Exploration of the Rapid Automatized Naming (RAN) Task:

(1) What should the "A" in RAN really stand for?
(2) Meta-analysis of empirical evidence

E. Borokhovski, R. Bernard, N. Segalowitz, A. Sokolovskaya

Concordia University
Psychology Department

CSLP (Center for the Study
of Learning and Performance)

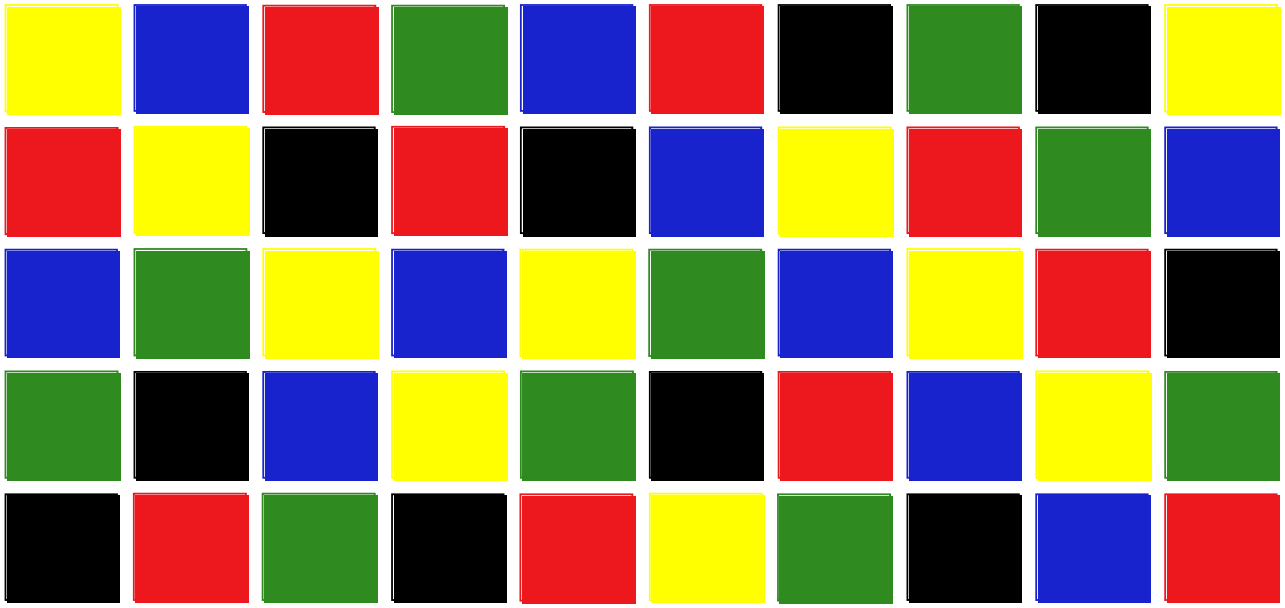
OUTLINE:

- Background & Rational
- Major Research Questions
- Experimental Findings
- Meta-Analysis:
  Summarizing empirical data on RAN-to-reading association
- General Discussion & Implications

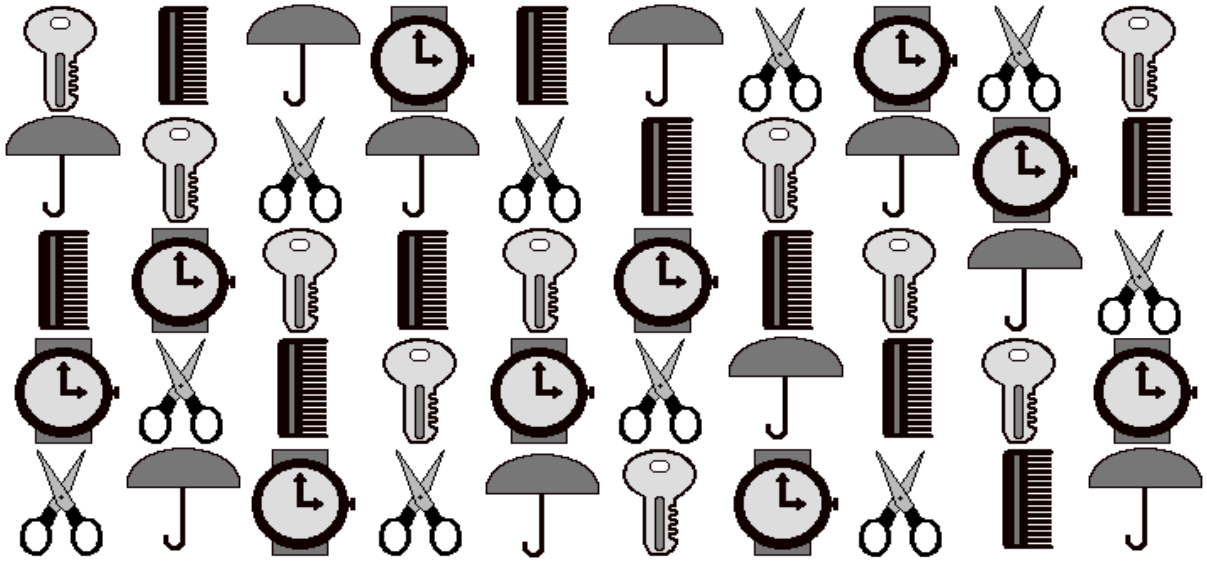
Background:
Diagnosis & Prognosis of Developmental Dyslexia

- Defining developmental dyslexia: The role of cognitive factors (e.g., Snowling, 2000)
- Double-deficit hypothesis (Wolf & Bowers, 1999, Wolf, Bowers, & Biddle, 2000, Wolf et al., 2002):
- Phonological awareness - grapheme / phoneme correspondence (e.g.,Rayner et al., 2001, Stanovich, 2000)
- Naming speed: Measured by RAN task performance (Denckla & Rudel, 1974, 1976)

NON-SYMBOLIC (COLORS) RAN



NON-SYMBOLIC (OBJECTS) RAN



SYMBOLIC (LETTERS) RAN

o a s d p a o s p d

s d a p d o a p s o

a o s a s d p o d a

d s p o d s a s o p

s a d p a p o a p s

SYMBOLIC (DIGITS) RAN

2 4 6 9 4 6 7 9 7 2

6 2 7 6 7 4 2 6 9 4

4 9 2 4 2 9 4 2 6 7

9 7 4 2 9 7 6 4 2 9

7 6 9 7 6 2 9 7 4 6

Background: RAN & reading

- Wolf, Bowers, & Biddle (2000), Wolf et al. (2002):
  - Cross-sectional
  - Longitudinal
  - Different ages
  - Different languages
  - Savage et al. (2005), Torgesen & Burgess (1998):
    Phonological nature of RAN
  - Schatschneider et al. (2002):
    Research design concern
  - Swanson et al. (2003), Hammill (2004):
    Emphasis on other correlates of reading
- The cognitive nature of RAN remains an open question…

Major Research Questions

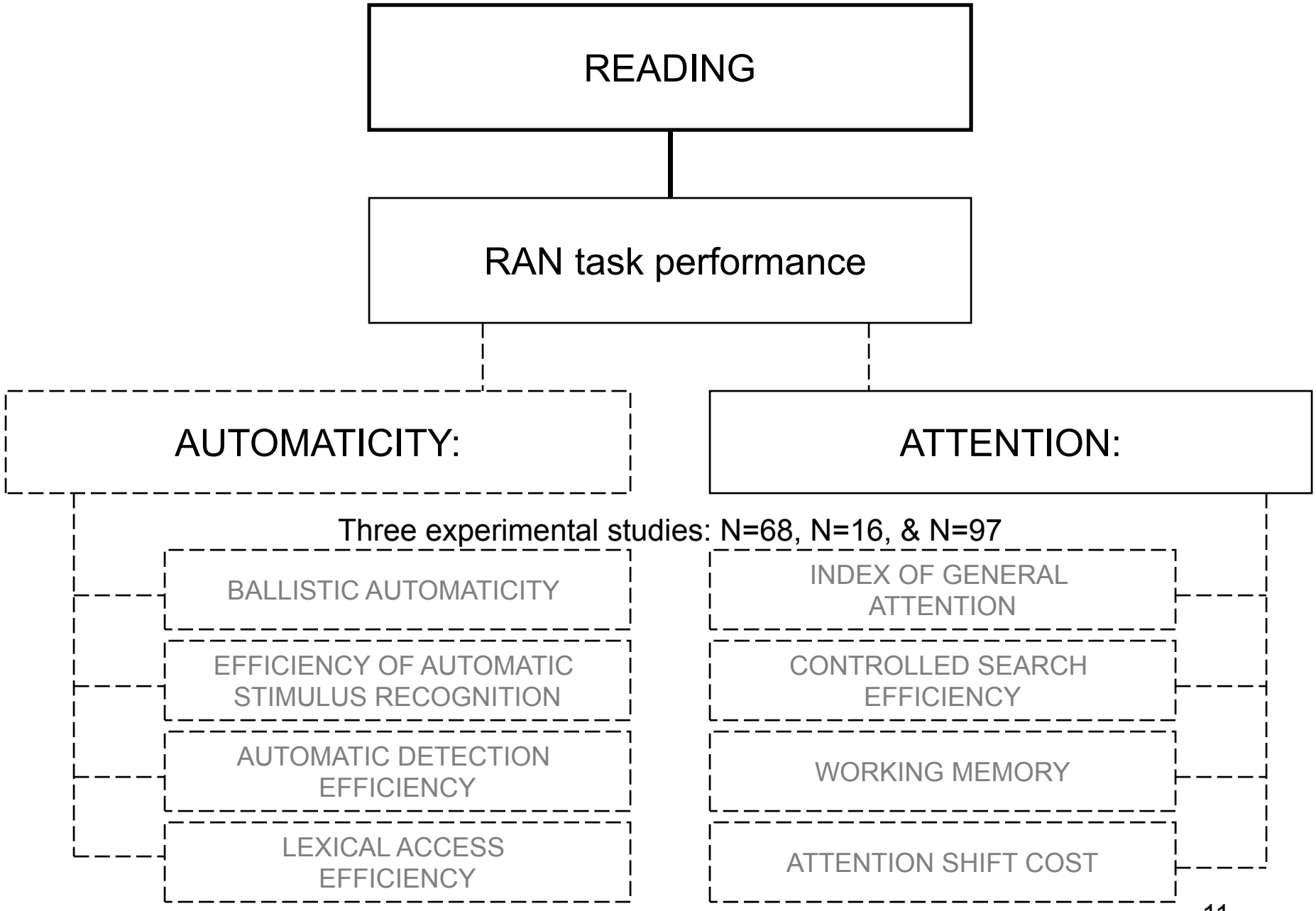
- **What should the "A" in RAN stand for?**
  Does RAN performance reflect automatic or attention-based processing?
  - Specifying and testing automaticity account
  - Exploring aspects of attention account

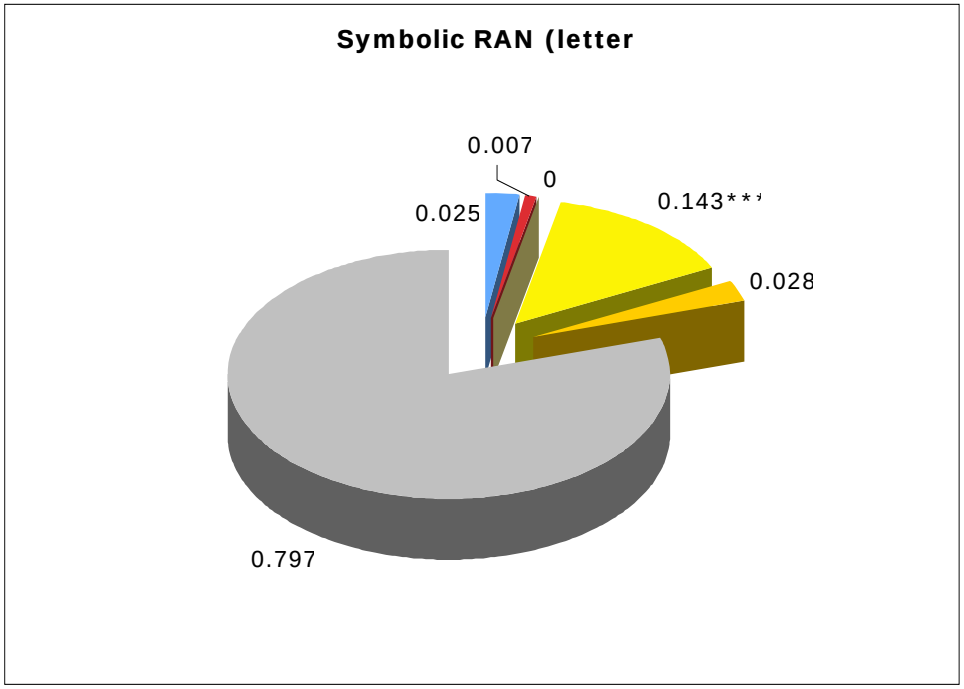
  Estimating relative contributions of automaticity and attention-based processing to RAN task performance

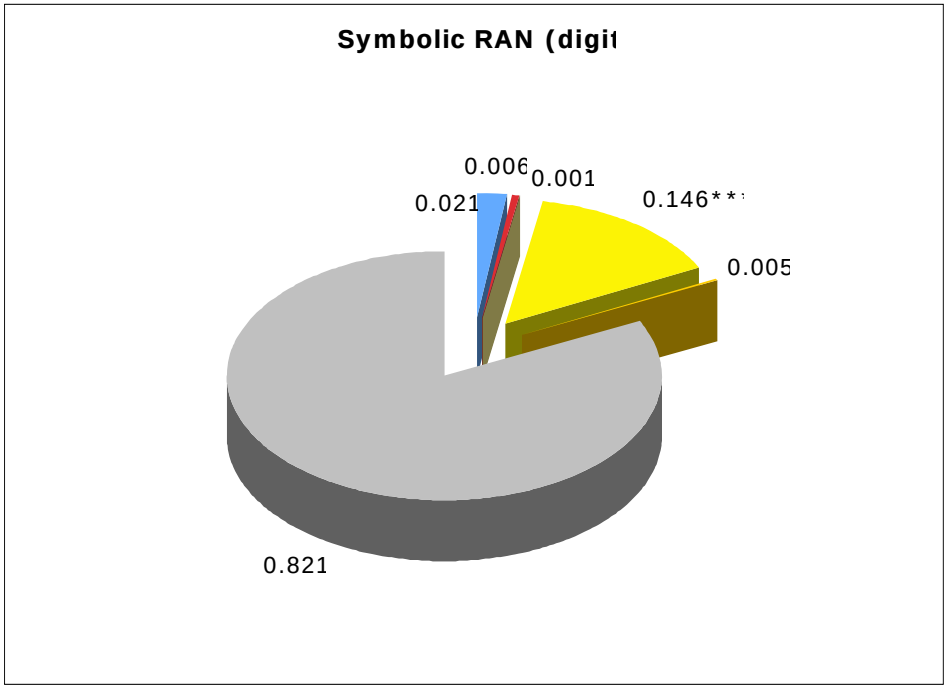
- **How different are symbolic and non-symbolic RAN subtasks?**
  - *In underlying cognitive mechanisms*
  - ***In connection with different aspects of reading skills***

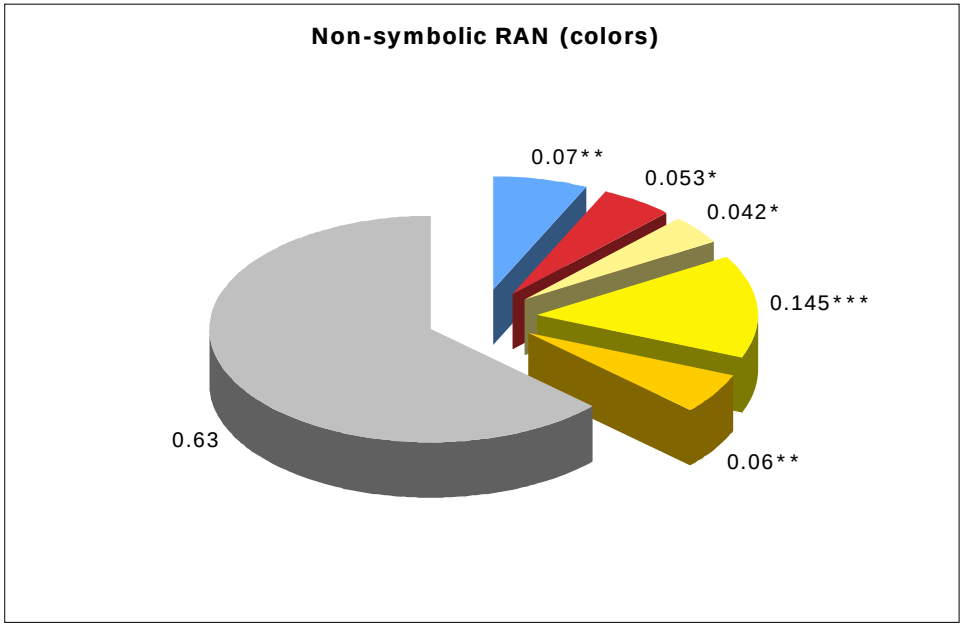
MAJOR FINDINGS:

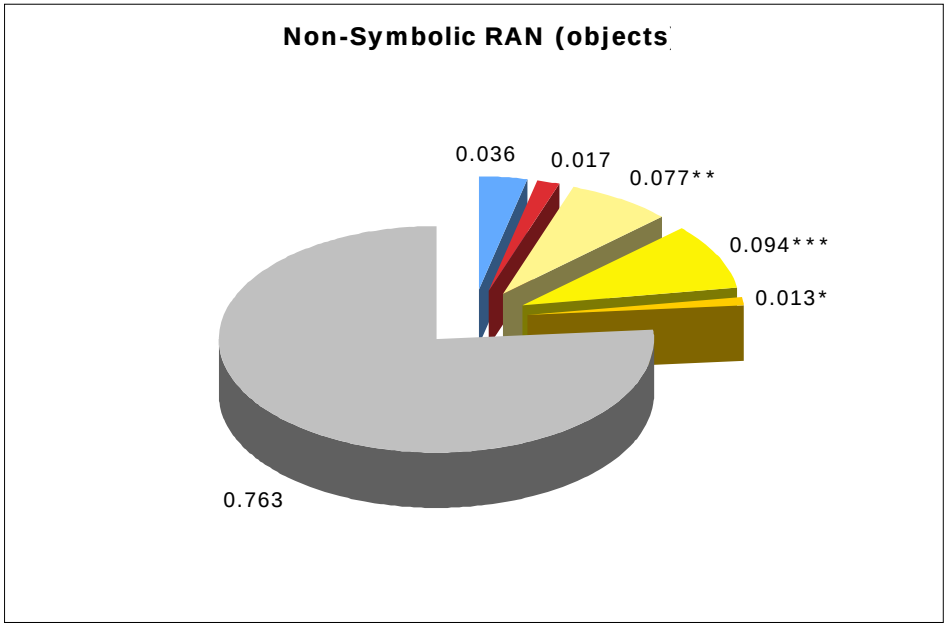
- Attention > Automaticity
- Symbolic RAN ≠ Non-symbolic RAN
- *r* (RAN, reading) = *f* (Attention Demand)


READING
RAN task performance
AUTOMATICITY:
ATTENTION:
Three experimental studies: N=68, N=16, & N=97
BALLISTIC AUTOMATICITY
EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
AUTOMATIC DETECTION EFFICIENCY
LEXICAL ACCESS EFFICIENCY
INDEX OF GENERAL ATTENTION
CONTROLLED SEARCH EFFICIENCY
WORKING MEMORY
ATTENTION SHIFT COST

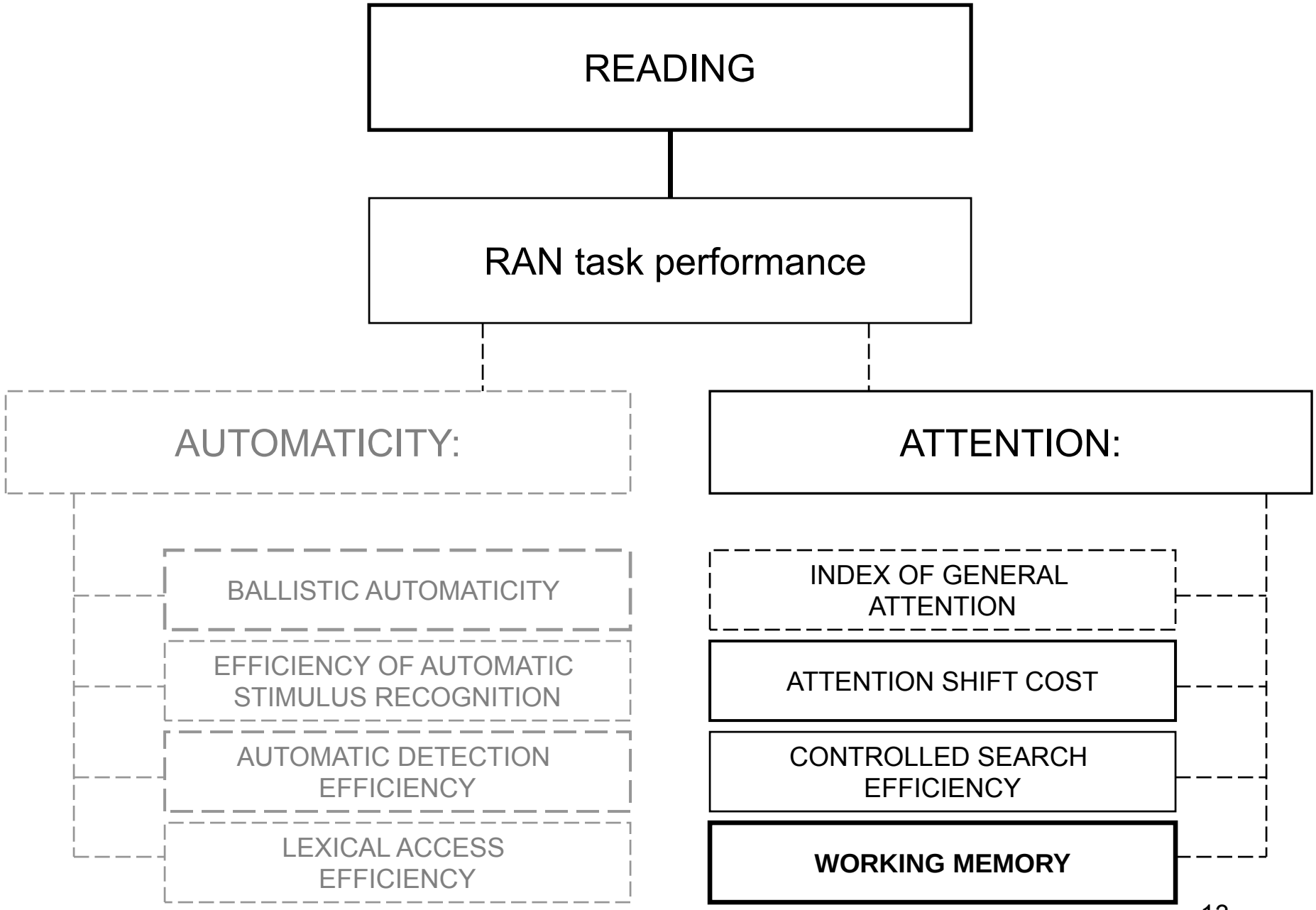








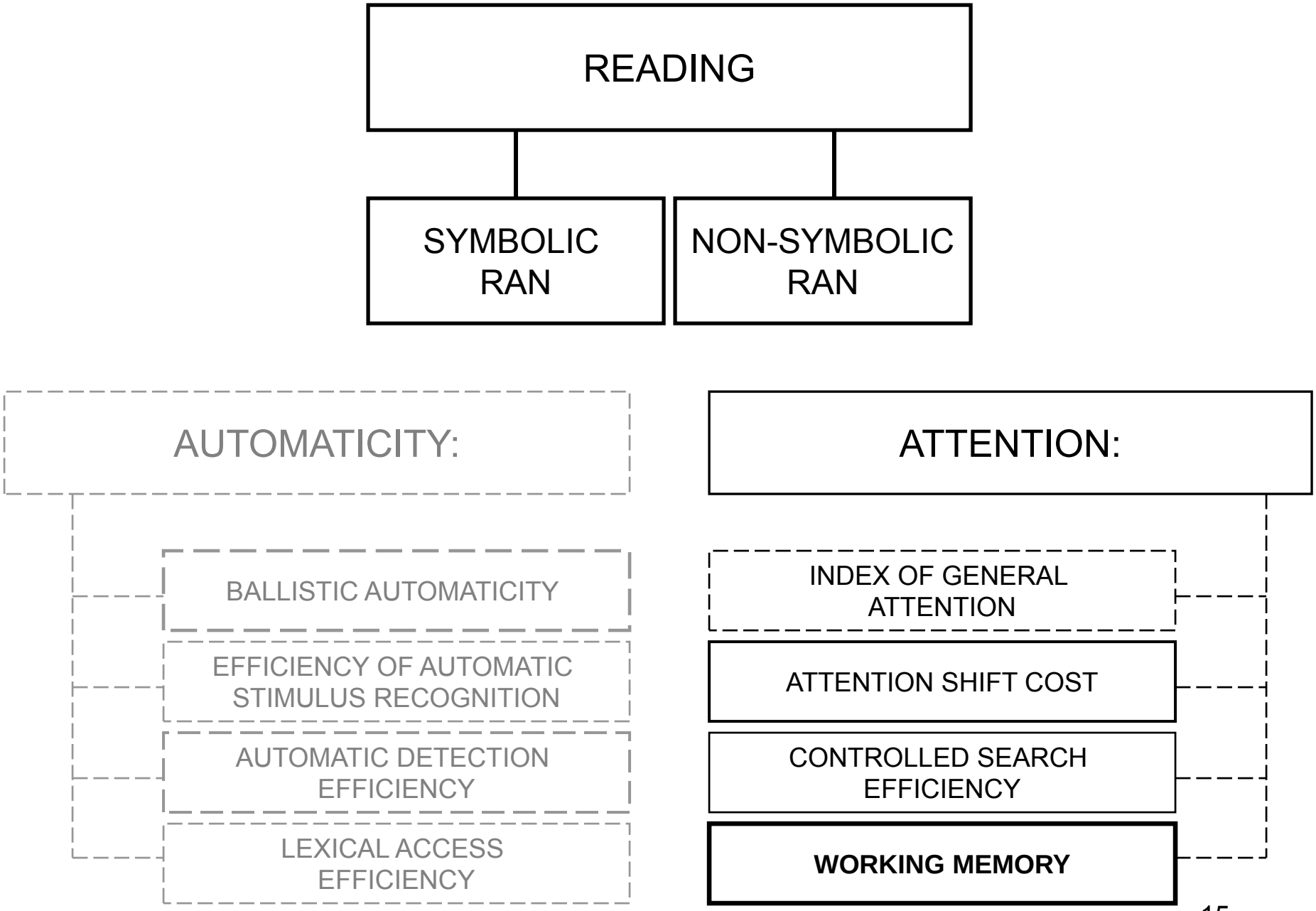
Aut o m a tic d ete c tio n
Lexic a l acces s
Co n trolle d searc h
W orking m e mory
A tten tion sh ift co st
U n explai n ed

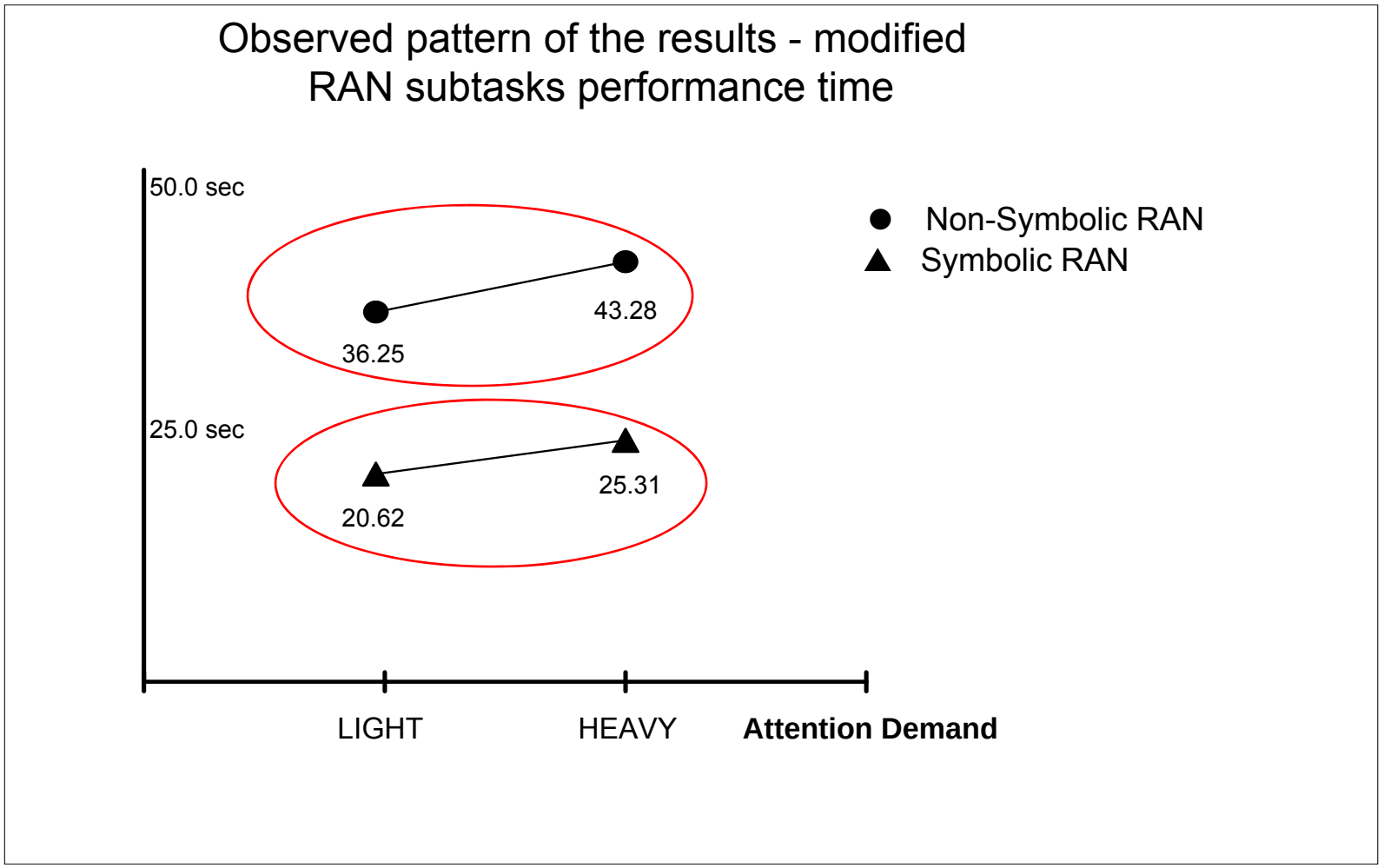

READING
RAN task performance
AUTOMATICITY:
ATTENTION:
BALLISTIC AUTOMATICITY
EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
AUTOMATIC DETECTION EFFICIENCY
LEXICAL ACCESS EFFICIENCY
INDEX OF GENERAL ATTENTION
ATTENTION SHIFT COST
CONTROLLED SEARCH EFFICIENCY
WORKING MEMORY

Major Research Questions

- **What should the "A" in RAN stand for?**
  Does RAN performance reflect automatic or attention-based processing?
  - Specifying and testing automaticity account
  - Exploring aspects of attention account
  - Estimating relative contributions of automaticity and attention-based processing to RAN task performance

- **How different are symbolic and non-symbolic RAN subtasks?**
  - In underlying cognitive mechanisms
  - In connection with different aspects of reading skills


READING
SYMBOLIC RAN
NON-SYMBOLIC RAN
AUTOMATICITY:
BALLISTIC AUTOMATICITY
EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
AUTOMATIC DETECTION EFFICIENCY
LEXICAL ACCESS EFFICIENCY
ATTENTION:
INDEX OF GENERAL ATTENTION
ATTENTION SHIFT COST
CONTROLLED SEARCH EFFICIENCY
WORKING MEMORY



Stimulus Type: $F(1, 95) = 910.2$, $p < .001$, partial $\eta^2 = .906$

READING

***r*-values: < .25 (1/8)**

SYMBOLIC RAN

NON-SYMBOLIC RAN

AUTOMATICITY:

- BALLISTIC AUTOMATICITY
- EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
- AUTOMATIC DETECTION EFFICIENCY
- LEXICAL ACCESS EFFICIENCY

ATTENTION:

- INDEX OF GENERAL ATTENTION
- ATTENTION SHIFT COST
- CONTROLLED SEARCH EFFICIENCY
- **WORKING MEMORY**

READING

r-values: < .25 (1/8)

***r*-values: ≤ .41 (3/8)**

SYMBOLIC RAN

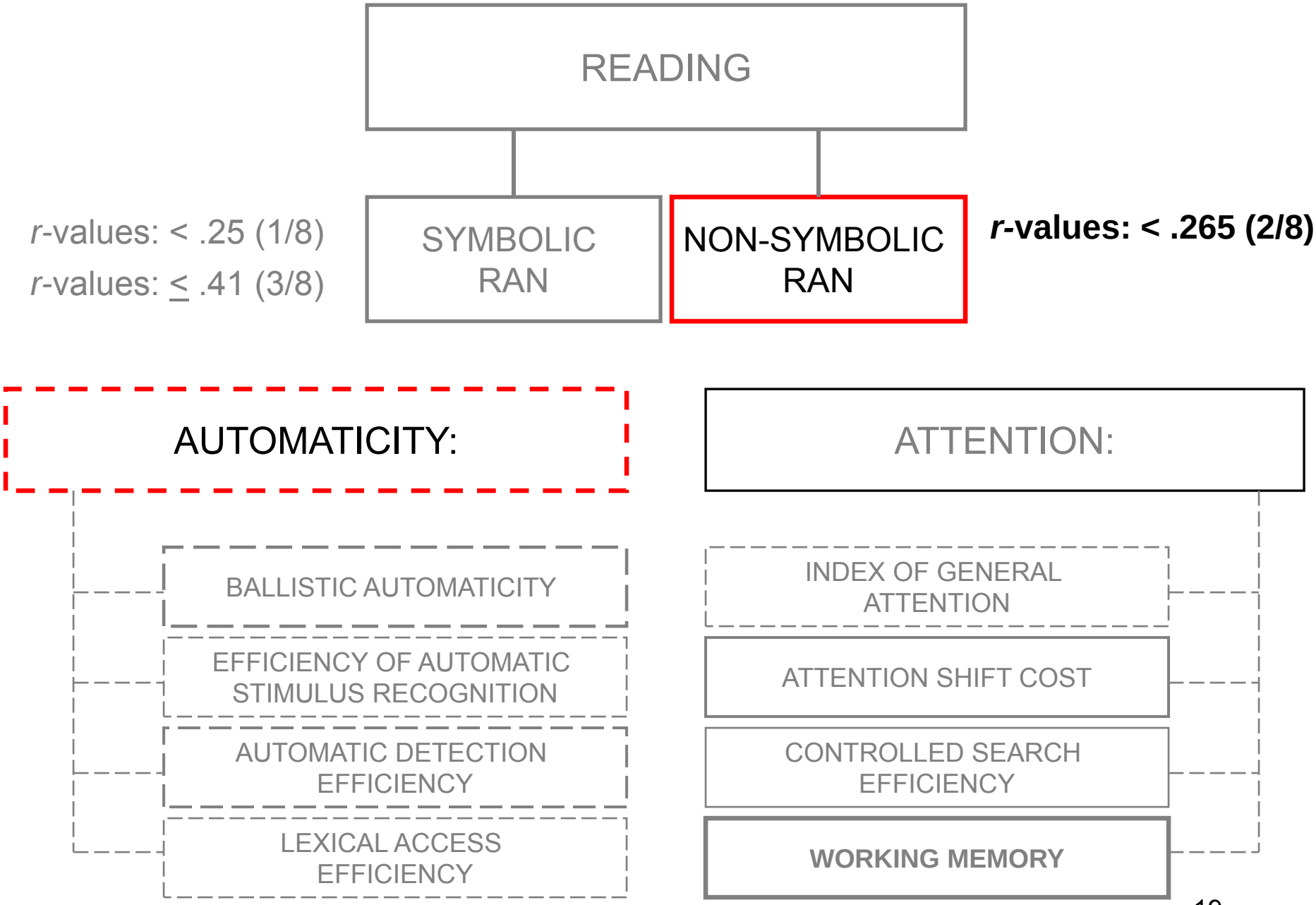
NON-SYMBOLIC RAN

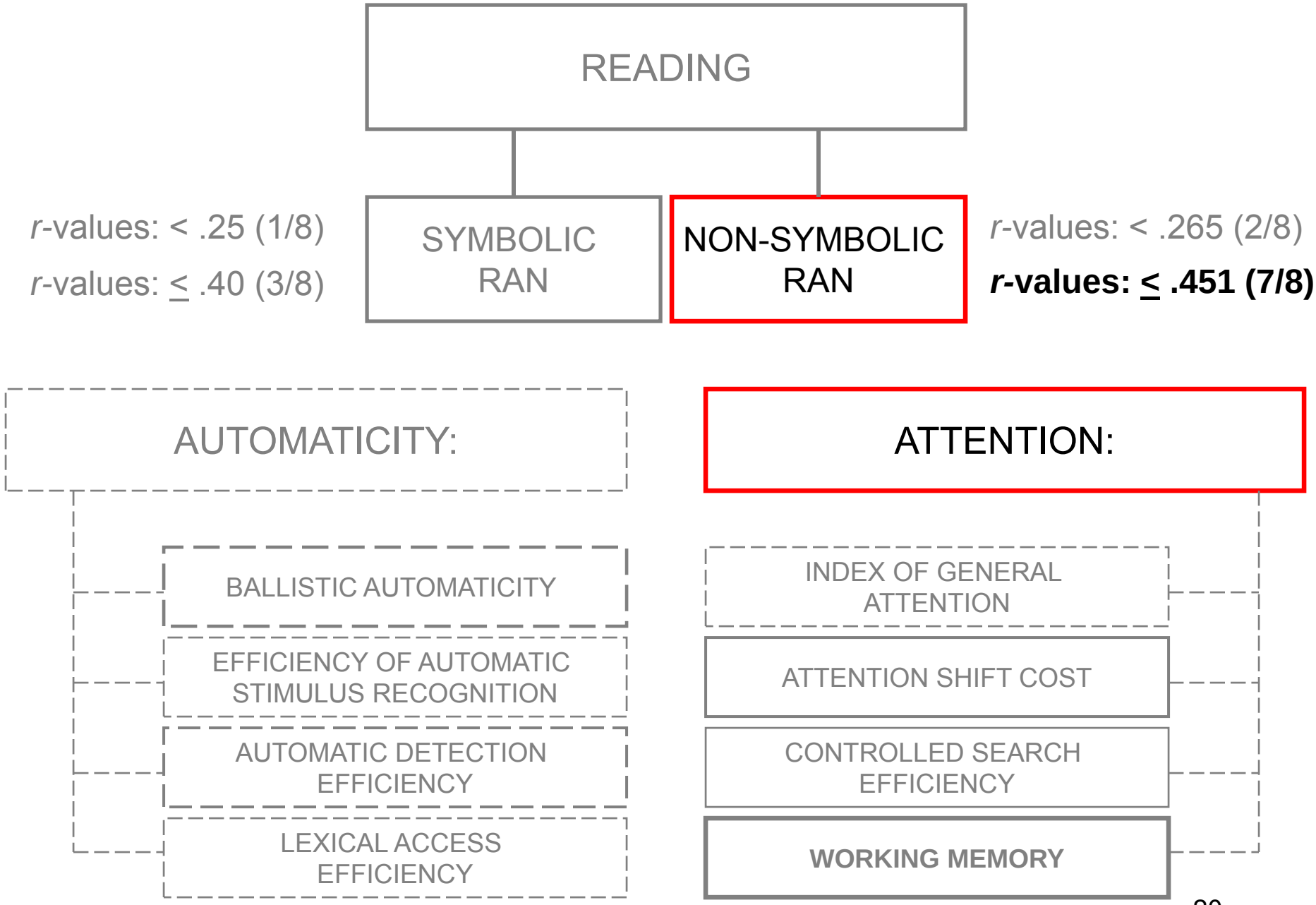
AUTOMATICITY:

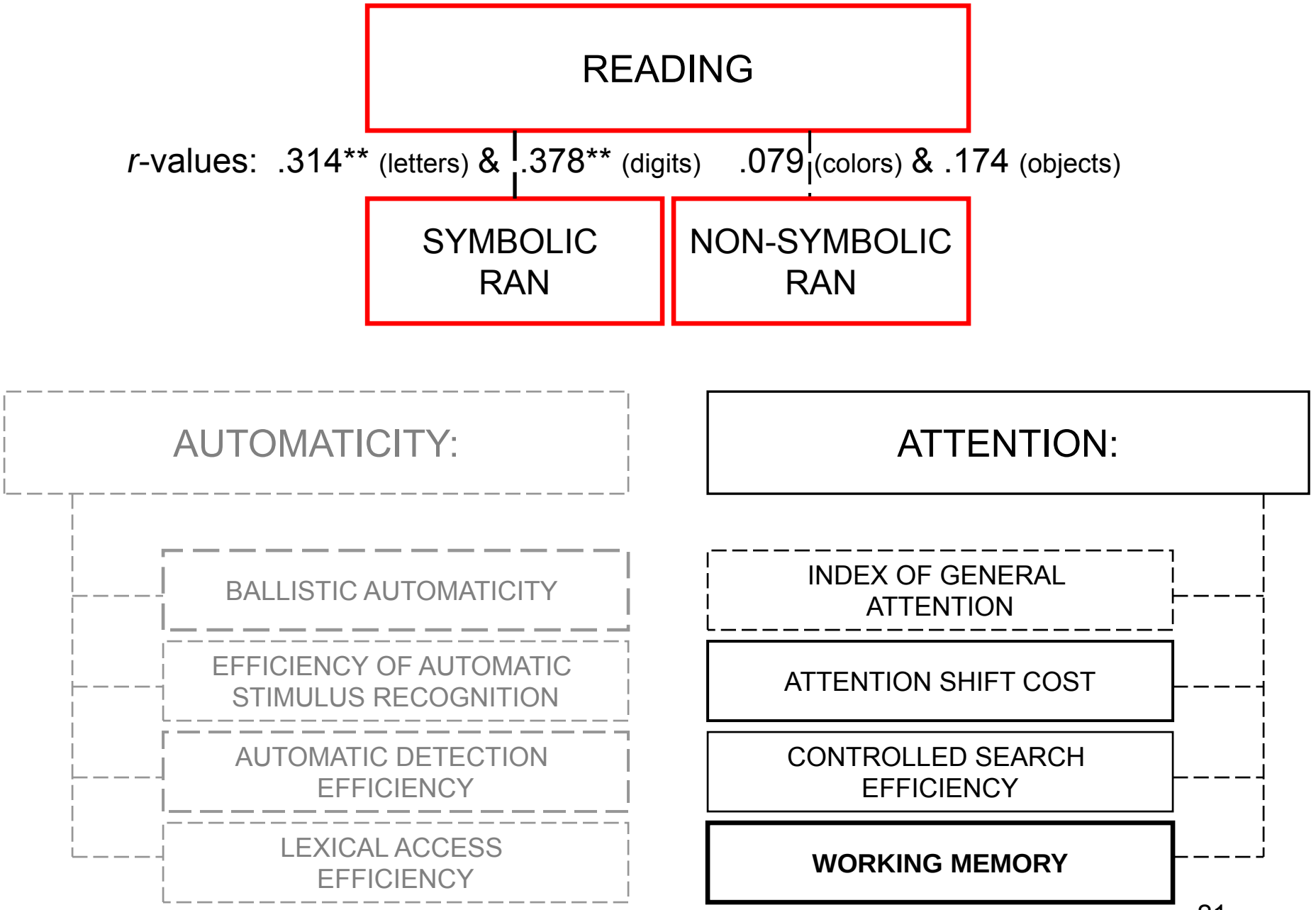
- BALLISTIC AUTOMATICITY
- EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
- AUTOMATIC DETECTION EFFICIENCY
- LEXICAL ACCESS EFFICIENCY

ATTENTION:

- INDEX OF GENERAL ATTENTION
- ATTENTION SHIFT COST
- CONTROLLED SEARCH EFFICIENCY
- **WORKING MEMORY**


READING
SYMBOLIC RAN
NON-SYMBOLIC RAN
r-values: < .25 (1/8)
r-values: ≤ .41 (3/8)
r-values: < .265 (2/8)
AUTOMATICITY:
BALLISTIC AUTOMATICITY
EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
AUTOMATIC DETECTION EFFICIENCY
LEXICAL ACCESS EFFICIENCY
ATTENTION:
INDEX OF GENERAL ATTENTION
ATTENTION SHIFT COST
CONTROLLED SEARCH EFFICIENCY
WORKING MEMORY


READING
SYMBOLIC RAN
NON-SYMBOLIC RAN
r-values: < .25 (1/8)
r-values: ≤ .40 (3/8)
r-values: < .265 (2/8)
r-values: ≤ .451 (7/8)
AUTOMATICITY:
BALLISTIC AUTOMATICITY
EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
AUTOMATIC DETECTION EFFICIENCY
LEXICAL ACCESS EFFICIENCY
ATTENTION:
INDEX OF GENERAL ATTENTION
ATTENTION SHIFT COST
CONTROLLED SEARCH EFFICIENCY
WORKING MEMORY


READING
r-values: .314** (letters) & .378** (digits) .079 (colors) & .174 (objects)
SYMBOLIC RAN
NON-SYMBOLIC RAN
AUTOMATICITY:
BALLISTIC AUTOMATICITY
EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
AUTOMATIC DETECTION EFFICIENCY
LEXICAL ACCESS EFFICIENCY
ATTENTION:
INDEX OF GENERAL ATTENTION
ATTENTION SHIFT COST
CONTROLLED SEARCH EFFICIENCY
WORKING MEMORY

READING RATE

READING COMPREHENSION

r-values: **.389*** & .402*****

SYMBOLIC RAN

NON-SYMBOLIC RAN

AUTOMATICITY:

- BALLISTIC AUTOMATICITY
- EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
- AUTOMATIC DETECTION EFFICIENCY
- LEXICAL ACCESS EFFICIENCY

ATTENTION:

- INDEX OF GENERAL ATTENTION
- ATTENTION SHIFT COST
- CONTROLLED SEARCH EFFICIENCY
- **WORKING MEMORY**

READING RATE

READING COMPREHENSION

r-values: .389*** & .402*** **.138 & .128**

SYMBOLIC RAN

NON-SYMBOLIC RAN

AUTOMATICITY:

- BALLISTIC AUTOMATICITY
- EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
- AUTOMATIC DETECTION EFFICIENCY
- LEXICAL ACCESS EFFICIENCY

ATTENTION:

- INDEX OF GENERAL ATTENTION
- ATTENTION SHIFT COST
- CONTROLLED SEARCH EFFICIENCY
- **WORKING MEMORY**

READING RATE

READING COMPREHENSION

r-values: **.307** & .187**

SYMBOLIC RAN

NON-SYMBOLIC RAN

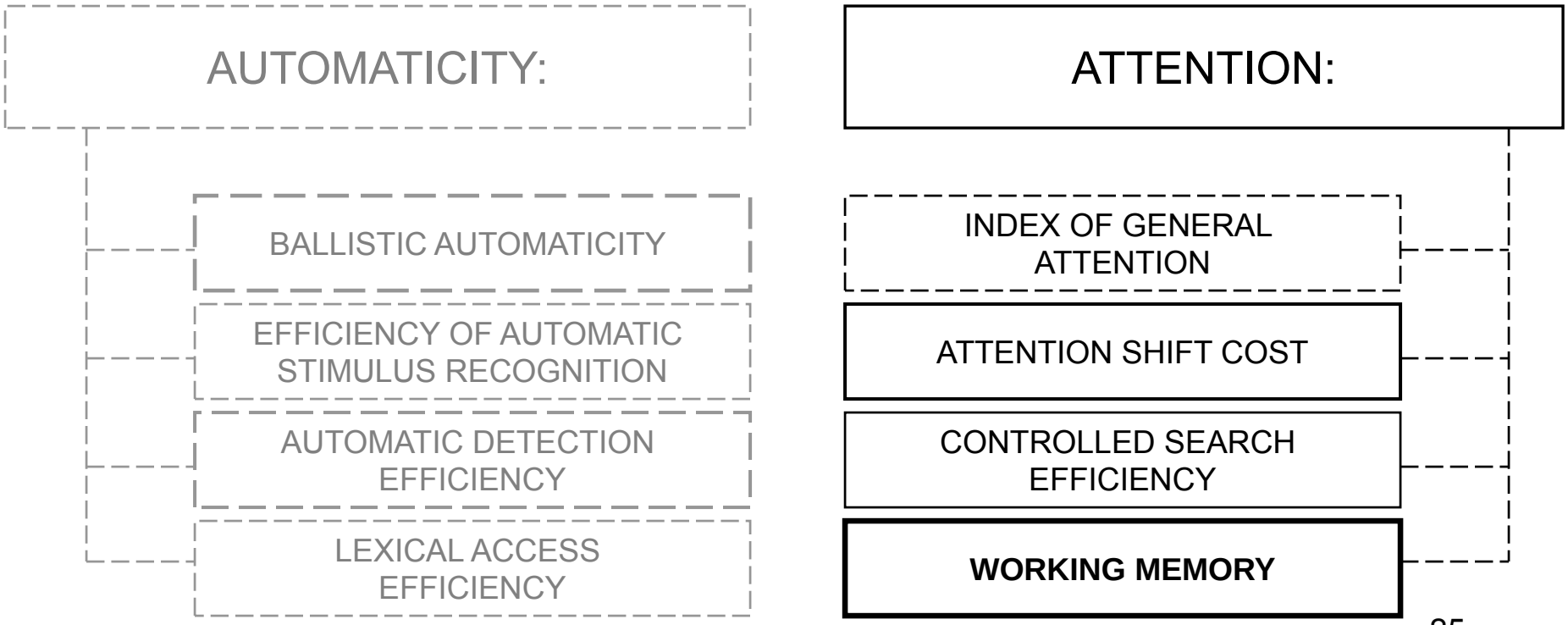
AUTOMATICITY:

- BALLISTIC AUTOMATICITY
- EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
- AUTOMATIC DETECTION EFFICIENCY
- LEXICAL ACCESS EFFICIENCY

ATTENTION:

- INDEX OF GENERAL ATTENTION
- ATTENTION SHIFT COST
- CONTROLLED SEARCH EFFICIENCY
- **WORKING MEMORY**

	READING RATE	READING COMPREHENSION
r-values:	.307** & .187	**.259* & .155**
	SYMBOLIC RAN	NON-SYMBOLIC RAN



READING RATE

READING COMPREHENSION

r-values: .180* - .415*** (4/4) .229** - .368*** (4/4)

MODIFIED RAN (M-RAN-HEAVY)

AUTOMATICITY:

- BALLISTIC AUTOMATICITY
- EFFICIENCY OF AUTOMATIC STIMULUS RECOGNITION
- AUTOMATIC DETECTION EFFICIENCY
- LEXICAL ACCESS EFFICIENCY

ATTENTION:

- INDEX OF GENERAL ATTENTION
- ATTENTION SHIFT COST
- CONTROLLED SEARCH EFFICIENCY
- **WORKING MEMORY**

META-ANALYSIS:

Summarizing empirical evidence of RAN-to-reading association

- What is the point estimate (an average effect size) of the degree of association between the RAN task and reading?
- What factors (methodological and substantive study features) affect (increase or reduce) the strength of this association and to what extent?
- What is known from previous meta-analytical research?
- Swanson et al. (2003)

  RAN/Word Reading: $r+ = .49$

  RAN/Reading Comprehension: $r+ = .53$
- Hammill (2004)

  RAN/Reading: $r+ = .44$
- RAN definition & selection of Study Features

META-ANALYSIS:

Summarizing empirical evidence of RAN-to-reading association

- Searches (1976 - 2006): **735** studies

  ("RAN"/"rapid naming"/"automatized naming"/"serial naming"/"naming speed") & ("literacy", "read", "dyslex*")*

  PSYCInfo, PubMed, ERIC, ProQuest Dissertations and Theses & branching

- Inclusion/Exclusion review:

  N-NSM – study contains no naming speed measure

  N-RPM – study contains no measure of reading performance

  N-PER – not a primary empirical research study

  N-MDA – study does not report any measure of degree of association between RAN & reading

- Inter-rater agreement:

  Abstract review – 92.65 % (r = 0.852, p < 0.01)

  Full-text review – 93.33 % (r = 0.846, p < 0.01)

  Number and selection of the effect sizes (on a selected sample) – 93.18 %

  Study Features coding (on a selected sample) – 89.09 %.

META-ANALYSIS:

Summarizing empirical evidence of RAN-to-reading association

- Effect Size: Weighted Pearson product-moment correlation coefficients (*r*)
- Cross-sectional studies
- Longitudinal studies
- Study Features:

  Type of RAN task: Symbolic / Non-symbolic

  Type of reading measure:

  Decoding / Word reading / Reading rate / Reading comprehension / Vocabulary / Spelling / Orthography / Composite

  Participants' age:

  Kindergarten / Elementary school / Secondary school / Adolescents / Adults / Mixed groups

  Dominant language:

  English / Romance-Germanic family / Not alphabet based / Fluent bilinguals

  Reading abilities:

  Dyslexia / Learning disabilities / Age-adequate / Mixed groups

  Time lag: Within a year / Several years longitudinal

META-ANALYSIS:

Summarizing data on RAN-to-reading association

- A representative sample of 65 empirical studies reporting RAN-to-reading correlations
- Cross-sectional design: *k* = 422, N = 6495, *r*+ = .345
- Longitudinal design: *k* = 108, N = 2060, *r*+ = .398
- Predictive power of RAN
- Symbolic RAN subtasks are more consistently associated with speed-dependent aspects of reading
- Non-symbolic RAN subtasks are primarily connected to rule-based and comprehension-oriented aspects of reading
- Efficient attention management

META-ANALYSIS:

Summarizing data on RAN-to-reading association

RESULTS (Cross-sectional design):

Effect size (*r*+) for the overall RAN-to-reading association

Model:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Fixed	422	0.345	0.334	0.355	58.861***
Random	422	0.350	0.334	0.367	38.210***

*** $p < .001$

Heterogeneity analysis (*Q* and I^2) for the overall RAN-to-reading association

RAN Ğreading *r*	*k*	Heterogeneity			
		Q-value	Df (Q)	*p*	I-squared
Total:	422	890.713	421	< 0.001	52.735

META-ANALYSIS:

Summarizing data on RAN-to-reading association

RESULTS (Longitudinal design):

Effect size ($r+$) for the overall RAN-to-reading association

Model:	k	Effect size	95% confidence interval		Test of null
		$r+$	Lower limit	Upper limit	Z-value
Fixed	108	0.398	0.373	0.422	28.250***
Random	108	0.394	0.360	0.426	20.819***

*** $p < .001$

Heterogeneity analysis (Q and I^2) for the overall RAN-to-reading association

RAN Ğreading $r+$	k	Heterogeneity			
		Q-value	Df (Q)	p	I-squared
Total:	108	149.175	107	0.004	28.272

Effect size (*r*+) of RAN-to-reading association for RAN type / reading measure type interactions (cross-sectional design)

RAN type X Type of reading measure:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Symbolic RAN X Decoding skills	**65**	**0.384**	**0.357**	**0.410**	**25.377*** **
Symbolic RAN X Word reading	95	0.438	0.416	0.461	33.164***
Symbolic RAN X Reading rate	**20**	**0.438**	**0.380**	**0.492**	**13.272*** **
Symbolic RAN X Comprehension	**44**	**0.396**	**0.362**	**0.429**	**20.505*** **
Symbolic RAN X Vocabulary	25	0.091	0.038	0.142	3.399**
Symbolic RAN X Orthography	**11**	**0.407**	**0.320**	**0.487**	**8.411*** **
Symbolic RAN X Spelling	18	0.270	0.228	0.311	12.085***
Non-symbolic RAN X Decoding	**24**	**0.302**	**0.261**	**0.342**	**13.680*** **
Non-symbolic RAN X Word reading	37	0.321	0.282	0.358	15.404***
Non-symbolic RAN X Reading rate	10	0.319	0.216	0.415	5.814***
Non-symbolic RAN X Comprehension	**18**	**0.341**	**0.285**	**0.396**	**11.070*** **
Non-symbolic RAN X Vocabulary	**11**	**0.244**	**0.188**	**0.299**	**8.249*** **
Overall»	422 »	0.345	0.334	0.355	58.861***

** $p < .01$ & *** $p < .001$

»*Note: only interactions with k ≥ 10 are included into the table*

Effect size (*r+*) of RAN-to-reading association for RAN type / reading measure type interactions (longitudinal design)

RAN type X Type of reading measure:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Symbolic RAN X Decoding skills	**14**	**0.445**	**0.344**	**0.537**	**7.781*** **
Symbolic RAN X Word reading	14	0.537	0.495	0.577	20.391***
Symbolic RAN X Reading rate	**18**	**0.470**	**0.273**	**0.629**	**4.349*** **
Symbolic RAN X Comprehension	**21**	**0.355**	**0.266**	**0.438**	**7.392*** **
Symbolic RAN X Vocabulary knowledge	1	0.020	-0.302	0.388	0.118
Symbolic RAN X Orthographic skills	2	0.523	0.303	0.690	4.256***
Non-symbolic RAN X Decoding	9	0.261	0.180	0.338	6.136***
Non-symbolic RAN X Word reading	10	0.343	0.274	0.408	9.229***
Non-symbolic RAN X Reading rate	4	0.357	0.230	0.472	5.247***
Non-symbolic RAN X Comprehension	8	0.324	0.256	0.389	8.884***
Non-symbolic RAN X Orthography	4	0.318	0.215	0.413	5.823***
Mixed RAN X Decoding skills	1	0.530	0.356	0.668	5.317***
Mixed RAN X Composite index	2	0.473	0.208	0.674	3.321**
Overall[a]	108	0.398	0.373	0.422	28.250***

** $p < .01$ & *** $p < .001$

META-ANALYSIS:

Summarizing data on RAN-to-reading association

RESULTS (Cross-sectional design):

Moderator variable:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Kindergarteners	**41**	**0.329**	**0.294**	**0.362**	**17.623*** **
Secondary school students	**22**	**0.359**	**0.302**	**0.413**	**11.514*** **
Other (Romance-Germanic) with more transparent phonemic structure	**33**	**0.349**	**0.313**	**0.384**	**17.526*** **
Other languages (e.g., Japanese etc.)	**30**	**0.303**	**0.262**	**0.343**	**13.786*** **

*** $p < .001$

META-ANALYSIS:

Summarizing data on RAN-to-reading association

RESULTS (Longitudinal design):

Moderator variable:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Kindergarteners	**46**	**0.348**	**0.315**	**0.380**	**19.452*** **
Elementary school students	**62**	**0.480**	**0.373**	**0.422**	**21.127*** **
Other from Romance-Germanic group with more transparent phonemic structure	8	0.368	0.303	0.429	10.328***
Longer than a year	**88**	**0.359**	**0.327**	**0.391**	**20.286*** **
Reading impaired (dyslexics)	**43**	**0.423**	**0.347**	**0.493**	**9.967*** **

*** $p < .001$

MAJOR FINDINGS:

- Attention > Automaticity
- Symbolic RAN ≠ Non-symbolic RAN
- *r* (RAN, reading) = *f* (Attention Demand)

IMPLICATIONS

- **Applied value of RAN**
- **Selectivity in use**
- **Potential for increased efficiency**
- **Attention to practice**
- **Attention to attention**
- **Cognitive complexity**
- **Further research**

Acknowledgment:

Guy Lacroix
Michael Von Grunau
Roberto de Almeida
Rick Gurnsey
Irene O`Brien
Marlene Taube-Schiff
Talia Grumberg
Christina Tapler
Anna Peretiatcowitz
Anne-Marie Linnen
Adam Christian
Alla Sorokin

Concordia
UNIVERSITY

CSLP/CEAP
CENTRE FOR THE STUDY OF LEARNING AND PERFORMANCE
CENTRE D'ÉTUDES SUR L'APPRENTISSAGE ET LA PERFORMANCE

Fonds de recherche
sur la société
et la culture
Québec

NSERC
CRSNG

CONTACT: *eborokhovski@education.concordia.ca*)


THANK YOU!

Table 6.6a. Effect size (*r*+) of RAN-to-reading association by languages (cross-sectional design)

Language:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
English	330	0.355	0.344	0.367	54.575***
Other (Romance-Germanic) with more transparent phonemic structure	**33**	**0.349**	**0.313**	**0.384**	**17.526*** **
Other languages (e.g., Japanese etc.)	**30**	**0.303**	**0.262**	**0.343**	**13.786*** **
Bilinguals	29	0.173	0.112	0.233	5.478*
Overall	422	0.345	0.334	0.355	58.861***

* $p < .05$ & *** $p < .001$

Table 6.7a. Effect size (*r*+) of RAN-to-reading association by population type (cross-sectional design)

Population type:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Reading impaired (dyslexics)	140	0.355	0.338	0.371	39.408***
Normal (age adequate) readers	179	0.349	0.332	0.366	36.625***
Mixed (age adequate and impaired readers together)	93	0.336	0.310	0.361	23.690***
Readers with learning (but not reading) problems	10	0.196	0.129	0.261	5.690***
Overall	422	0.345	0.334	0.355	58.861***

*** $p < .001$

Table 6.2a. Effect size (*r*+) of RAN-to-reading association for each type of RAN (cross-sectional design)

Type of RAN:	*K*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Symbolic RAN	279	0.371	0.358	0.385	49.174***
Non-symbolic RAN	**119**	**0.292**	**0.272**	**0.313**	**26.585*** **
Mixed measures	24	0.335	0.304	0.366	19.522***
Overall	422	0.345	0.334	0.355	58.861***

*** $p < .001$

Table 6.9a. Effect size (*r*+) of RAN-to-reading association for each type of RAN (longitudinal design)

Type of RAN:	*k*	Effect size	95% confidence interval		Test of null
		r+	Lower limit	Upper limit	Z-value
Symbolic RAN	**70**	**0.481**	**0.446**	**0.514**	**23.292*** **
Non-symbolic RAN	**35**	**0.318**	**0.281**	**0.353**	**16.131*** **
Mixed measures	3	0.511	0.369	0.630	6.256***
Overall	108	0.398	0.373	0.422	28.250***

*** $p < .001$