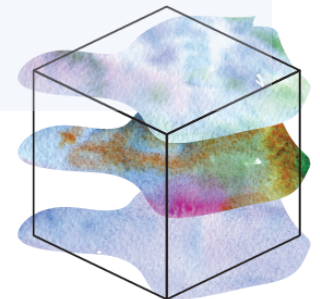


Complexity of Reading within Cognitive Science

Jurgis Šķilters

jurgis.skilters@lu.lv

<https://www.lpcs.lu.lv/>



Outline

1. *Interrelations between vision, language comprehension, and other cognitive and perceptual processes during reading*
 - *Eye movement research*
2. *Impact of format of tools on the reading comprehension*
 - *Reading as a part of a central cognitive extension enabling the modern society and science*
3. *Multi-facetedness of reading*
 - *A cross-disciplinary collaboration between different research areas and fields in the research on reading*
 - *Architecture of reading*

1.

*Interrelations between vision,
language comprehension, spatial
cognition, and other cognitive and
perceptual processes during reading*

What is reading?

*“reading is the ability to extract **visual** information from the page and comprehend the meaning of the **text**”*

Rayner, K., Pollatsek, A., Ashby, J., & Clifton Jr, C. (2012).
Psychology of reading. 2nd Ed.
New York: Psychology Press. p. 19

visual information

language, **text**

Research on eye movements

Since late 70ties

Groundbreaking work
in linking visual and
linguistic processing



Table 1

Approximate Mean Fixation Duration and Saccade Length in Reading, Visual Search, Scene Perception, Music Reading, and Typing

Task	Mean fixation duration (ms)	Mean saccade size (degrees)
Silent reading	225	2 (about 8 letters)
Oral reading	275	1.5 (about 6 letters)
Visual search	275	3
Scene perception	330	4
Music reading	375	1
Typing	400	1 (about 4 letters)

Note. Values are taken from a number of sources and vary depending on a number of factors (see Rayner, 1984).

Psychological Bulletin
1998, Vol. 124, No. 3, 372–422

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0033-2909/98/\$3.00

Eye
movements:
sensitive to

- the type of visual task and
- type of reading

Eye Movements in Reading and Information Processing: 20 Years of Research

Keith Rayner
University of Massachusetts at Amherst

Visual attention in reading: Eye movements reflect cognitive processes

KEITH RAYNER

University of Rochester, Rochester, New York 14627

Two hypotheses regarding the nature of fixation durations in reading were discussed. One position suggests that semantic processing lags behind the perceptual input of information. The other position suggests that semantic processing is more rapid and immediate. Eye movement data of skilled readers reading passages of text were analyzed. It was found that the main verb of the sentence received more visual attention than other key grammatical elements within a sentence. On the basis of the overall result pattern, it was argued that eye movements are affected by cognitive processes occurring at the time of the fixations.

“On the basis of the overall result pattern, it was argued that eye movements are affected by cognitive processes occurring at the time of the fixations.” (my emphasis: JS)

Table 1

Means of Significant Effects

	The	S	V	the	O	F Value*	Significance Level
Number of Fixations**							
Forward Fixations	10.5	47.4	47.2	21.8	42.5	78.30	.001
Regressive Fixations	2.7	8.1	8.1	3.6	7.5	9.05	.001
Fixation Durations (msec)							
Forward Fixations	167	204	231	208	214	14.43	.001
Regressive Fixations	123	185	233	135	212	5.51	.002
Total Time (msec)							
Per Character F	15	35	41	36	36	19.18	.001
Total Time Per Character	19	42	49	41	44	22.82	.001

*The degrees of freedom in all cases are 4/36.

**Mean number of fixations per subject (based on 45 sentences per subject).

Eye movements as sensitive to different parts of sentence

Eye movements during reading: some current controversies

Matthew S. Starr and Keith Rayner

Table I. Developmental characteristics of eye movements during reading

	Grade level ^a						
	1	2	3	4	5	6	Adult
Fixation duration (ms)	355	306	286	266	255	240	233
Fixations per 100 words	191	151	131	121	117	106	94
Frequency of regressions (%)	28	26	25	26	26	22	14
^a Grade 1 children in the US are typically 6 years old, when reading instruction begins.							

Eye movements as **developmentally**
sensitive and informative

Eye movements as sensitive to the type of text

96 Skilled reading of text

TABLE 4.1 Variability in adults reading different types of text

<i>Topic</i>	<i>Fixation duration^a</i>	<i>Saccade length^b</i>	<i>Regressions (%)^c</i>	<i>WPM</i>
Light fiction	202	9.2	3	365
Newspaper article	209	8.3	6	321
History	222	8.3	4	313
Psychology	216	8.1	11	308
English literature	220	7.9	10	305
Economics	233	7.0	11	268
Mathematics	254	7.3	18	243
Physics	261	6.9	17	238
Biology	264	6.8	18	233
<i>M</i>	231	7.8	11	288

Mean fixation duration, mean saccade length, proportion of fixations that were regressions, and words per minute reading time (WPM) for 10 good college-age readers reading different types of text.

^a In ms.

^b In character spaces (4 character spaces = 1° of visual angle).

^c Percentage of total fixations that were regressions.

Rayner, K., Pollatsek, A., Ashby, J., & Clifton Jr, C. (2012). *Psychology of reading*. 2nd Ed. New York: Psychology Press. p. 96

- In exploring a visual and oculomotor process, we are exploring reading...
- **Reading as a mapping between visual and linguistic processes**

visual information

language, text

In cognitive science we are interested in elaborating

cognitive architectures

of human perceptual and cognitive processes...

What is the cognitive architecture of reading?

Before answering let me briefly give
an overview of the involved processes

- Visual processing,
- horizontal scanning
 - feature detectors

Visual word lexicon /
Stored representations of
words

semantics

Grapheme-to-phoneme
conversion

Stored lexical phonology

Sub-lexical phonological
recoding (without semantics)

...the situation is even more
complex

Harley, T. A. (2014). *The psychology of language: From data to theory*. 4th Edition.
London: Psychology press.

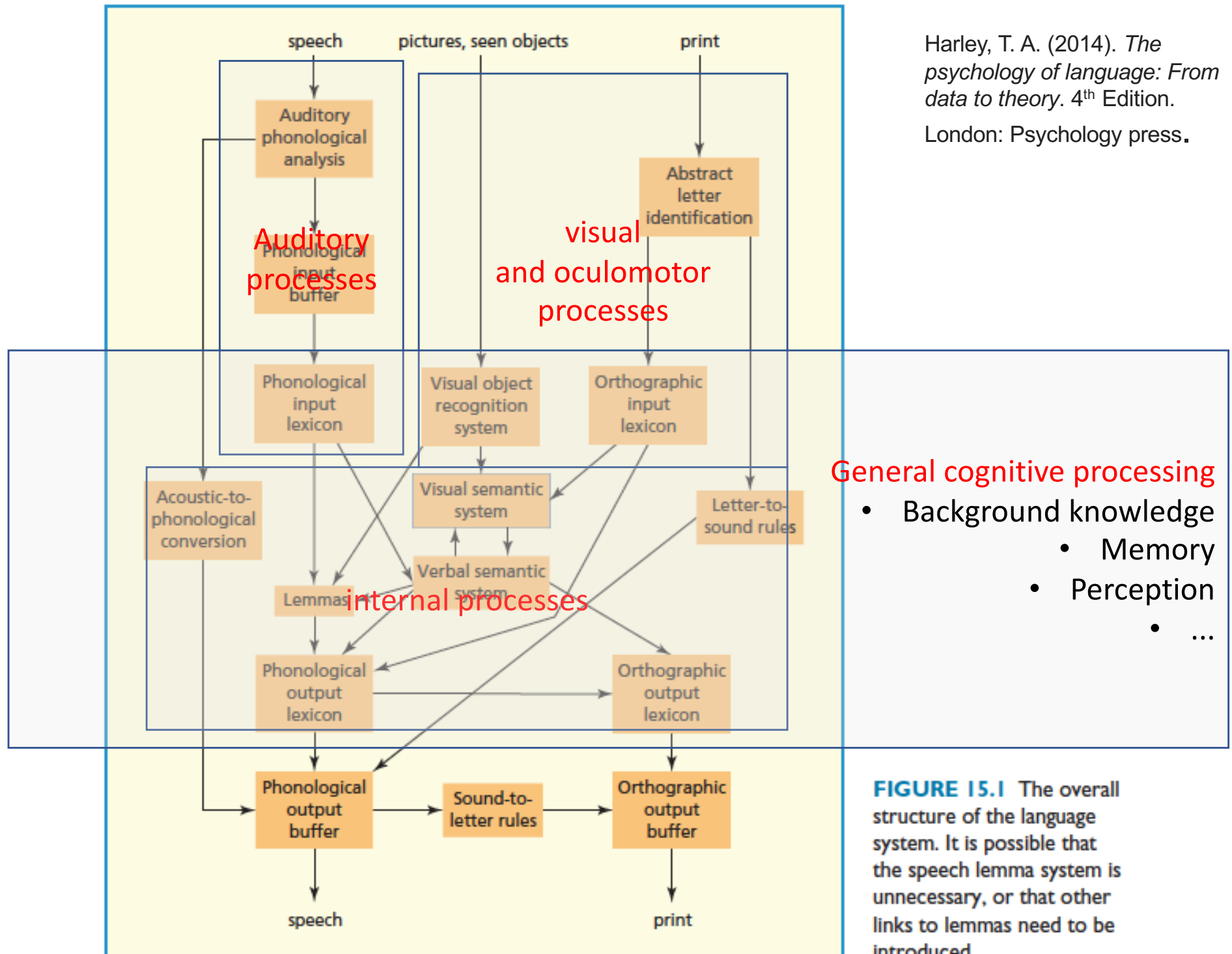


FIGURE 15.1 The overall structure of the language system. It is possible that the speech lemma system is unnecessary, or that other links to lemmas need to be introduced.

What is the cognitive architecture
of reading?

some sketches

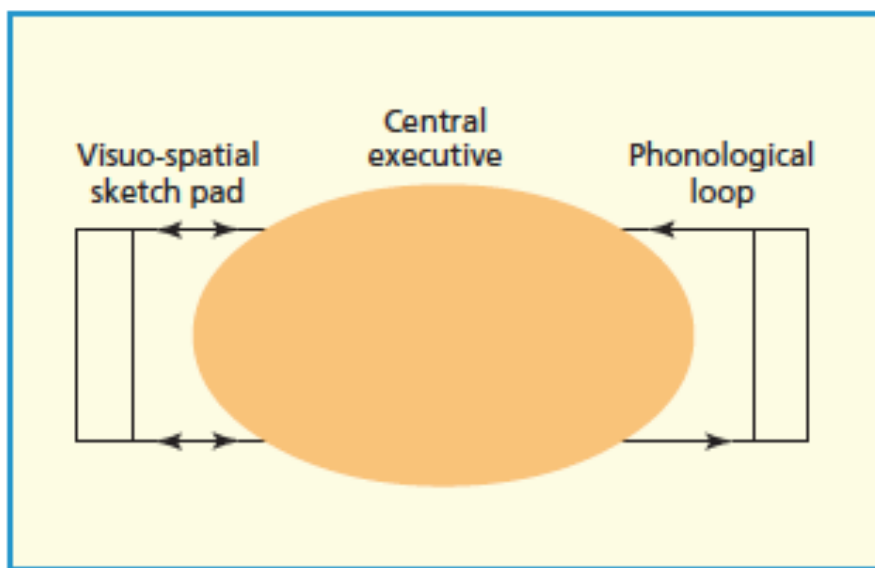


FIGURE 15.2 A simplified representation of the working memory model (based on Baddeley & Hitch, 1974).

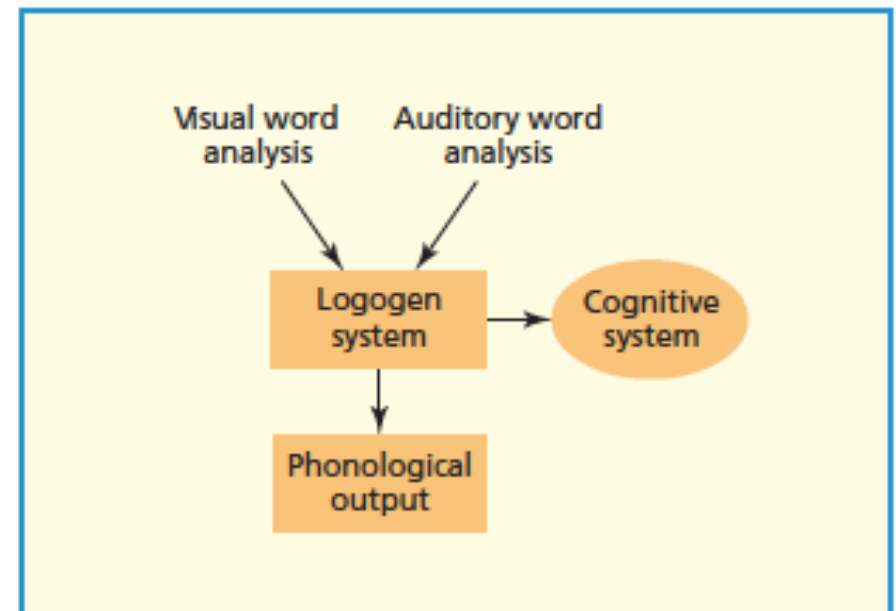


FIGURE 6.7 The original logogen model of lexical access (based on Morton, 1979b).

The role
of the
(central)
cognitive
system

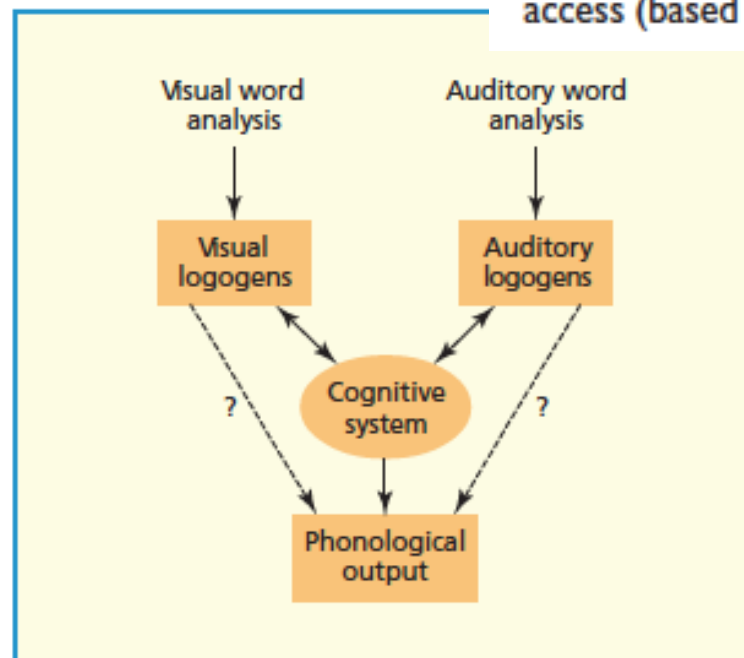


FIGURE 6.8 The revised logogen model of lexical access (based on Morton, 1979b).

Harley, T. A. (2014). *The psychology of language: From data to theory*. 4th Edition.
London: Psychology press.

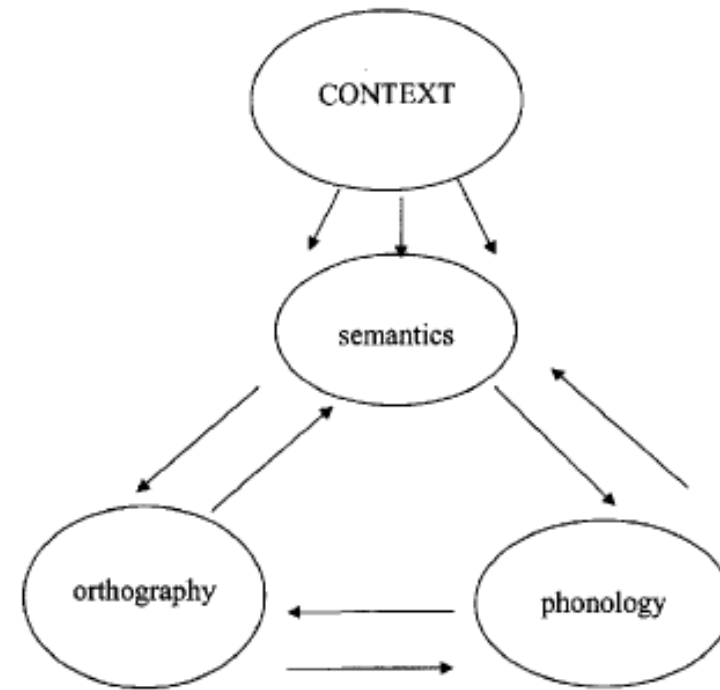


FIG. 4.1. The Triangle model of reading (after Seidenberg & McClelland, 1989).

Or: is reading an **interactive** process?

The role and impact of other cognitive processes on reading

- The **central processing** hypothesis:
 - The **underlying cognitive processes** are determining
- The **script dependent** hypothesis:
 - **Orthographic processing / orthographic transparency**
- In fact, both approaches are **complementary**

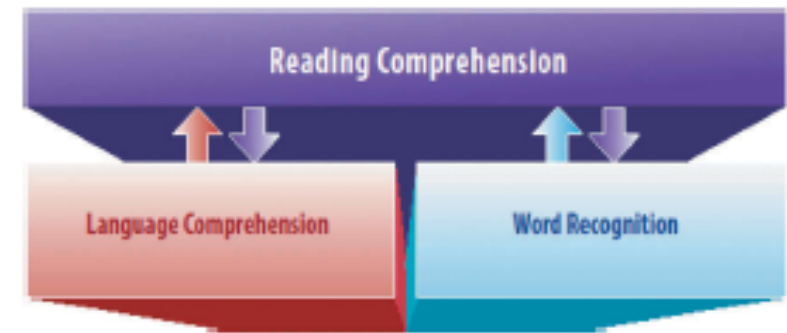
Geva, E., & Siegel, L. S. (2000). Orthographic and cognitive factors in the concurrent development of basic reading skills in two languages. *Reading and Writing*, 12(1-2), 1-30.

- These 'architectures' are neglecting that
 - **perception**
 - attention
 - memory
 - tactile/haptic abilities
 - visuo-spatial abilities
- contribute as well
- but to a different extent

- However, there does not seem to be a **straightforward link between cognitive abilities (e.g., intelligence tests) and reading comprehension**

Cutting, L. E., & Scarborough, H. S. (2006). Prediction of reading comprehension: Relative contributions of word recognition, language proficiency, and other cognitive skills can depend on how comprehension is measured. *Scientific studies of reading*, 10(3), 277-299.

Cognitive foundations framework (2019)



This corresponds to the idea (popular in cognitive science...) that reading ability is a result of

a modality free general language comprehension factor

(i.e., general language comprehension)

and a name retrieval factor
simple symbol activation from visual input

(when symbol is retrieved from memory as a response to visual input).

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2019, VOL. 24, NO. 1, 75–93
<https://doi.org/10.1080/19404158.2019.1614081>

 **Routledge**
Taylor & Francis Group

LEARNING DIFFICULTIES AUSTRALIA EMINENT RESEARCH
AWARD WINNER 2019

The cognitive foundations of learning to read: a framework
for preventing and remediating reading difficulties

William E. Tunmer^a and Wesley A. Hoover^b

^aInstitute of Education, Massey University, Palmerston North, New Zealand; ^bAmerican Institutes for Research (retired), Austin, TX, USA



Perfetti, C. A. (1986). Cognitive and linguistic components of reading ability. In *Acquisition of Reading Skills* (1986) (pp. 11-40). Routledge.

Reading comprehension

Language comprehension

Word recognition

Back-
ground
knowledge

Linguistic
knowledge

Alphabetic coding skill

Phono-
logic k.

Syn-
tactic
k.

Se-
man-
tic k.

Con-
cepts
about
print

Knowledge about
alphabetic principle

Letter
knowledge

Phonemic
awareness

1. Word / sentence length
2. Word / sentence frequency
3. Morphology

Comprehension
requires **grammar** and **semantics** to be
interrelated with the relevant **situation**
model (Kintsch & Rawson, 2005)

To sum up so far:

- Reading as an interaction between
- Visual, linguistic processing and background knowledge
 - But attentional, sensorimotor, perceptual processes are involved as well
 - Cognitive architecture of reading and the impact of cognitive and perceptual factors – not entirely clear yet

2.

*Impact of **format of tools** on the
reading comprehension*

- We are adjusting our perception to the format and
- We are adjusting the format to our perception

Risko, E. F., & Gilbert, S. J. (2016).
Cognitive offloading. *Trends in cognitive sciences*, 20(9), 676-688.

Format matters ...

- Format (screen) does have impact
 - (cp. work by prof. Mangen)
- Digital reading:
- Switching between applications
- Multitasking
- Hyperlinks
- Instead of horizontal scanning in analogue reading

adaptive process

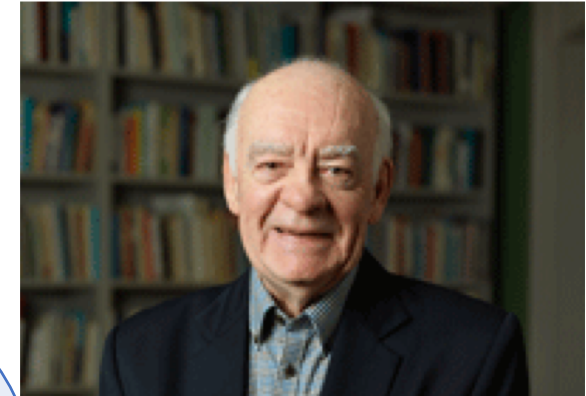
- “Cognitive chameleons”
- we are good in adapting to new formats and this might have consequences –
 - a more superficial way of reading, memorizing, and recalling
 - E.g., Speed over accuracy... shallow processing... Recall limits

- *reading is a part of a central cognitive extension enabling the modern society and science*
- We are cognitive hybrids
 - Combining external and internal resources
- History of modern human mind is a history of cognitive hybridization / complementarization

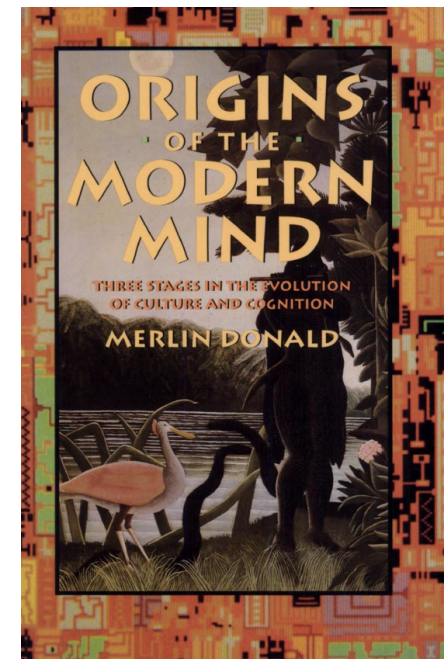
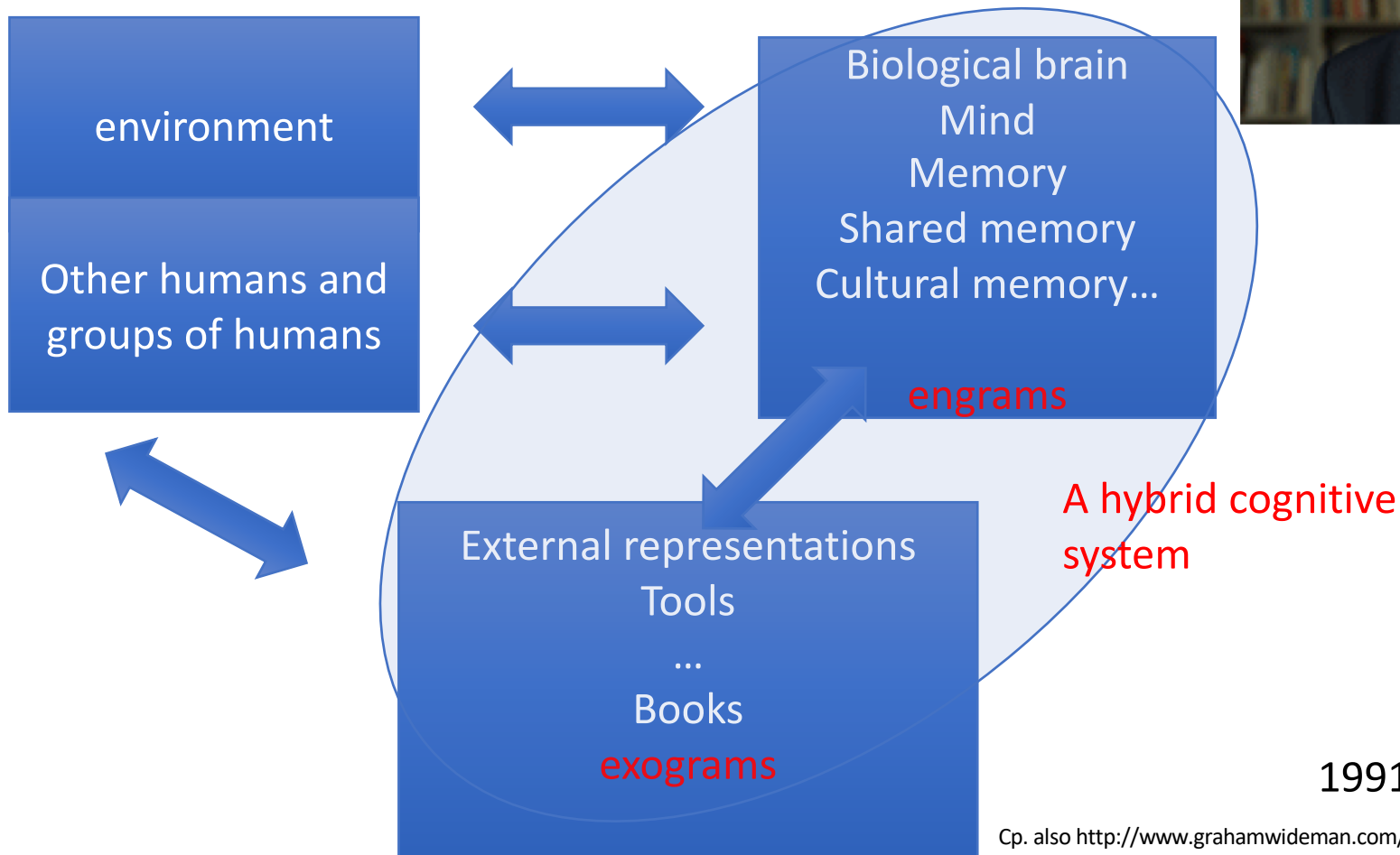
We are still in the same paradigm that was established when the typographic culture was established.

Merlin Donald: Modern culture as an continuous interaction between exograms and engrams

Why is our culture, technology, and society so powerful?



www.swedishcollegium.se



1991

Cp. also <http://www.grahamwideman.com/gw/xm/concmod/humanrelknow.htm>

Complementing internal resources with external tools has **benefits** and supports our perception, memory, math, ... and has critically contributed to the development of abstract knowledge

Zhang, J., & Norman, D. A. (1994). Representations in distributed cognitive tasks. *Cognitive science*, 18(1), 87-122.

Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, 20(9), 676-688.

90

ZHANG AND NORMAN

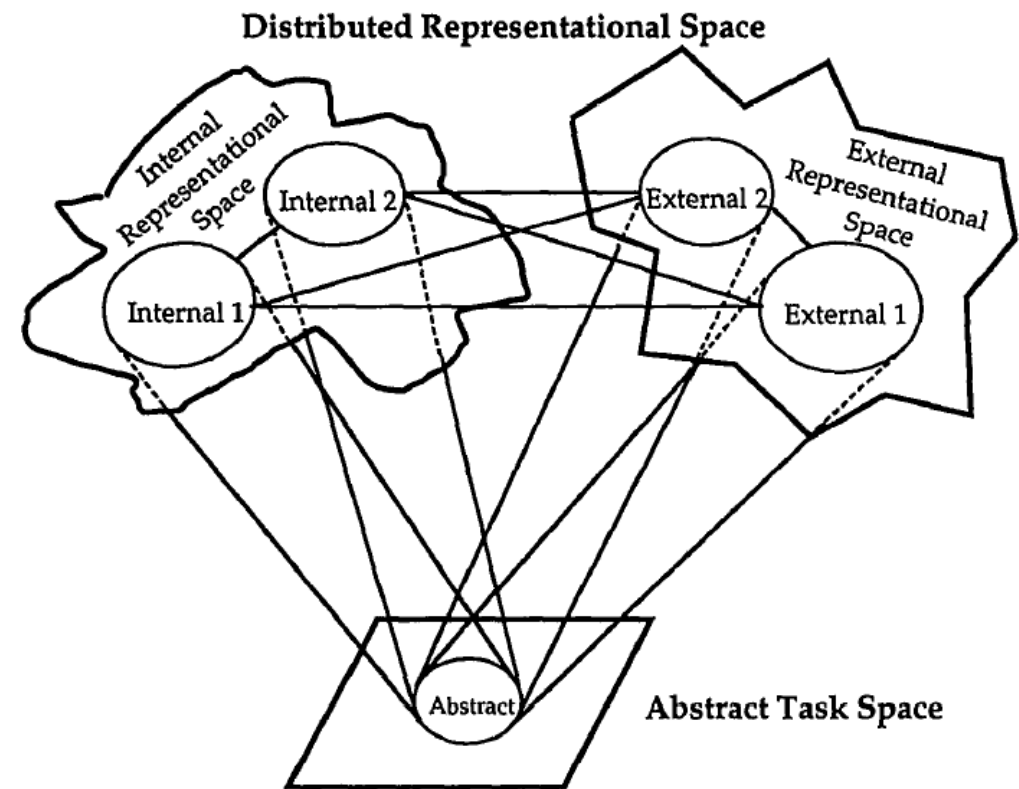


Figure 1. The theoretical framework of distributed representations. The internal representations form an internal representational space, and the external representations form an external representational space. The internal and external representational spaces together form a distributed representational space, which is the representation of the abstract task space.

Offloading of internal memory onto external [digital] tools is crucial in the 21st century

- One of the most automatic and natural routines
- Shared knowledge and shared memory
 - Nothing extraordinary new....

but

- **it also leaves memory and knowledge vulnerable to manipulation**

Risko, E. F., Kelly, M. O., Patel, P., & Gaspar, C. (2019). Offloading memory leaves us vulnerable to memory manipulation. *Cognition*, 191, 103954.

- But once the external media are rapid and fragile in terms of changes made by others...
 - ...internal memories are increasingly fragile and exposed to manipulation
 - In fact, the frequent users do not necessarily notice manipulations and encode the manipulated content back into the biological memory (generating false memory)
 - Source information as inherently uncertain and sometimes obscure
- This is rarely the case with the printed media and hand-written media

Risko, E. F., Kelly, M. O., Patel, P., & Gaspar, C. (2019). Offloading memory leaves us vulnerable to memory manipulation. *Cognition*, 191, 103954.

Marsh, E. J., & Rajaram, S. (2019). The digital expansion of the mind: Implications of internet usage for memory and cognition. *Journal of Applied Research in Memory and Cognition*.

- Repeated content (*seems to be truer, easier to process*) impacts the spread of manipulated messages
 - Although initial accuracy seems to prevent it...
 - ***Illusory truth effect*** – repeated messages in campaigns, political propaganda

Brashier, N. M., Eliseev, E. D., & Marsh, E. J. (2020). An initial accuracy focus prevents illusory truth. *Cognition*, 194, 104054.

To sum up so far:

- Humans as hybrids are powerful
 - and ability to map internal and external contents is a cause of modern science and society
- Fast-changing digital media are making humans
 - Less focused
 - Not able to select the content
 - vulnerable to manipulated facts and less accurate content in general
- Changes in the social function of digital social networks
 - Support-feedback-cycle instead of information transmission
 - False collective memories
 - Tool in strategical communication

3.

*Multi-facetedness of reading;
A **cross-disciplinary collaboration**
between different research areas and
fields in the research on reading*

What is reading?

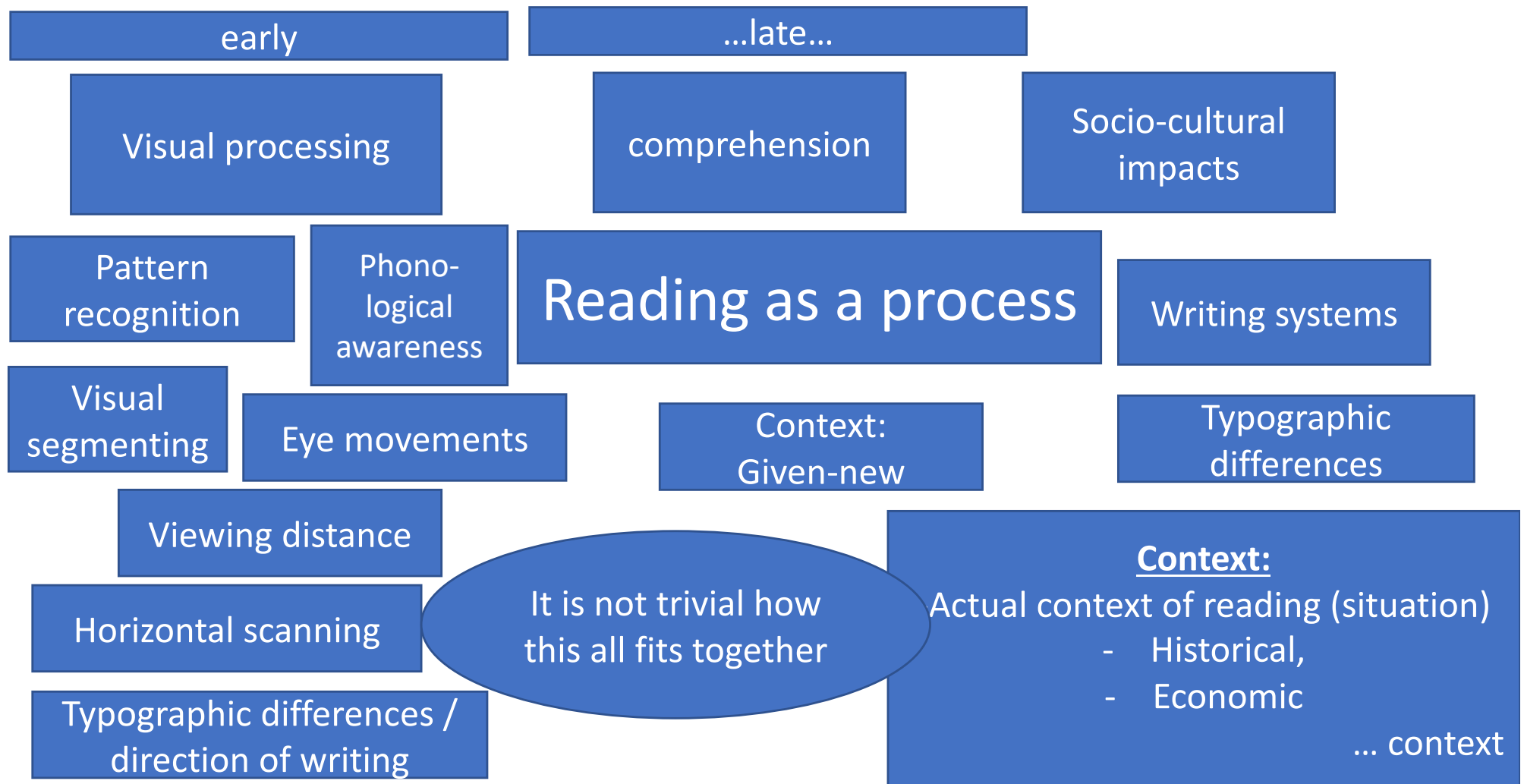
*Let me return to the question regarding the **cognitive architecture** of reading...*

- Linguistic process
- Visual process
- Socio-cultural & historic process
- Cognitive process
- Perceptual process (involving other modalities than just vision)
- ???

- All answers are correct
- All answers are necessary to understand the reading in all its complexity

Research on reading involves all disciplines mentioned before

- Reading is a stage-wise **process**
- Therefore, research can focus on a particular stage of it



Core argument and summary

Core argument and summary

1. Reading as a process involving visual, linguistic but also other perceptual and cognitive abilities

- There is no single cognitive architecture of reading although there are several plausible sketches of it....

2. Format critically constrains reading and comprehension;

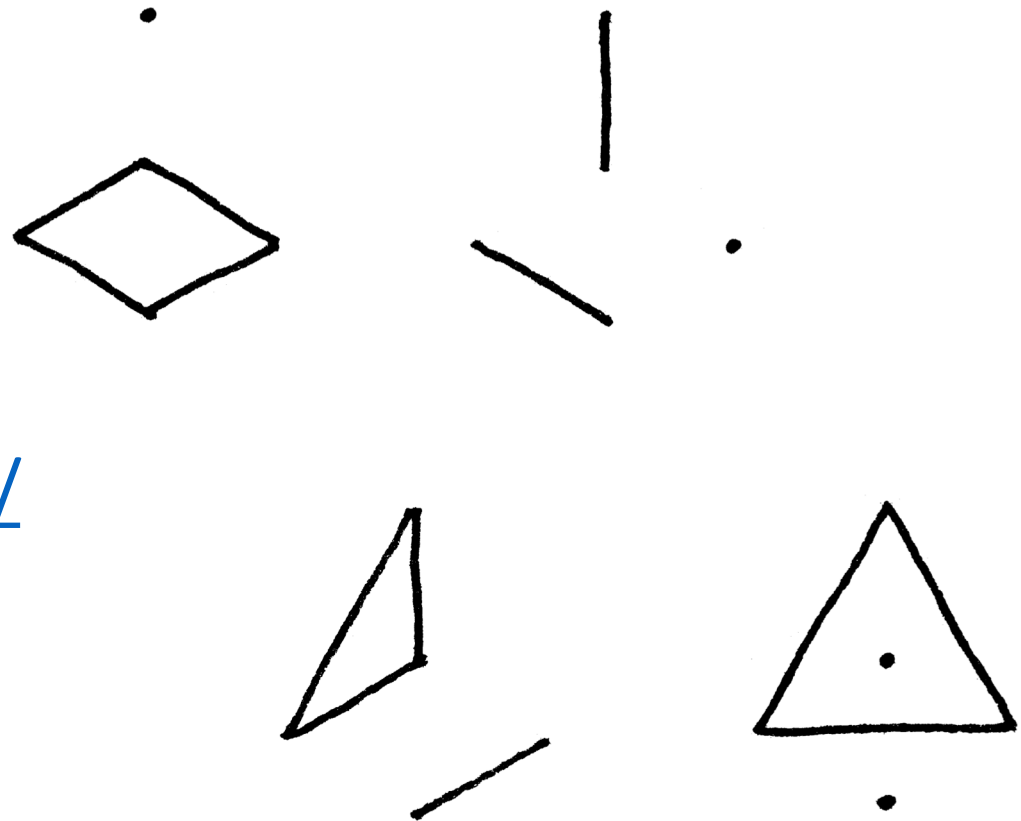
- Humans are “cognitive chameleons” in adjusting to different formats; there are costs and benefits of them..
- External (not only digital) format enables a hybrid cognitive processing which is the core of modern knowledge society and culture
- Manipulability and vulnerability of content in digital format...

Core argument and summary *(continued)*

3. Reading as a stage-wise process for integrating different areas, research fields and enabling a cross-disciplinary work to elaborate an empirically supported comprehensive **cognitive and cultural architecture of reading**

- We do not have it yet in 2019!

- Thanks!
- jurgis.skilters@lu.lv
- <https://www.lpcs.lu.lv/>

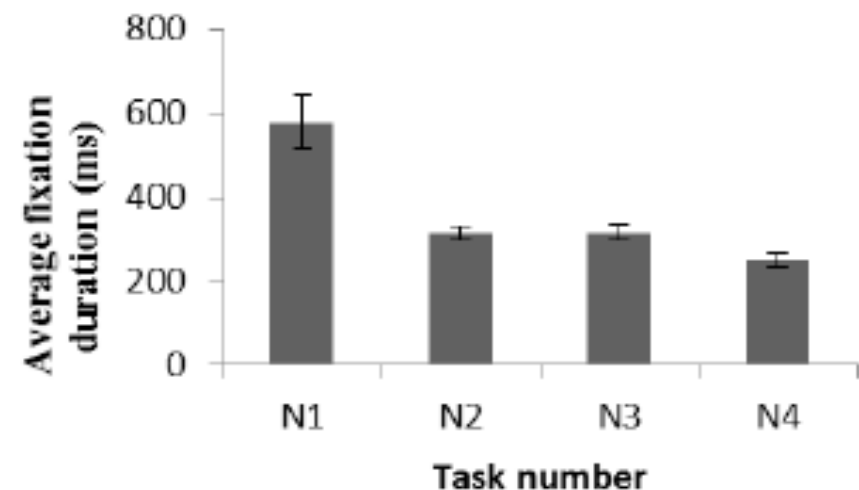
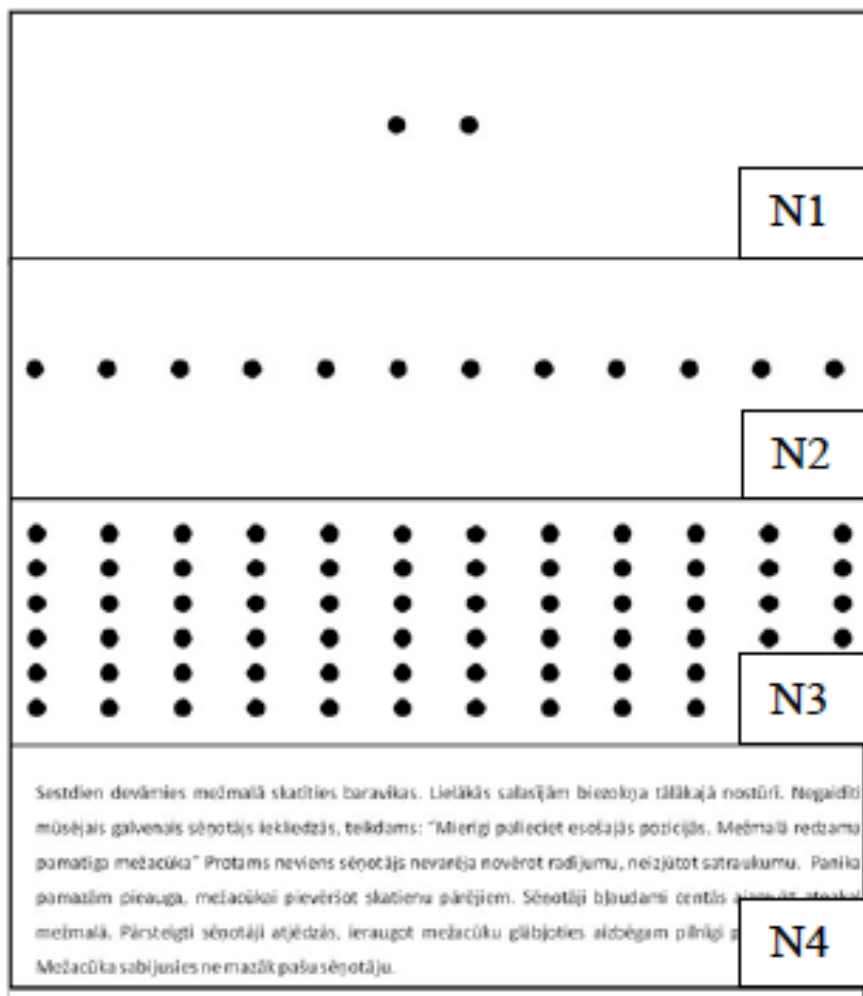


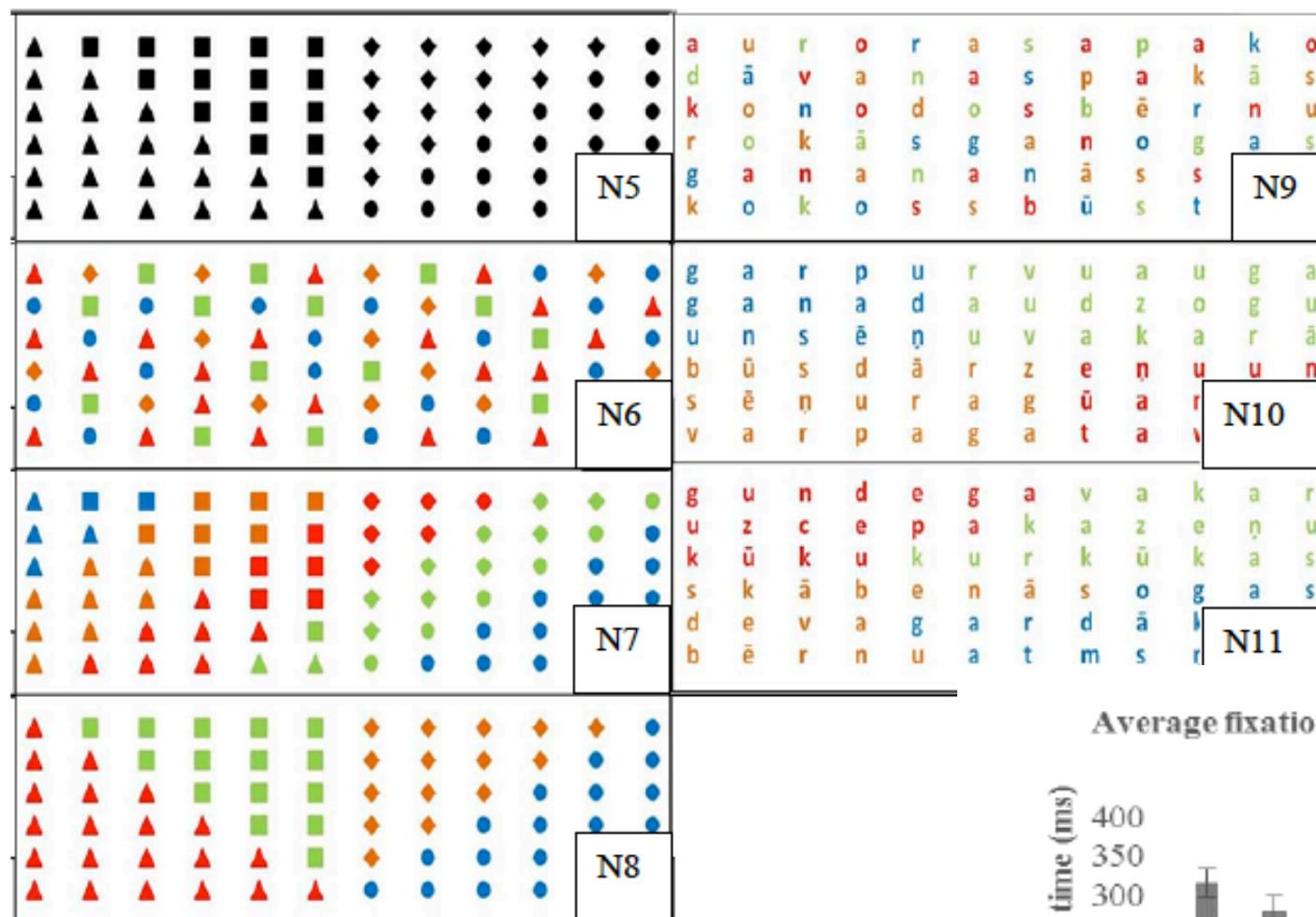
Simple Configuration Effects on Eye Movements in Horizontal Scanning Tasks

Ilze Laicane
University of Latvia

Jurgis Skilters
University of Latvia

Ivars Lacis
University of Latvia



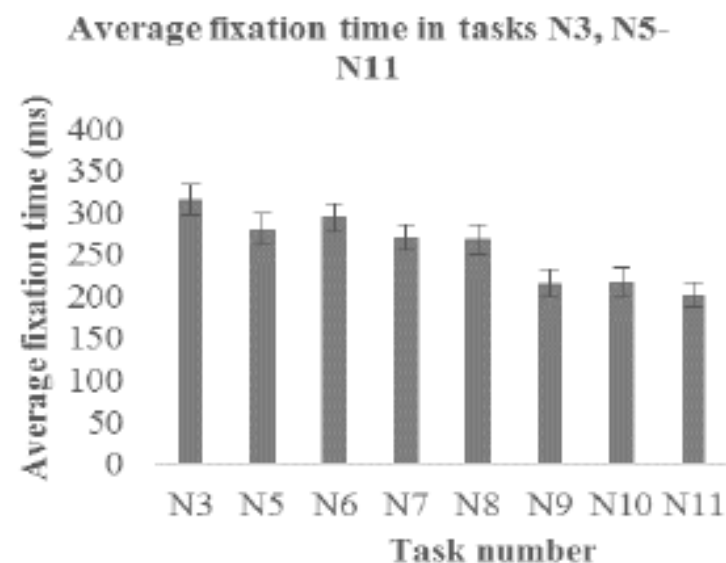


Simple Configuration Effects on Eye Movements in Horizontal Scanning Tasks

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How strong and weak readers perform on the Developmental Eye Movement test (DEM): norms for Latvian school-aged children

Jelena Serdjukova¹ · Lasma Ekimane¹ ·
Janis Valeinis² · Jurgis Skilters³ · Gunta Krumina¹

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Attention as a
strong predictor
of reading skills

Visuo-spatial deficits
cause phonological
deficits (Vidyasagar &
Pammer, 2009)

Problems in attention → problems
in grapheme processing ,
translation of graphematic
information into phonemic
information and development of
phonemic awareness

How strong and weak readers perform on the developmental...

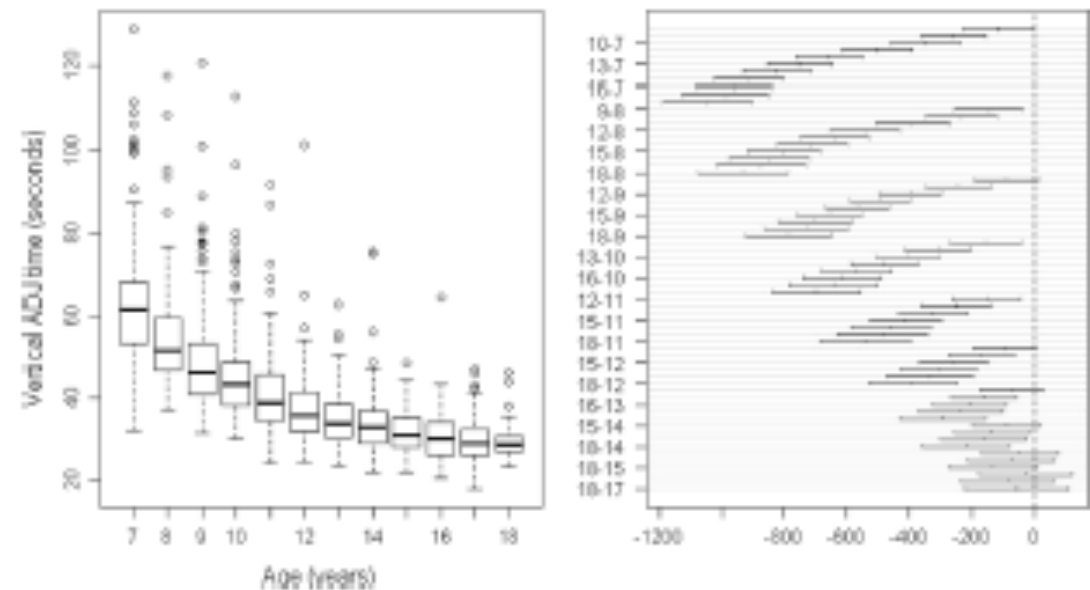


Fig. 1 Box plots for vertical DEM scores by age group (left plot); 95 % confidence intervals for the mean differences of vertical DEM scores between any two age groups via Tukey's HSD test using ANOVA on marked data (right plot); ADJ time adjusted time

