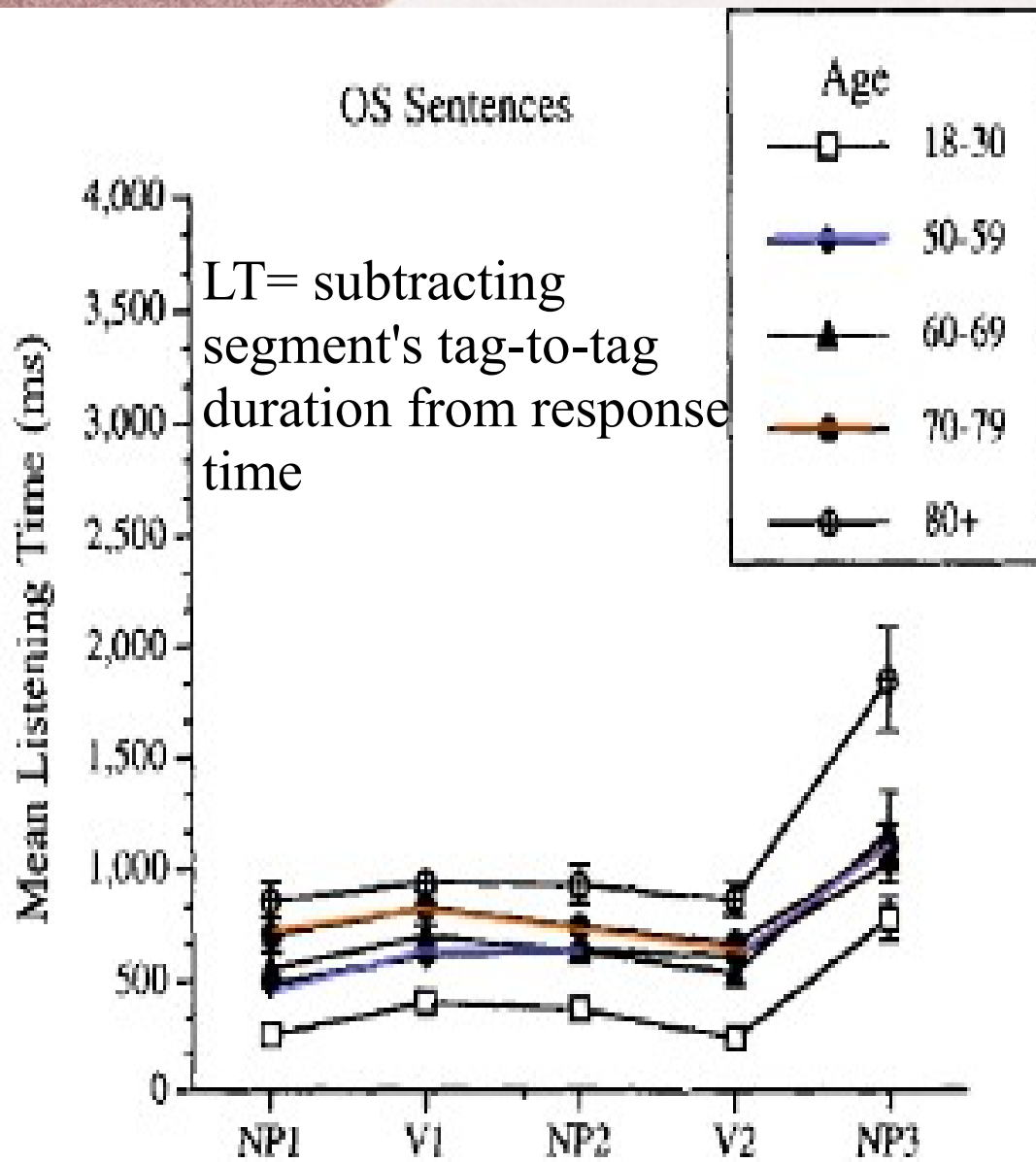
Expt Auditory Moving Window

- 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

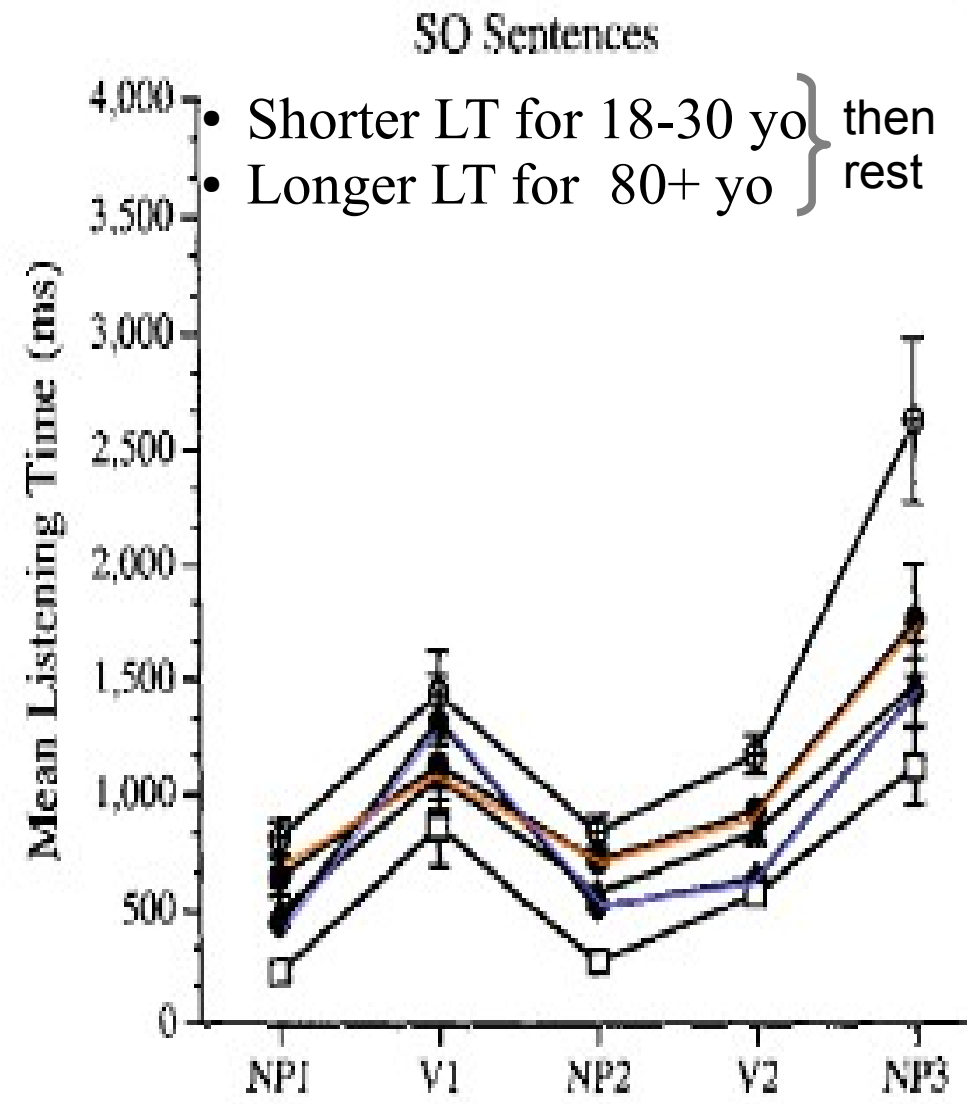
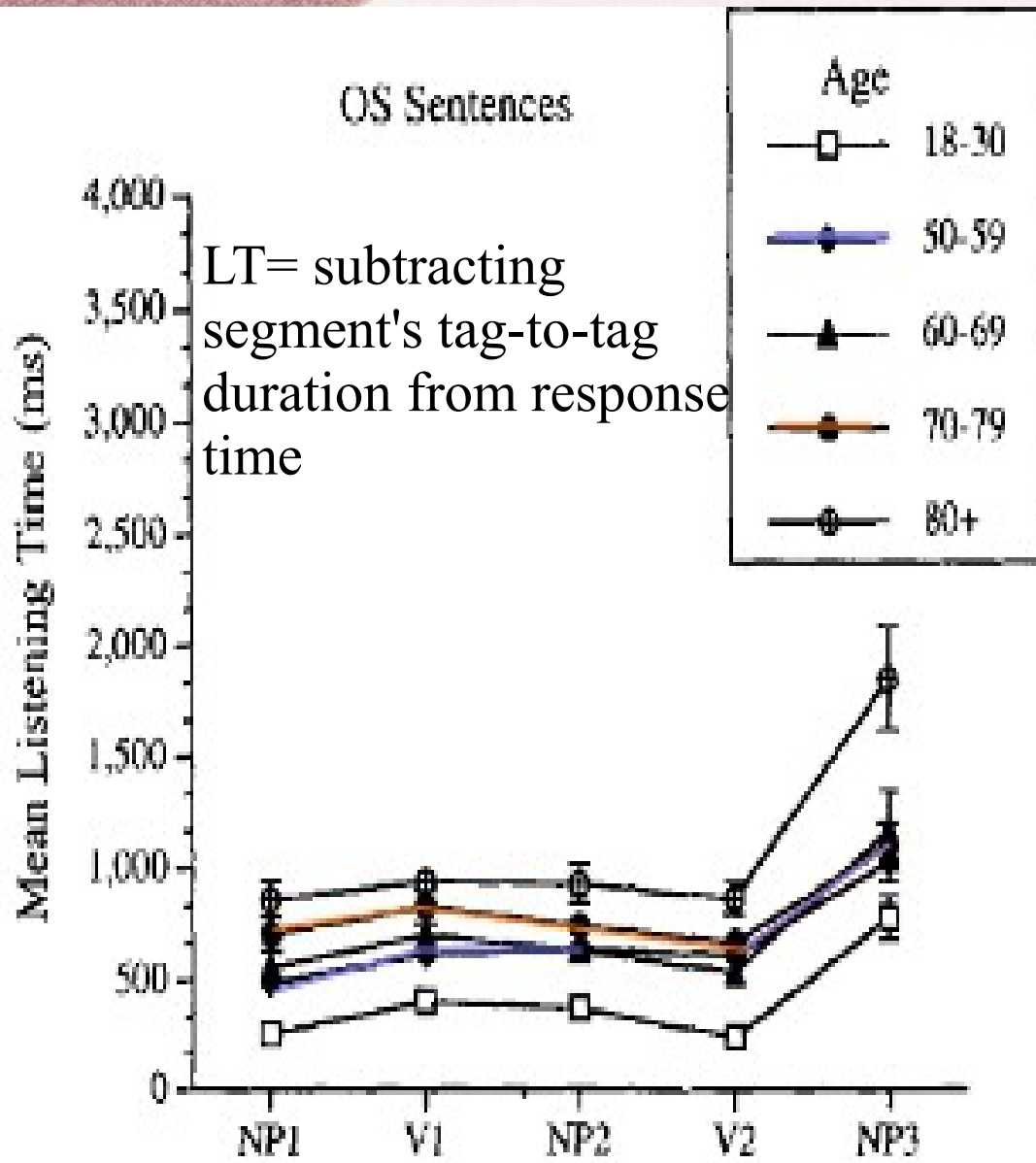
On-line Measure of Sentence-Processing Efficiency



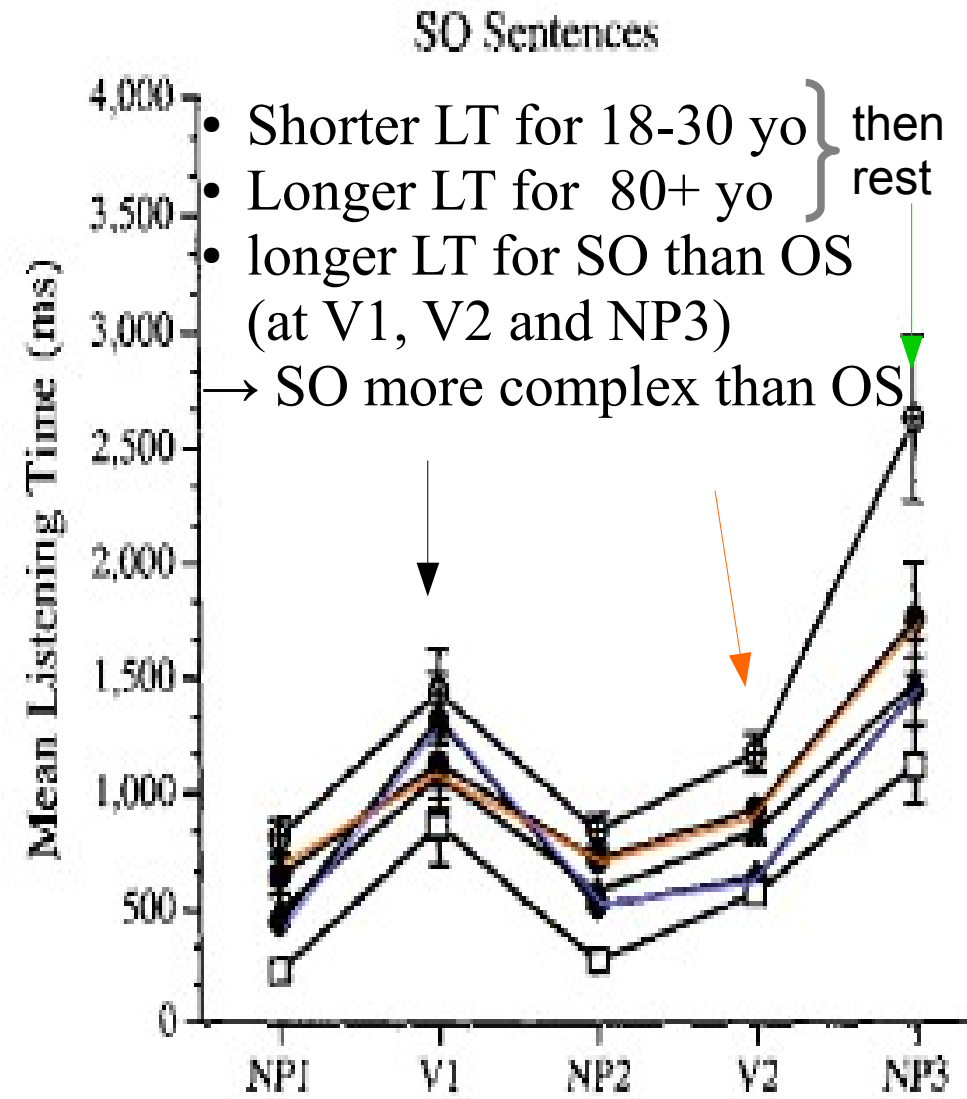
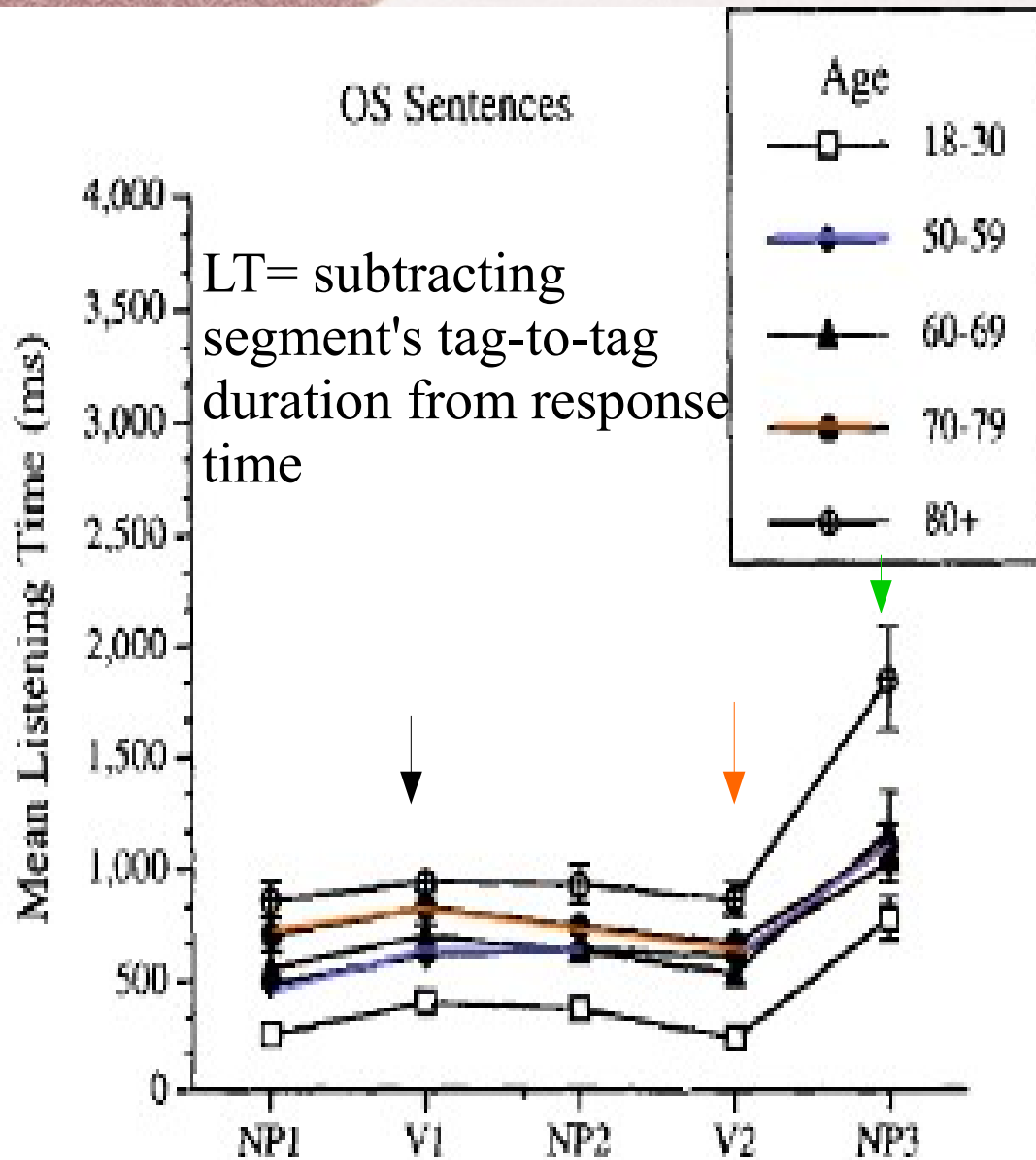
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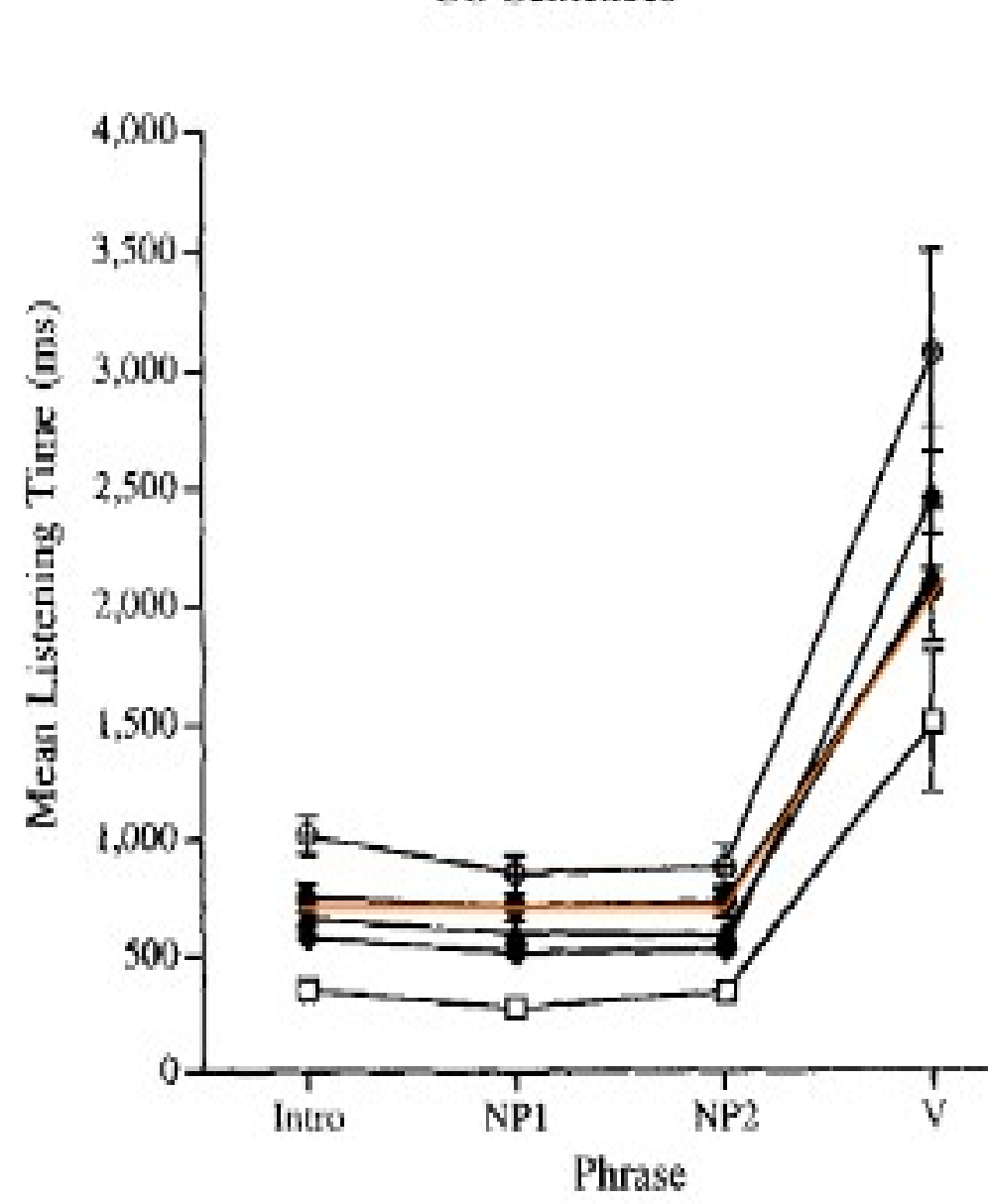
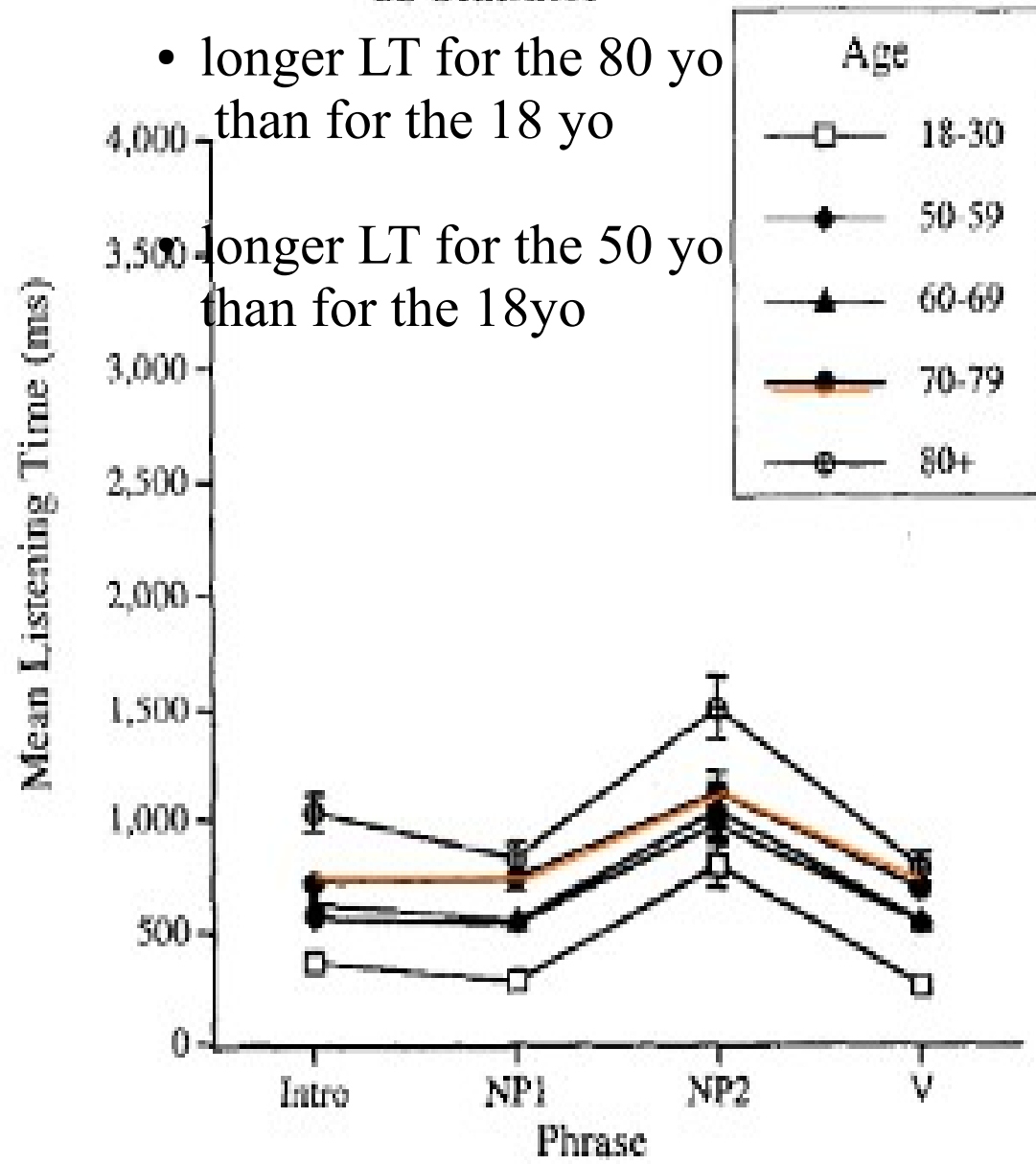


On-line Measure of Sentence-Processing Efficiency

CS Sentences

CO Sentences

- longer LT for the 80 yo than for the 18 yo
- longer LT for the 50 yo than for the 18yo

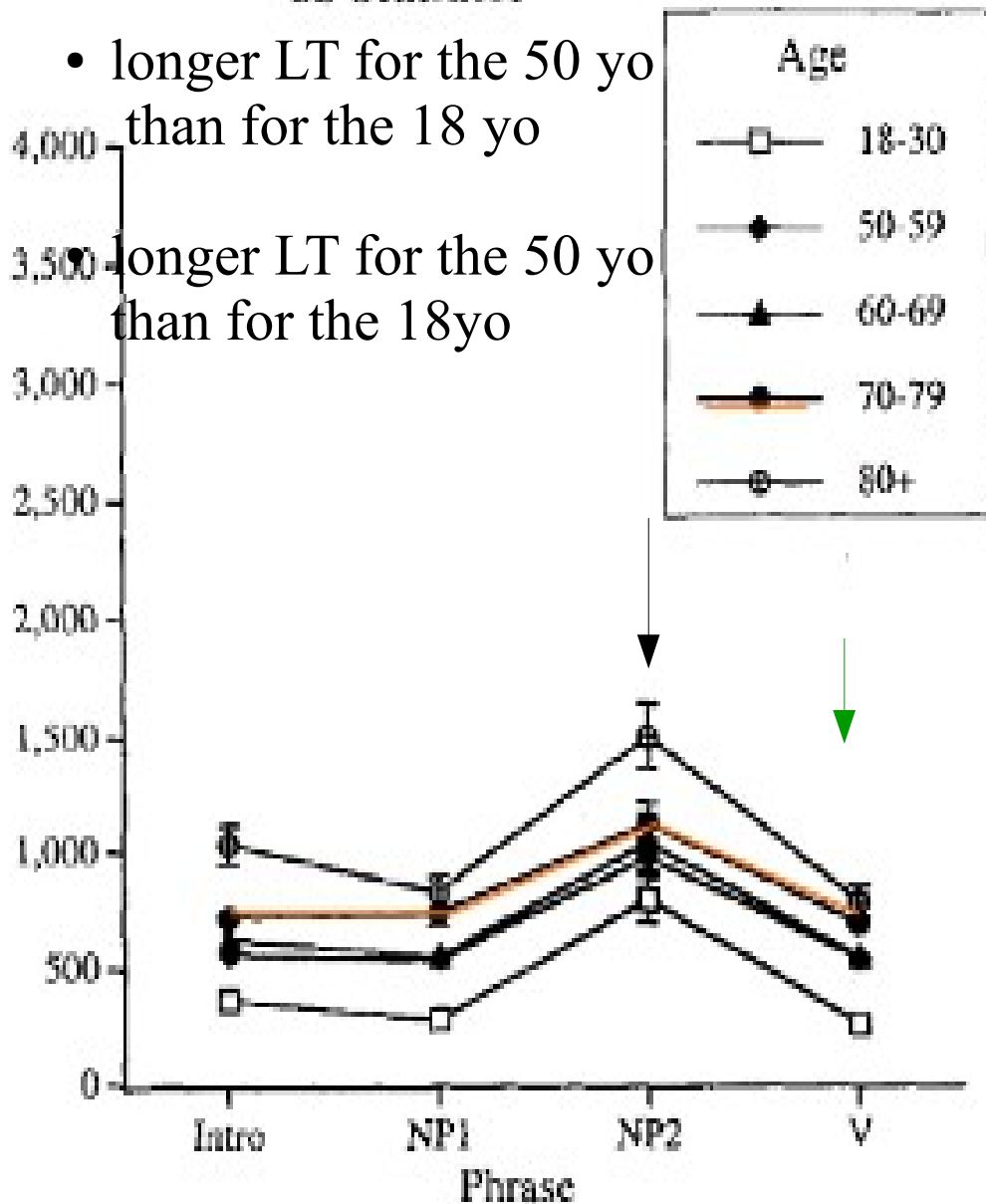


On-line Measure of Sentence-Processing Efficiency

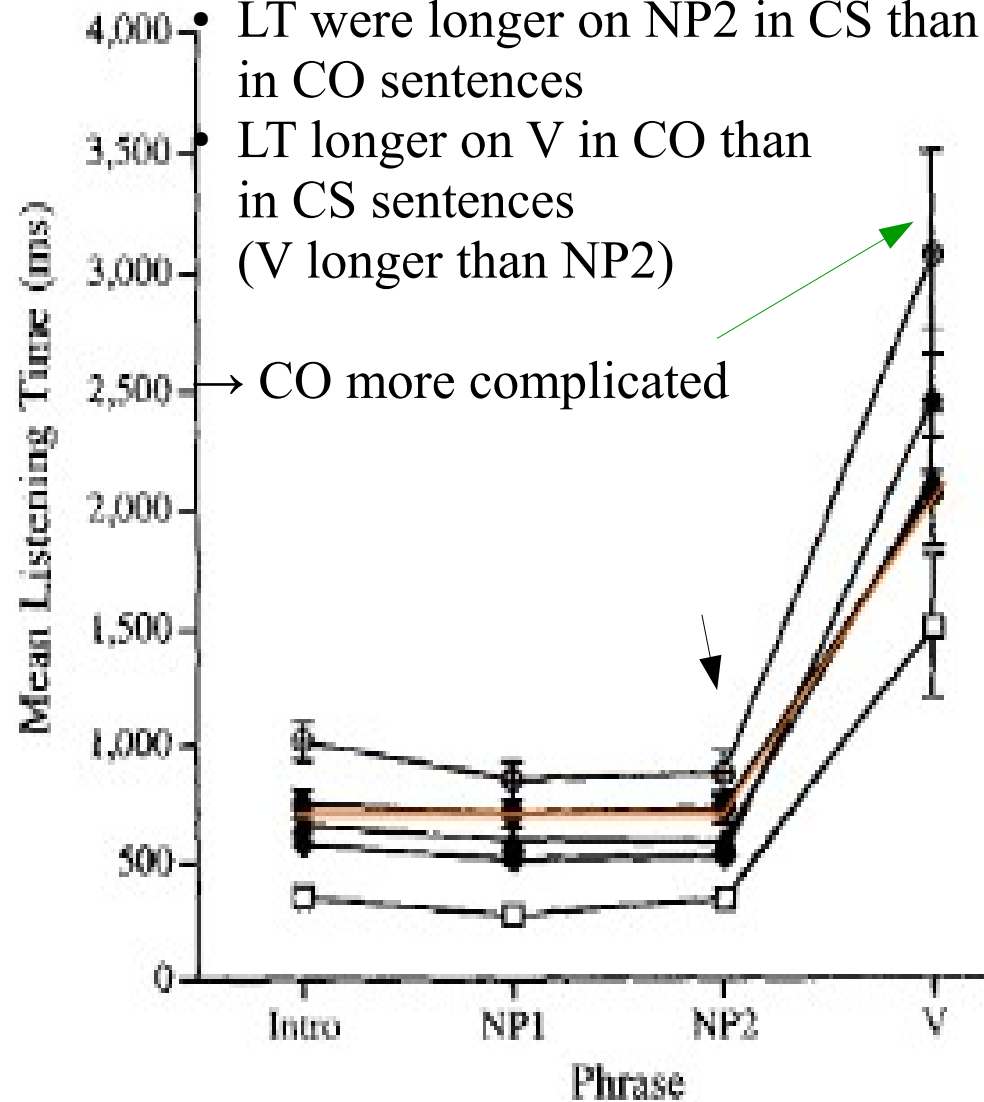
CS Sentences

CO Sentences

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



- 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)



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

How much time one need to decide about Acceptability in ms

Sentence type

Age (years)	CS	CO	OS	SO
18-30	632.33	1,037.14	688.97	731.45
50-59	674.79	1,351.45	691.55	879.58
60-69	938.29	1,671.07	1,086.01	1,151.99
70-79	1,150.34	1,849.25	1,086.24	1,617.52
80+	1,300.59	2,035.20	1,195.11	1,613.75

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Off-line Measure of Sentence-Processing Efficiency

How much time one need to decide about Acceptability in ms

RT faster for CS then for CO

Sentence type

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	CS	CO	OS	SO	OS	SO
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double



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

Off-line Measure of Sentence-Processing Efficiency

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Off-line Measure of Sentence-Processing Efficiency

How much time one need to decide about Acceptability in ms

Age (years)	RT faster for CS then for CO		Sentence type		RT faster for OS than for SO (only 70,80 year old)	
	CS	CO	OS	SO		
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80+	1,300.59	2,035.20	1,195.11	1,613.75	→	

- 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

Sentence type

Age (years)	CS	CO	OS	SO
18-30	0.986 (0.018)	0.938 (0.085)	0.982 (0.025)	0.951 (0.053)
50-59	0.912 (0.086)	0.887 (0.103)	0.940 (0.061)	0.892 (0.087)
60-69	0.937 (0.060)	0.878 (0.171)	0.934 (0.067)	0.879 (0.084)
70-79	0.916 (0.062)	0.906 (0.069)	0.923 (0.060)	0.848 (0.058)
80+	0.895 (0.062)	0.867 (0.080)	0.918 (0.086)	0.825 (0.084)

How much time one need to decide about Acceptability

Acceptability Judgment Mean Reaction Times (in Milliseconds)

Age (years)	Sentence type			
	CS	CO	OS	SO
18-30	632.33 (319.10)	1,037.14 (983.67)	688.97 (573.21)	731.45 (390.92)
50-59	674.79 (424.64)	1,351.45 (866.99)	691.55 (439.98)	879.58 (382.59)
60-69	938.29 (938.29)	1,671.07 (875.88)	1,086.01 (1049.27)	1,151.99 (678.28)
70-79	1,150.34 (606.43)	1,849.25 (1167.06)	1,086.24 (593.46)	1,617.52 (1278.02)
80+	1,300.59 (587.05)	2,035.20 (974.97)	1,195.11 (445.28)	1,613.75 (772.40)

Note. Standard deviations are shown in parentheses. CS = cleft subject; CO = cleft object; OS = object-subject; SO = subject-object.

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h
h

faster RT for CS than for CO



Acceptability Judgment Mean Reaction Times (in Milliseconds)

Age (years)	faster RT for CS than for CO		faster RT for OS than for SO	
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Acceptability Judgment Mean A' Scores

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faster RT for CS than for CO Sentence type **faster RT for OS than for SO**

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Acceptability Judgment Mean A' Scores

higher A's for CS than for CO Sentence type

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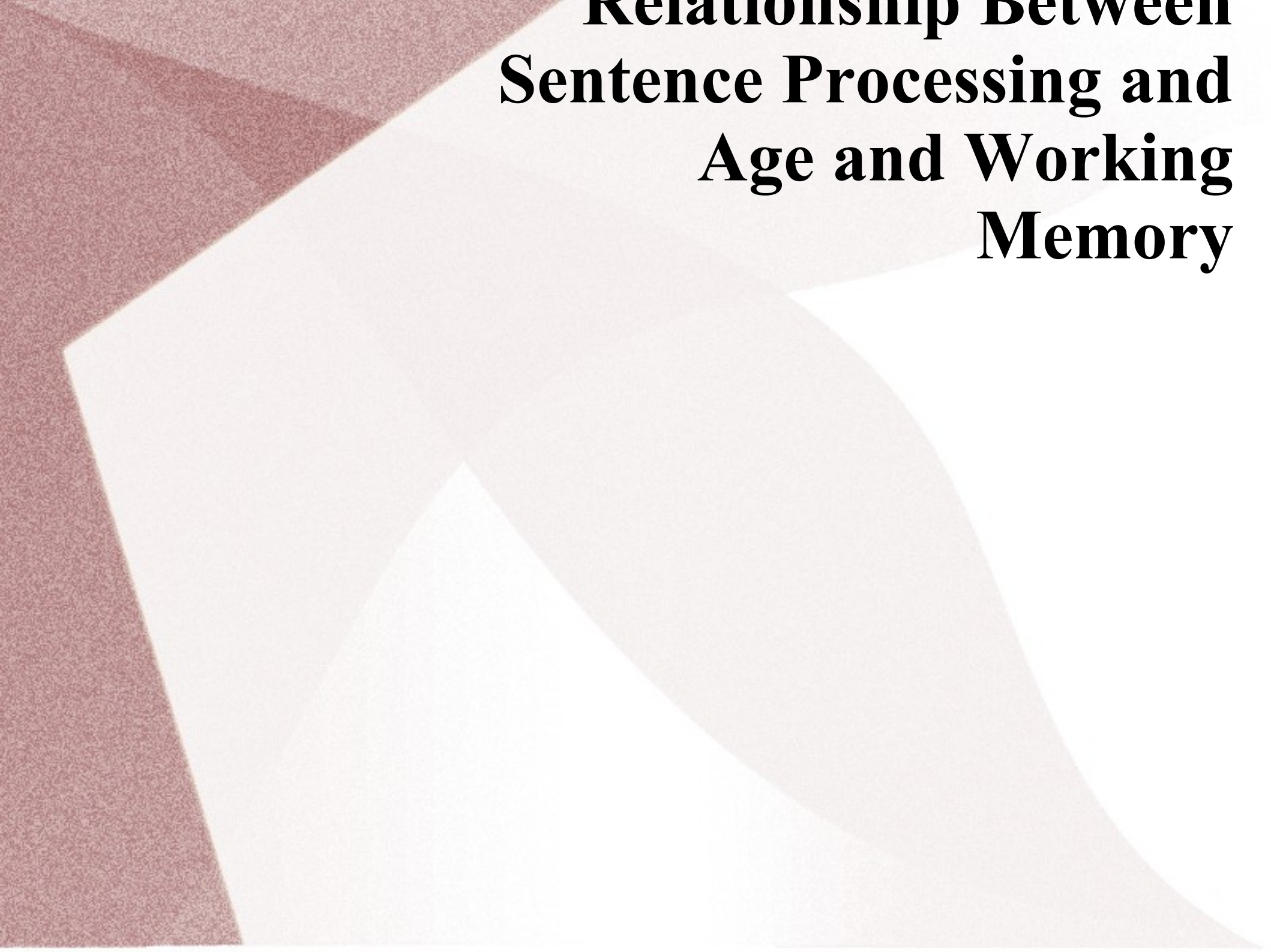
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Acceptability Judgment Mean A' Scores

higher A's for CS than for CO Sentence type **higher A's for OS than for SO**

Age (years)	CS	CO	OS	SO
18-30	0.986 (0.018)	0.938 (0.085)	0.982 (0.025)	0.951 (0.053)
50-59	0.912 (0.086)	0.887 (0.103)	0.940 (0.061)	0.892 (0.087)
60-69	0.937 (0.060)	0.878 (0.171)	0.934 (0.067)	0.879 (0.084)
70-79	0.916 (0.062)	0.906 (0.069)	0.923 (0.060)	0.848 (0.058)
80+	0.895 (0.062)	0.867 (0.080)	0.918 (0.086)	0.825 (0.084)

Note. Standard deviations are shown in parentheses.



Relationship Between Sentence Processing and Age and Working Memory

*Correlations Between Performance on the Auditory Moving-
Windows Task and Age*

Sentence type	Age	Age with WM span partialed out	Age with Comp Z partialed out
On-line measures			
CO vs. CS sentences			
COV - CSV	.11	.08	.05
COV - CSNP2	.13	.10	.08
SO vs. OS sentences			
SOV1 - OSV1	-.04	-.07	-.04
SOV2 - OSV2	-.01	-.04	-.06
Off-line measures			
CO vs. CS sentences			
CO - CS Acc RT	.16	.10	.10
CS Acc RT	.39*	.30*	.30
CO Acc RT	.33*	.24*	.24*
CO - CS A'	.07	.16	.16
CS A'	-.37*	-.34*	-.32*
CO A'	-.17	-.08	-.06
SO vs. OS sentences			
SO - OS Acc RT	.22*	.19*	.14
OS Acc RT	.25*	.18*	.17
SO Acc RT	.38*	.30*	.27*
SO - OS A'	-.26*	-.13	-.21*
OS A'	-.32*	-.28*	-.23*

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On-line measures			
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SO vs. OS sentences			
SOV1 – OSV1	–.04	–.07	–.04
SOV2 – OSV2	–.01	–.04	–.06

No significant correlation
between age & online
measures

Off-line measures			
CO vs. CS sentences			
CO – CS Acc RT	.16	.10	.10
CS Acc RT	.39*	.30*	.30
CO Acc RT	.33*	.24*	.24*
CO – CS A'	.07	.16	.16
CS A'	–.37*	–.34*	–.32*
CO A'	–.17	–.08	–.06
SO vs. OS sentences			
SO – OS Acc RT	<u>.22*</u>	.19*	.14
OS Acc RT	.25*	.18*	.17
SO Acc RT	<u>.38*</u>	.30*	.27*
SO – OS A'	<u>–.26*</u>	–.13	–.21*
OS A'	–.32*	–.28*	–.23*

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SO – OS A'	<u>–.26*</u>	<u>–.13</u>	<u>–.21*</u>
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SO Acc RT	.38*	.30*	.27*
SO – OS A'	<u>–.26*</u>	<u>–.13</u>	<u>–.21*</u>
OS A'	<u>–.32*</u>	<u>–.28*</u>	<u>–.23*</u>

Measures of WM:
 • Span
 • Comp Z

Correlations Between Performance on the Auditory Moving- Windows Task and Age

Sentence type	Age	Age with WM span partialed out	Age with Comp Z partialed out
On-line measures			
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SO – OS A'	<u>-.26*</u>	<u>-.13</u>	<u>-.21*</u>
OS A'	-.32*	-.28*	-.23*

Measures of WM:

- Span
- Comp Z

→ Judgments about SO
is partially due WM

Sentence type	WM span	WM Comp Z
On-line measures		
CO vs. CS sentences		
COV – CSV	–.05	–.16
COV – CSNP2	–.03	–.09
SO vs. OS sentences	WM not related to	On-line measures
SOV1 – OSV1	–.07	–.01
SOV2 – OSV2	–.09	–.18*
Off-line measures		
CO vs. CS sentences		
CO – CS Acc RT	–.09	–.16
CS Acc RT	–.19*	–.32*
CO Acc RT	–.18*	–.29*
CO – CS A'	.22*	.27*
CS A'	–.02	.12
CO A'	.17	.29*
SO vs. OS sentences		
SO – OS Acc RT	–.02	–.21*
OS Acc RT	–.13	–.23*
SO Acc RT	–.13	–.37*
SO – OS A'	.26*	.13
OS A'	.03	.23*
SO A'	.27*	.32*

Sentence type	WM span	WM Comp Z
On-line measures		
CO vs. CS sentences		
COV – CSV	–.05	–.16
COV – CSNP2	–.03	–.09
SO vs. OS sentences		
SOV1 – OSV1	–.07	–.01
SOV2 – OSV2	–.09	–.18*
Off-line measures		
CO vs. CS sentences		
CO – CS Acc RT	–.09	–.16
CS Acc RT	–.19*	–.32*
CO Acc RT	–.18*	–.29*
CO – CS A'	.22*	.27*
CS A'	–.02	.12
CO A'	.17	.29*
SO vs. OS sentences		
SO – OS Acc RT	–.02	–.21*
OS Acc RT	–.13	–.23*
SO Acc RT	–.13	–.37*
SO – OS A'	.26*	.13
OS A'	.03	.23*
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Sentence type	WM span	WM Comp Z
On-line measures		
CO vs. CS sentences		
COV – CSV	–.05	–.16
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SO vs. OS sentences		
SOV1 – OSV1	–.07	–.01
SOV2 – OSV2	–.09	–.18*

WM not related
to On-line
measures

Off-line measures		
CO vs. CS sentences		
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CS Acc RT	<u>–.19*</u>	–.32*
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SO vs. OS sentences		
SO – OS Acc RT	–.02	–.21*
OS Acc RT	–.13	–.23*
SO Acc RT	–.13	–.37*
SO – OS A'	<u>.26*</u>	.13
OS A'	.03	.23*
SO A'	<u>.27*</u>	.32*

Small
correlations

Sentence type	WM span	WM Comp Z
On-line measures		
CO vs. CS sentences		
COV – CSV	–.05	–.16
COV – CSNP2	–.03	–.09
SO vs. OS sentences		
SOV1 – OSV1	–.07	–.01
SOV2 – OSV2	–.09	–.18*

WM not related
to On-line
measures

V2 in SO compared
with OS sentences

Off-line measures		
CO vs. CS sentences		
CO – CS Acc RT	–.09	–.16
CS Acc RT	<u>–.19*</u>	–.32*
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On-line measures				
CO vs. CS sentences				
COV – CSV	–.05	–.16	WM not related to On-line measures	
COV – CSNP2	–.03	–.09		
SO vs. OS sentences				
SOV1 – OSV1	–.07	–.01		
SOV2 – OSV2	–.09	–.18*		→ V2 in SO compared with OS sentences
Off-line measures				
CO vs. CS sentences				
CO – CS Acc RT	–.09	–.16	Small correlations	
CS Acc RT	<u>–.19*</u>	–.32*		
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Small
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Bigger
correlations

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