Early identification and prevention of problems in read acquisition

Highlights from the Jyväskylä Longitudinal study of Dyslexia (JLD) & the Grapholearn Initiative

Heikki Lyytinen, Unesco Chair/professor
Agora Human Technology Center & Department of Psychology, University of Jyväskylä &
Niilo Mäki Institute, Jyväskylä, Finland

La School, Chile, 11. March, 2015

Important facts about reading acquisition

- Reading acquisition = learning to connect a spoken language to its written forms
- Written languages (orthographies) vary in terms of how this connection-building can be made
- Alphabetic orthographies such as Finnish, Spanish and most African languages are **consistent** at grapheme-phoneme level
- There are no challenges associated with choosing the items which had to be connected from spoken to written

Reading acquisition and the consistency of the connections between spoken and written

- If the reading instruction is organized optimally the time child needs for the acquisition of the basic reading skill is the shorter
  - the more consistent the connections are because no complexities/alternatives need to be learned
  - the smaller the number of connections one has to learn

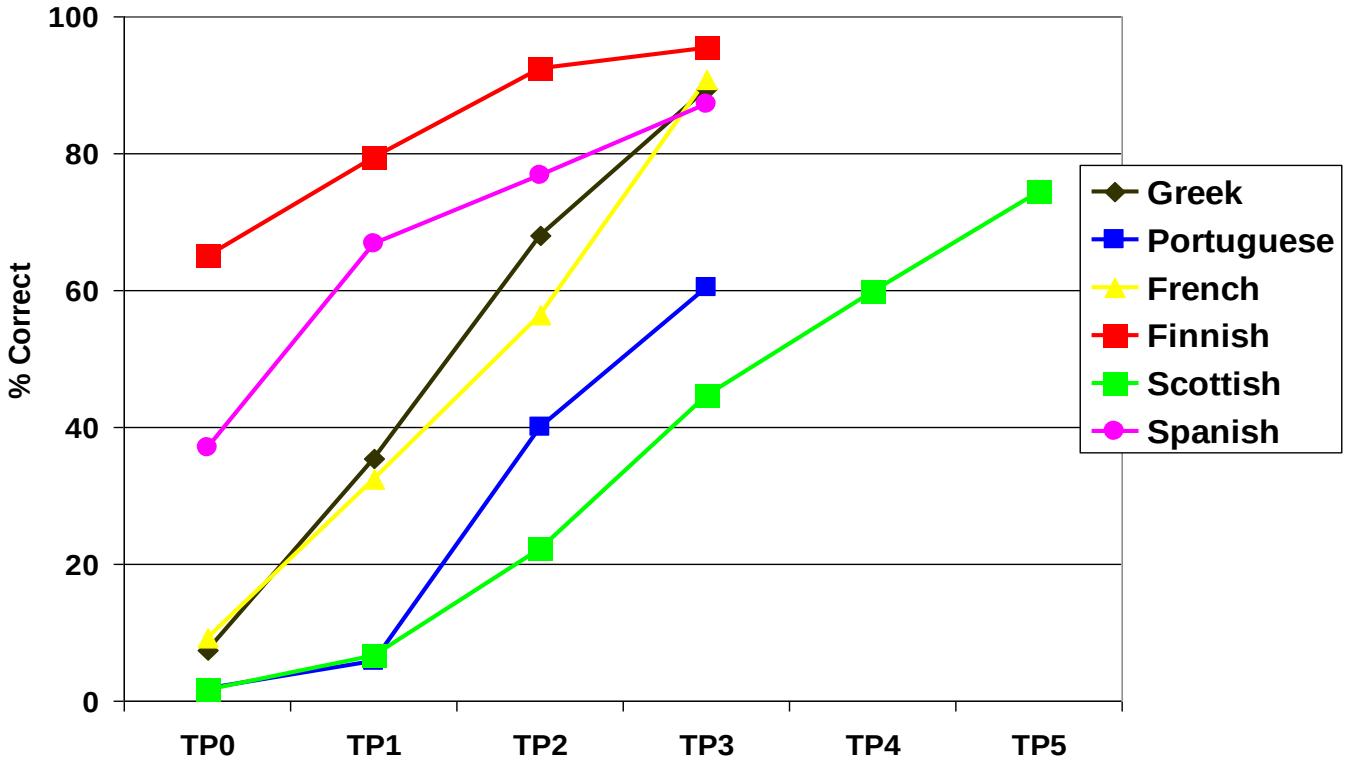
The consistency of the writing system

- In writing systems such as that of Finnish, Spanish and African languages
  - the connections are mostly **symmetrically consistent at grapheme-phoneme level**,

    ie. each letter (or two letter grapheme) represents only one phoneme and each phoneme has only one grapheme representing it; thus the connection building is 1 to 1, consistent to both reading and writing directions
  - therefore also the number of connections is small (mostly less than 30, ie.the number of phonemes)

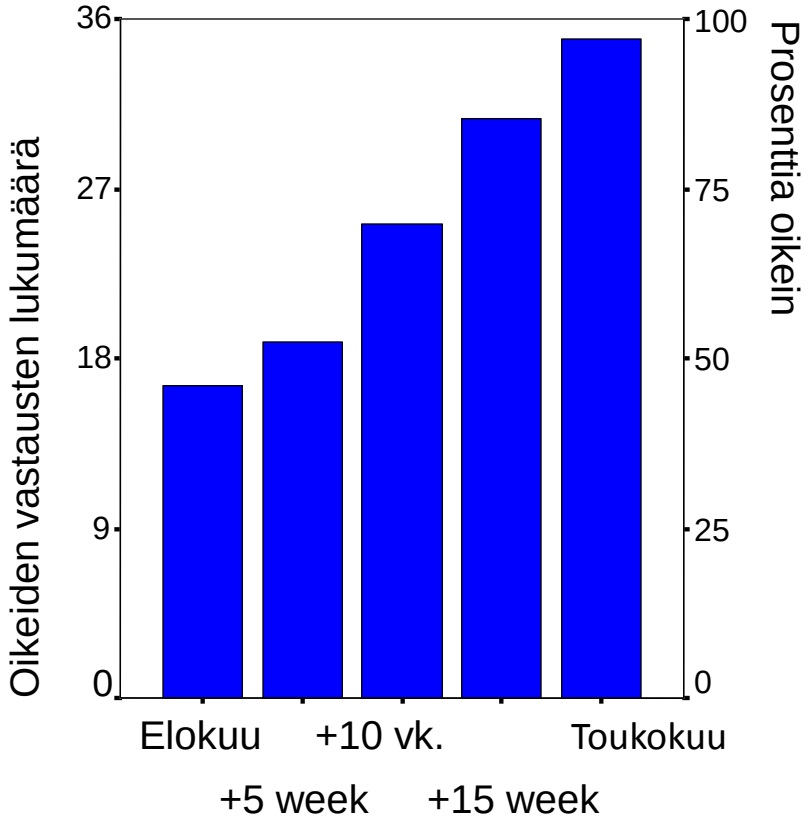
Development of Nonword Reading accuracy during 1st Grade

(Scottish data up to 2nd grade)

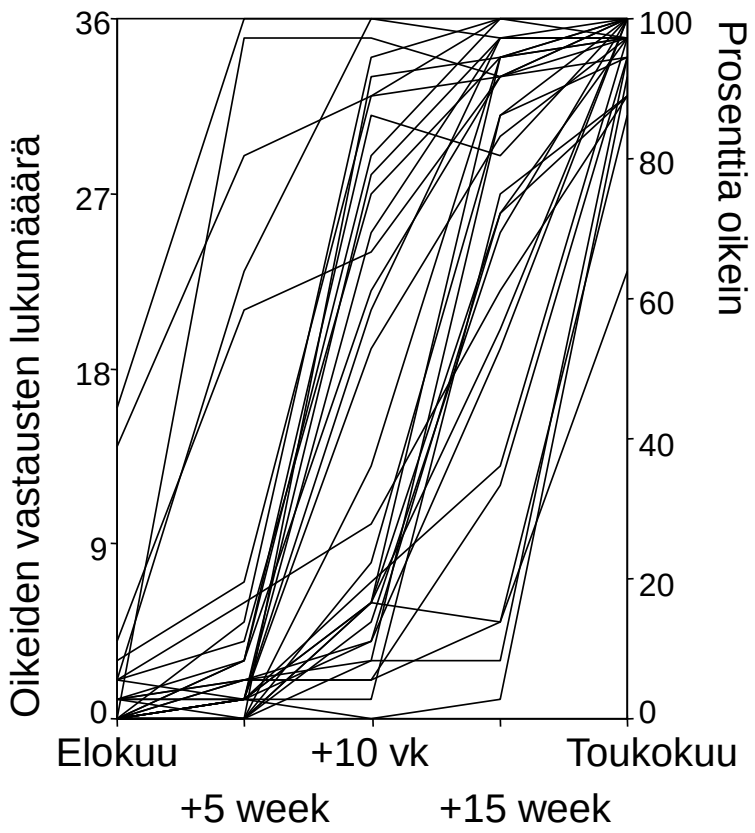


COST A8 results, 1998

The development of reading accuracy (% correct) during the 1. grade in Finland



The average development



Individual development

Aro et al., 2004

Globally 780 000 000 people are illiterate

- Biologic, educational and social problems

Jyväskylä Longitudinal study of Dyslexia (JLD) & Graphogame – our tool for the prevention of RDs

The Jyväskylä Longitudinal study of Dyslexia (JLD):

An intensive follow-up of children at familial risk for dyslexia from birth

> JLD 1994-

*Mikko Aro, *Timo Ahonen, Kenneth Eklund, Tomi Guttorm, *Leena Holopainen, Jarmo Hämäläinen, Ritva Ketonen, *Marja-Leena Laakso, Seija Leinonen, *Paavo Leppänen, ^Matti Leiwo, *Marja-Kristiina Lerkkanen, Kaisa Lohvansuu, ^Paula Lyytinen, Anna-Maija Oksanen, Kurt Muller, *Anna-Maija Poikkeus, Anne Puolakanaho, *Ulla Richardson, Paula Salmi, *Asko Tolvanen, *Minna Torppa, Helena Viholainen

> Graphogame (in Finland)

Ekapeli/Graphogame (ks.www.lukimat.fi; www.graphogame.com): Mikko Aro, Jane Erskine, Riikka Heikkilä, Sini Hintikka (Huemer), Ritva Ketonen, Janne Kujala, Emma Ojanen, Mikko Pitkänen, Miia Ronimus, Niina Saine, **Ulla Richardson**
Learning game programmers: Iivo Kapanen, Ville Mönkkönen, Miika Pekkarinen

Supported by EU,Niilo Mäki Foundation,The Academy of Finland,Univ.of Jyväskylä ,Tekes, RAY, Ministries of Education & Foreign Affairs Finland, NokiaOy,KoneOy, WärtsiläOy, Kela,The Finnish Cultural Funds

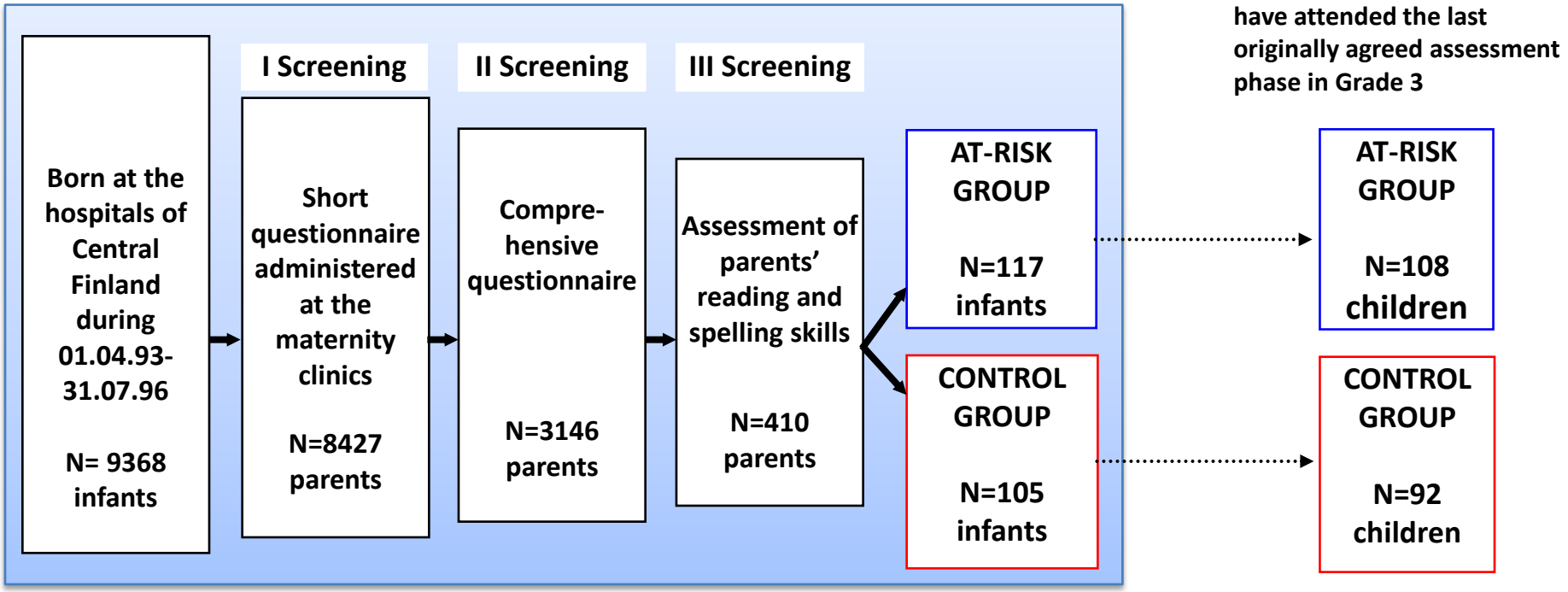
The goals of the JLD following children with familial risk for dyslexia from birth

to identify (from children at familial risk for dyslexia)

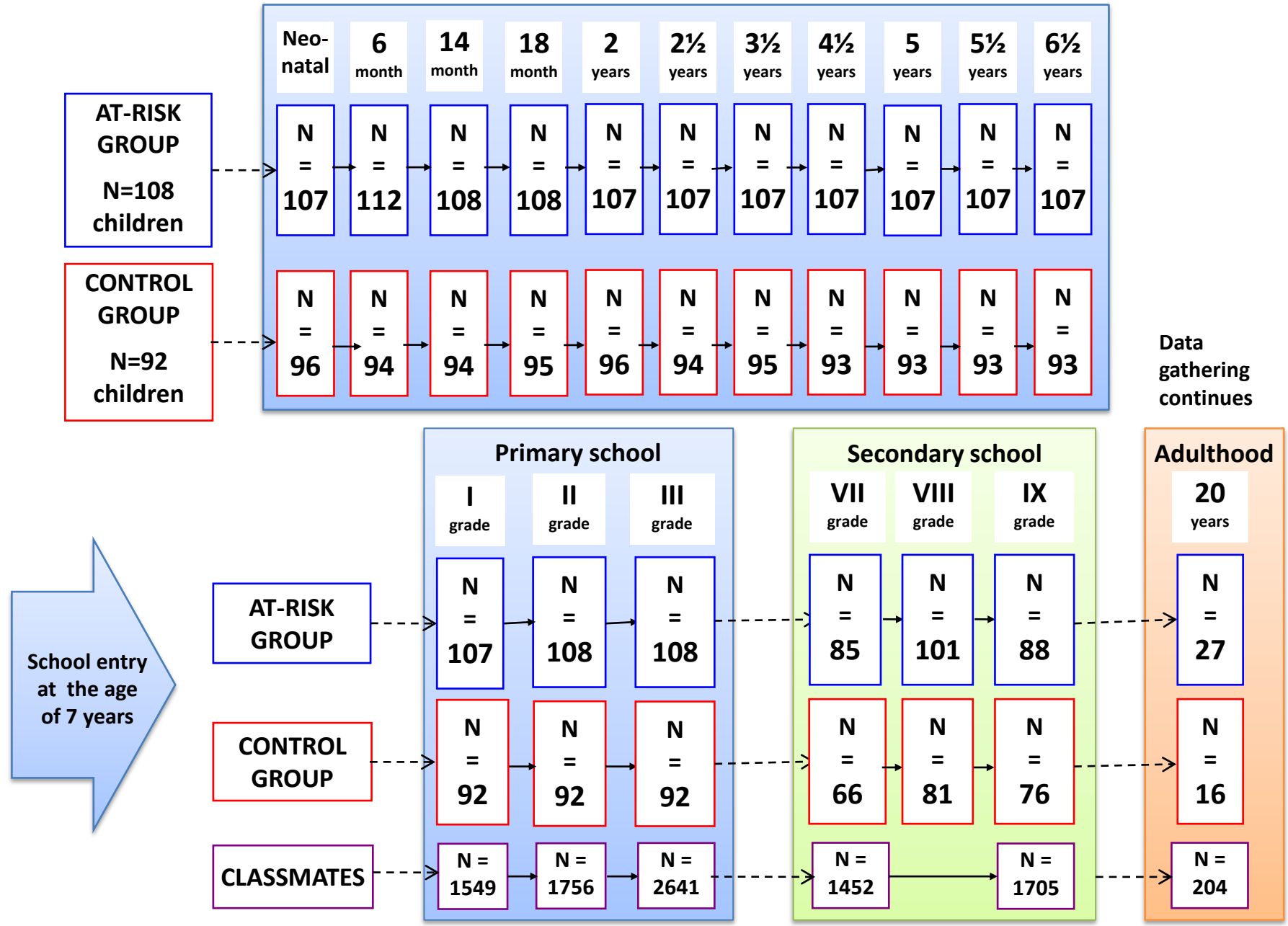
- **precursors of dyslexia**
- **predictors of compromised acquisition**
- **developmental paths leading to dyslexia**

The last step: the development of preventive measures

SCREENING OF THE FAMILIES



PHASES OF ASSESSMENTS



CRITERIA FOR DYSLEXIA

A child was considered to have dyslexia in Grade 8**, if she / he scored below the 10th percentile of Control group's performance in reading speed in at least two out of the three following tasks**:

1. Word list reading
2. Text reading
3. Pseudo word text reading

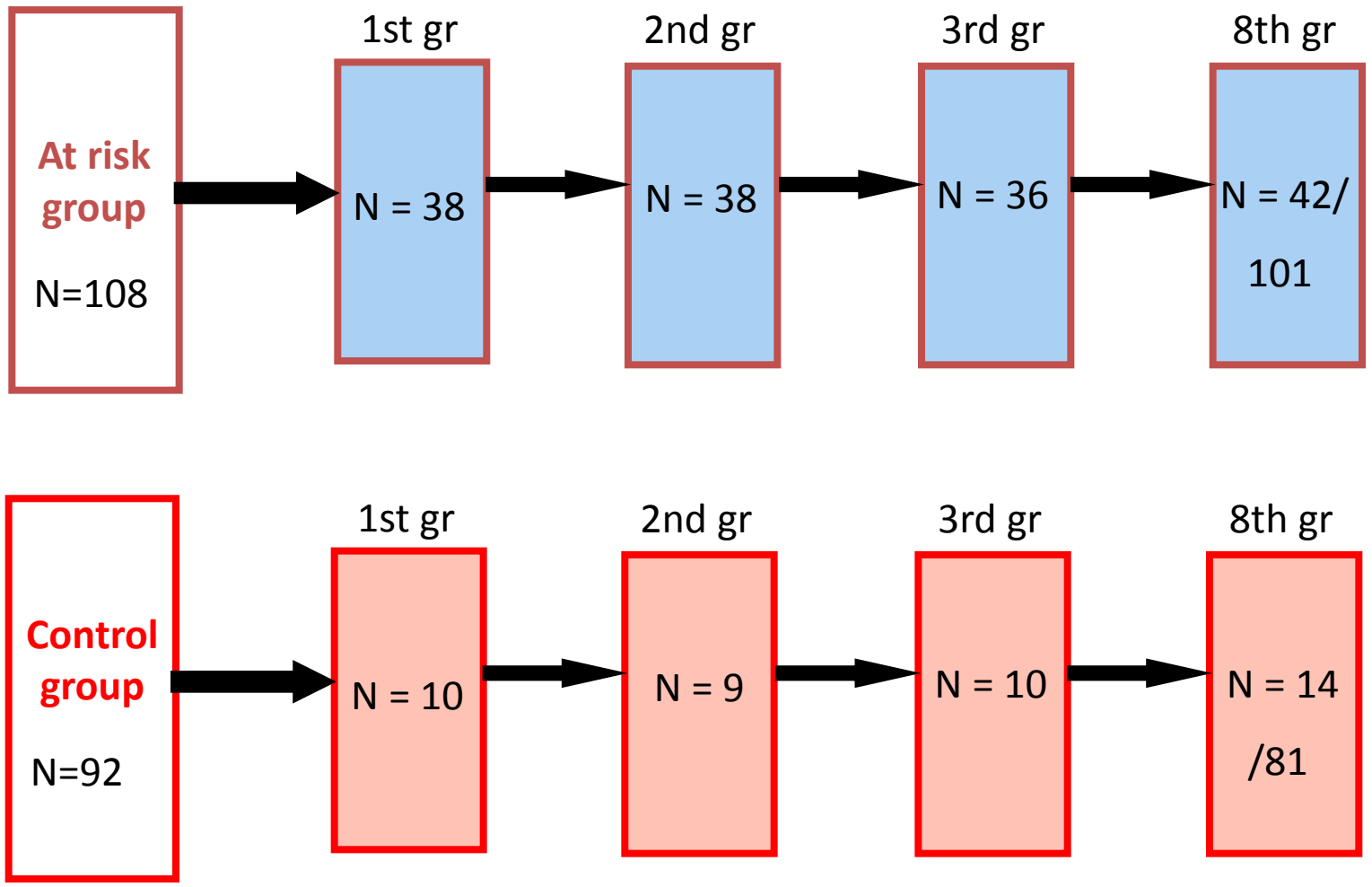
Altogether 185 children from the original sample (200) were reached in Grade 8. They were classified into four groups according to the criteria as follows:

1. At-risk with dyslexia, N = 33
2. At-risk with NO dyslexia, N = 68
3. Controls with NO dyslexia, N = 77
4. Controls with dyslexia, N = 7 (not included in the following analyses)

The reading status of children born at familial risk for dyslexia at school age

- **Expectation when one parent with dyslexia:**
  - > 1/2 of the children affected
- **The observed result: 42 / 108**
  - compromised initial reading acquisition 38 / 108; in 2.gr. >4x and in 8 gr. 3x compared to controls
  - persistent reading problems 42 / 101

Children with reading disability



SPEECH PERCEPTION, COMPREHENSION,PRODUCTION

- Auditory discrimination
- Phonological processing
- Vocalization
- Vocabulary, Morphology, Syntactic skills

CHILD'S CHARACTERISTICS

- Attention
- Psychophysiological
- Temperament

NEUROPSYCHO-LOGICAL FUNCTIONS

- Visuo-spatial skills
- Articulation, Motor Skills

ASSESSMENT DOMAINS

INTERVENTION

- Phonological
- Naming
- Family School

COGNITION

- IQ, Memory
- Associative learning

ACHIEVEMENT

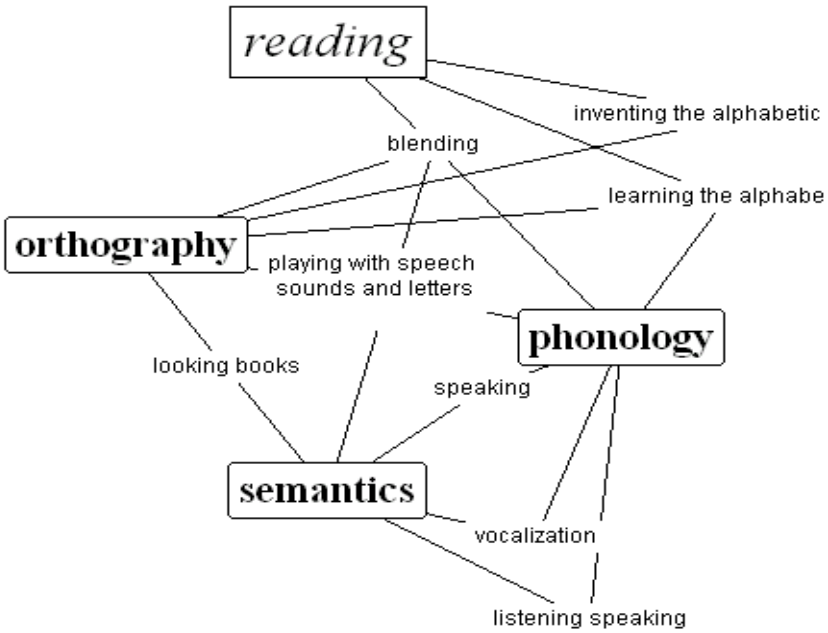
- Alphabetic skills
- Reading & Spelling
- Math skills

HOME ENVIRONMENT

- Parent-child interaction
- Print exposure
- Parenting, Stress

IDENTIFYING & PREDICTING RISK
a summary of significant measures

P = Predictors
D = Differences between groups



Age	Variable	
7 - yrs	Reading accuracy & speed	D
5 - yrs	Naming speed	P & D
4 - 6 yrs	Phonological manipulation	P & D
5 - 6 yrs	Letter knowledge	P & D
5 - yrs	Verbal memory	P & D
3 - 6 yrs	Phonological sensitivity	P & D
3 - 5 yrs	Inflectional skills	P & D
2 - 3 yrs	Articulation accuracy	P
2 yrs	Maximum sentence length	P & D
6 mth	Speech perception	P & D
Birth	ERP to speech sound	P & D

Lyytinen et al., Annals of Dyslexia, 2004; Dyslexia, 2004; Sage Handbook of Dyslexia, 2008

METHODS – ERP recording

From: F3, F4, C3, C4, P3, P4 (Ag/AgCl-electrodes), referred to ipsilateral mastoid

Bandpass: 0.5-35 Hz, sampling rate 200 Hz

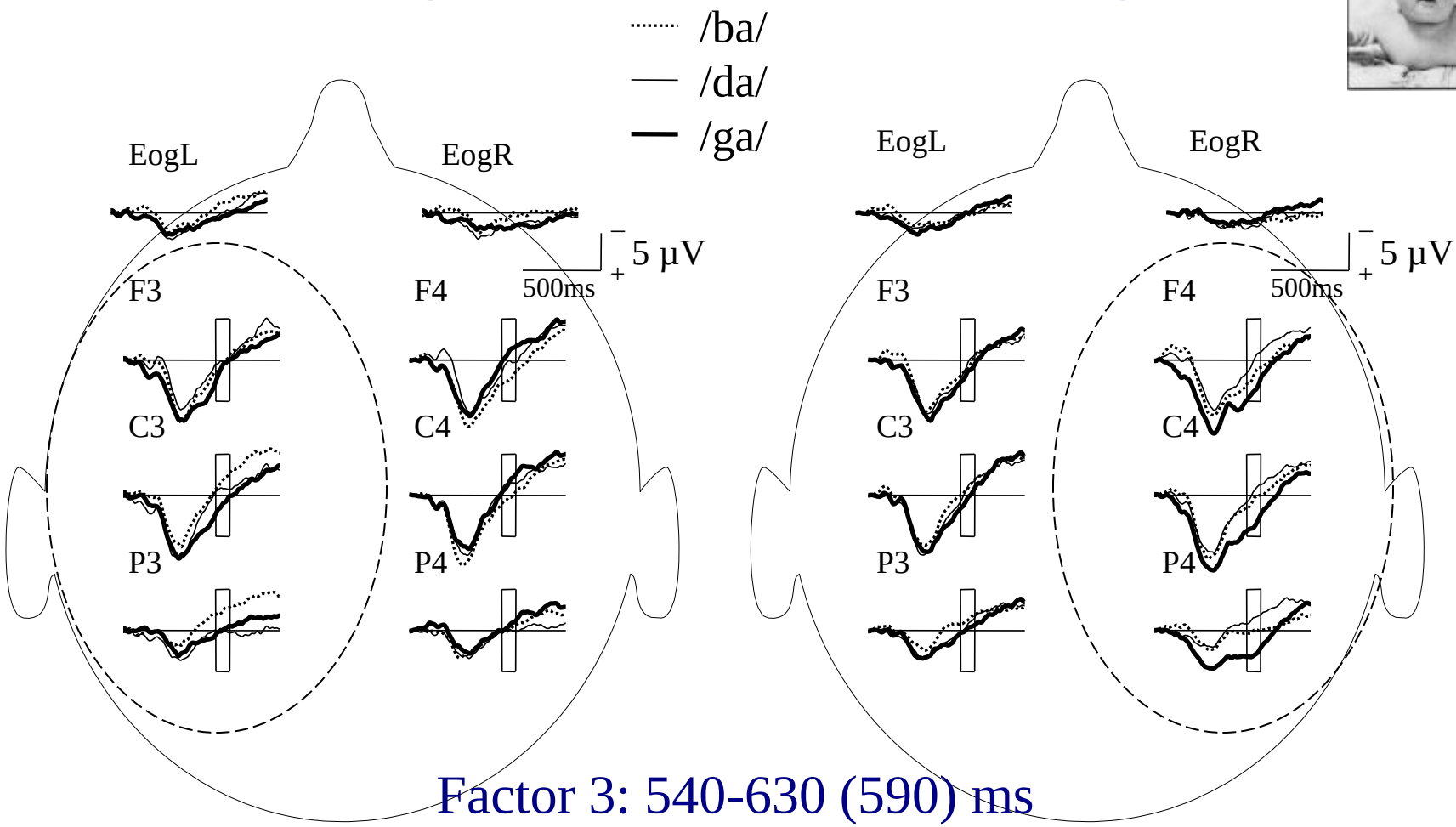
Prediction for the very early ERPs

Predictors:
Very early ERP responses to speech sounds predict the status of reading at school age (and is affected by the risk status)

Criterion measures:
Robust composite scores associated with early and later phases of reading acquisition

Control group

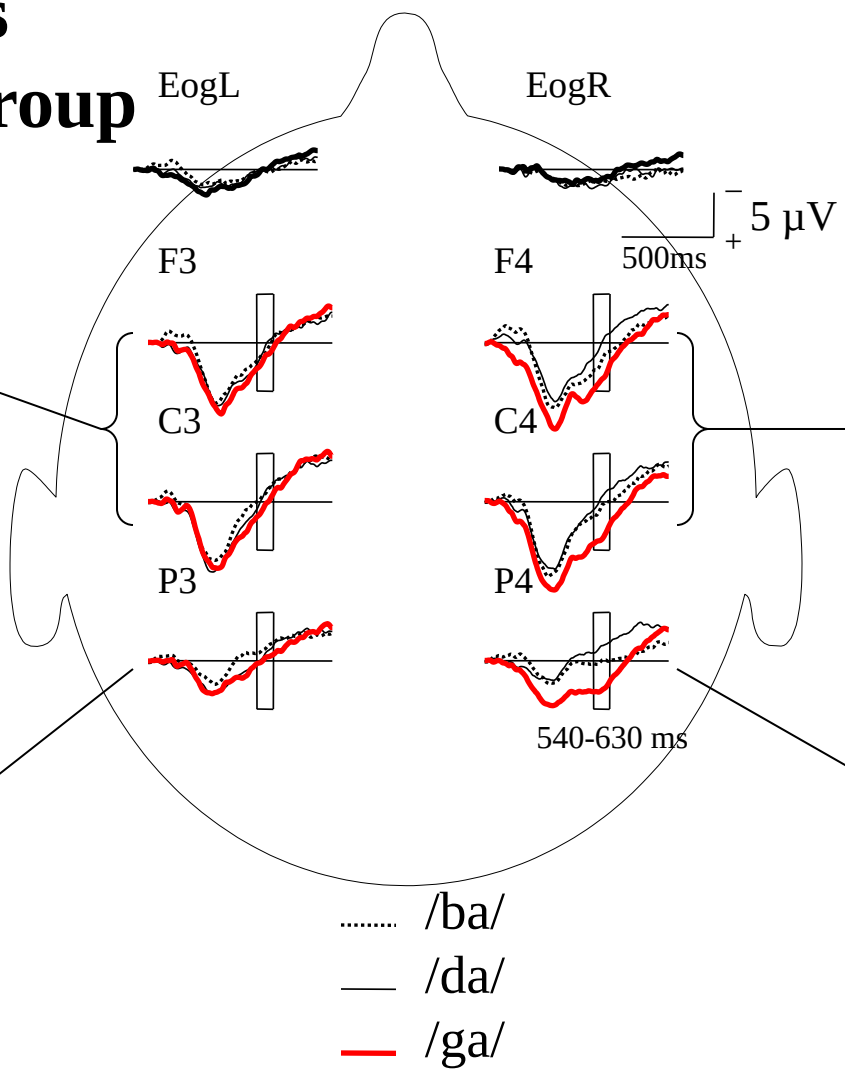
At-risk group



Factor 3: 540-630 (590) ms

Guttorm, Leppänen, Tolvanen, & Lyytinen (2003). Event-related potentials in newborns with and without familial risk for dyslexia: Principal component analysis reveals differences between the groups. *Journal of Neural Transmission, 110,* 1059-1074.

Newborn ERPs in the at-risk group



Boston Naming Test 5.5 y
-.311*

Audio-phonemic associations 5.5 y
-.451*

Word identification 6.5 y
-.308*

Phoneme Deletion 6.5 y
-.339*

Letter identification 6.5 y
-.339*

Word identification 6.5 y
-.339**

Writing letters 6.5 y -.336*

Reading 6.5 y -.329*

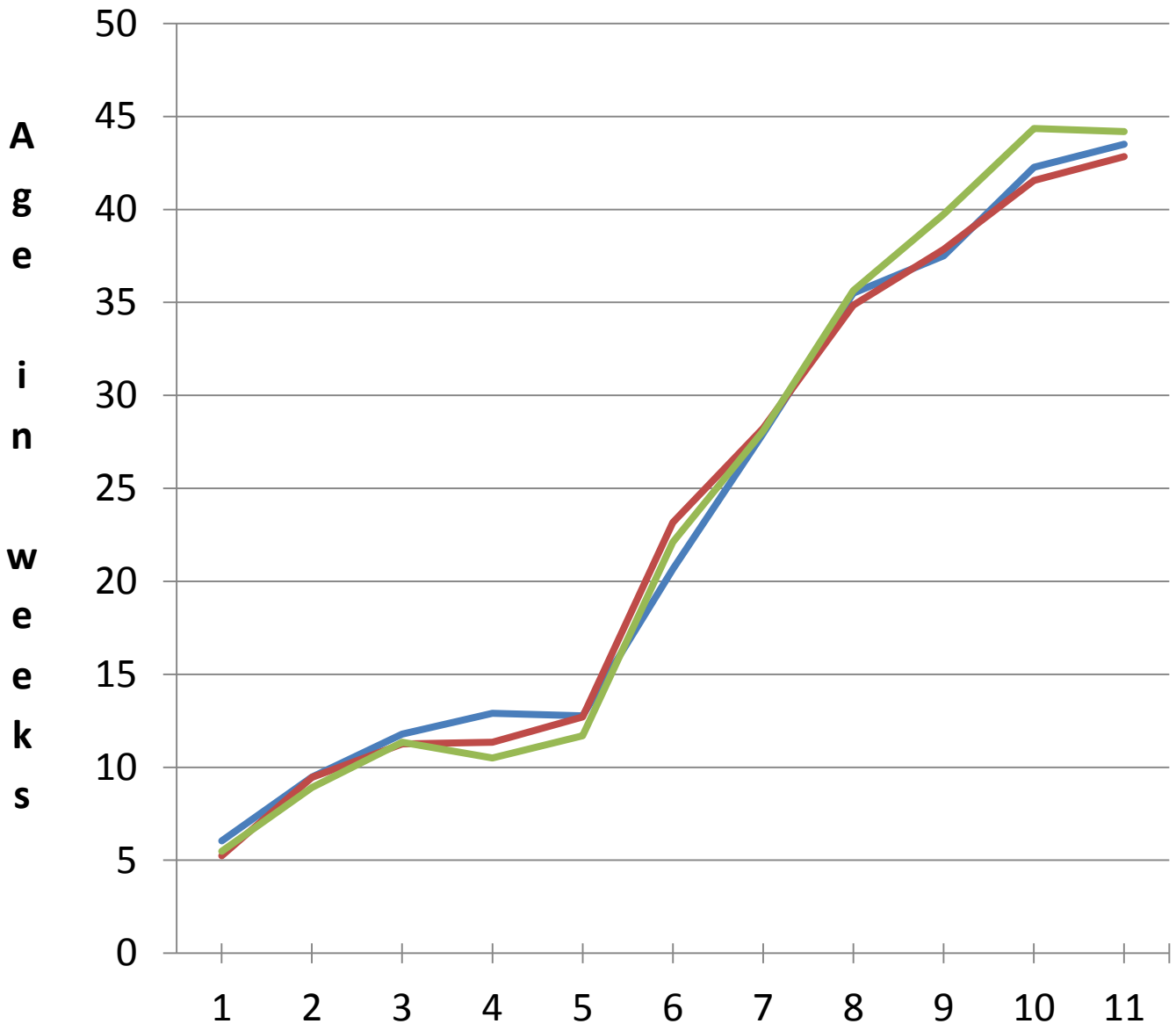
Rapid Naming: Faults 6.5 y
.414*

Naming 1st Phoneme 6.5 y
-.342*

Word identification 6.5 y
-.415**

Guttorm, et al. (2005) Cortex 41, 291-303.

DEVELOPMENT OF VOCALIZATION



1. Vocalizations which resembel sounds
2. Sustained vocalization
3. Cooing-like vocalization
4. Sustained vocalization with pauses
5. Two kind of vocalizations
6. Imitates parents' vocalizations
7. Initiates repetive babbling
8. Combines two different syllables
9. Uses gestures
10. Parallel pointing and volization when wants something
11. Uses word like expressions

PHONOLOGICAL PROCESSING

A. SPEECH PERCEPTION

ERP

Categorical perception

B. VERBAL MEMORY

C. NAMING

D. ARTICULATION

E. PHONOL. AWARENESS

- Identification, segmentation & manipulation of units of different sizes
  - 3.5 y
  - 4.5, 5.5 y
  - 5.5 y
  - 6.5 y
- Blending of units of different sizes
  - 5.5 y
  - 5.5 y
- Rhyme / Alliteration
  - 4.5 y

Phonemic lenght in Finnish and dyslexia: summary

UNIVERSITY OF JYVÄSKYLÄ

- Alteration of the duration of a phoneme changes the meaning
  > kuka(who) – kukka(flower); mato(worm) – matto(carpet); tuli(fire) – tuuli(wind)
- No concomitant change of e.g. stress or pitch
- Well defined in orthography (long=doubling the letter)

- Finnish *dyslexic readers make a disproportionately high number of quantity-related errors* when reading or spelling unfamiliar words
  > noted also in English (Steffens, et al. 1992, /sa/ to /sta/)

<u>Hypothesis:</u> dyslexia may involve a difficulty in categorizing speech sound according to sub-phonemic features such as duration

For details, see Lyytinen, et al. (2003)

CONSONANT DURATION CHANGE: BEHAVIORAL CONDITIONED HEAD-TURN EXPERIMENT

	ATA-Category				ATTA-Category			
stimuli	ata 1	ata 2	ata 3	ata 4	ata 5	ata 6	ata 7	ata 8
occlusion in ms	**95**	**115**	**135**	**155**	**175**	**195**	**215**	**255**

- The original stimulus taken from the speech of a female producing the pseudoword /*ata*/
- Duration of the silent closure stage of the word (medial dental stop, the /t/-sound) augmented in stepwise fashion
- Increments: 20 ms
- Total duration: 300 - 460 ms
- The impression of the perceived stimulus shifted from *ata* to *atta*

Richardson et. al., 2004,
Developmental Neuropsychology

Head turn conditioning

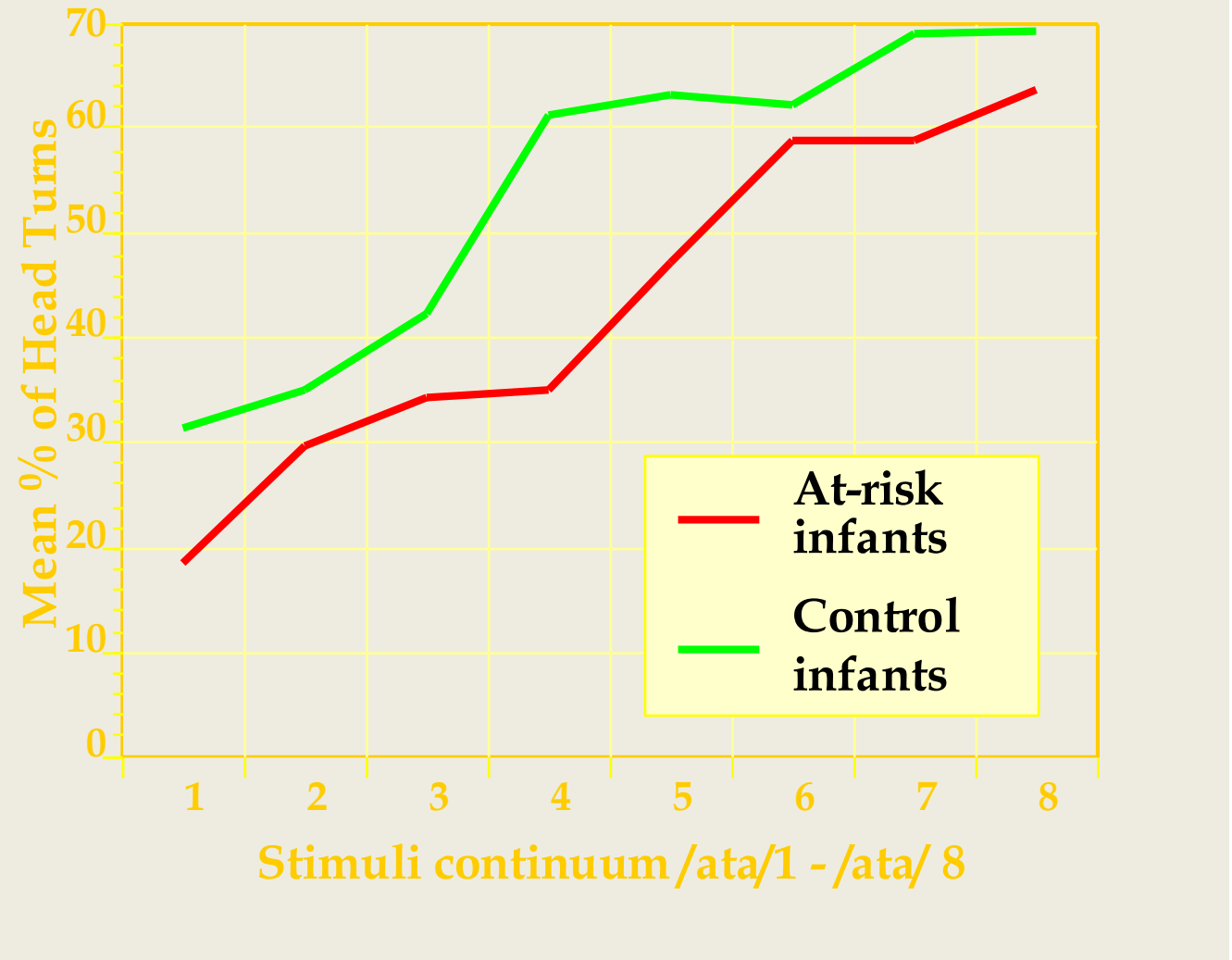
Infants were conditioned to turn their heads towards a visual reinforcer whenever they perceived a change within the /ata/ – /atta/ sequence.

Head turns to /atta/ (atta8) were visually reinforced using an animated toy during conditioning phase.

During the testing phase the original word /ata/ (stimulus ata1) was repeated with all variants of the "second stimuli" which had longer t-sounds in the change trials.

The stimuli were presented with a constant offset-to-onset interstimulus interval of 1000 msec.

The mean percentage of atta-categorizations in 6-month-old infants with high familial risk for dyslexia and control infants



The groups differ in their responses to /ata/4 (x^2 = 23.32, p = .0000)

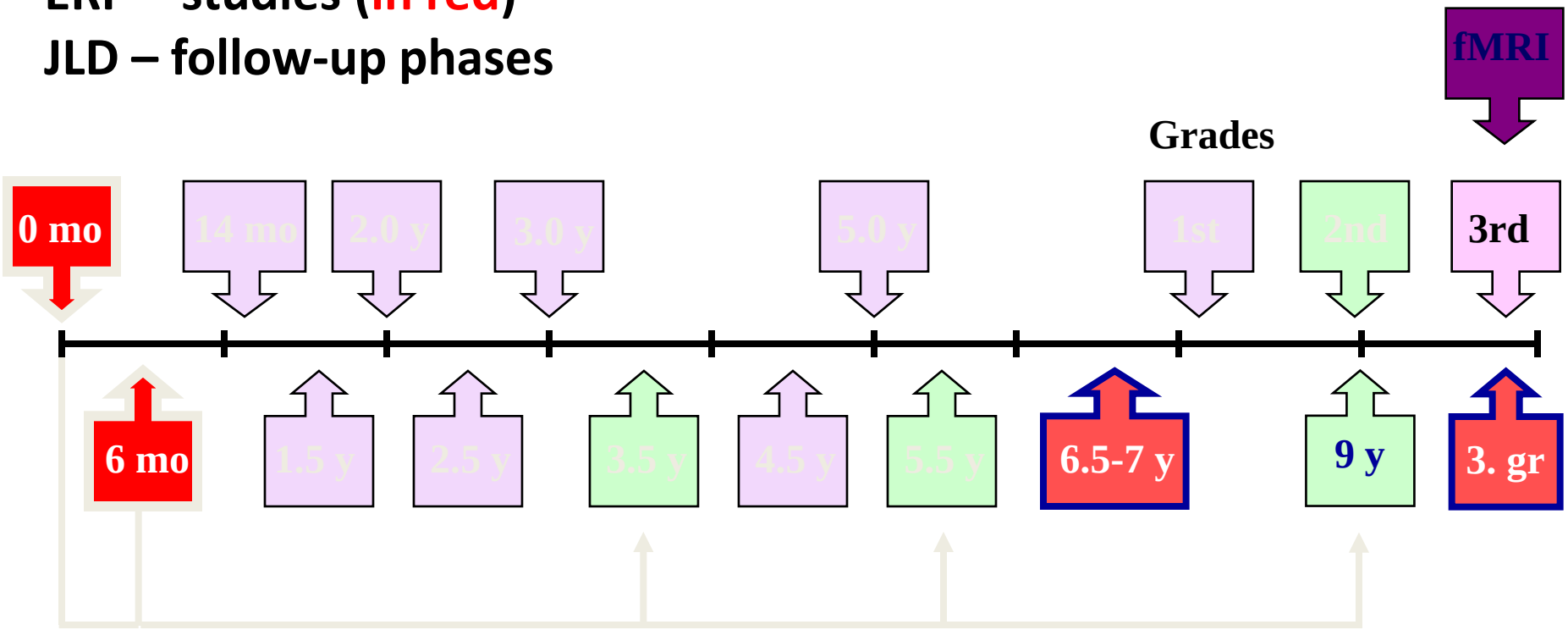
At-risk infants require longer /t/ (silent gap) duration to categorize the stimulus as */atta/*

Richardson et. al., 2003 Developmental Neuropsychology .

Jyväskylä Longitudinal Study Of Dyslexia:

ERP – studies (in red)

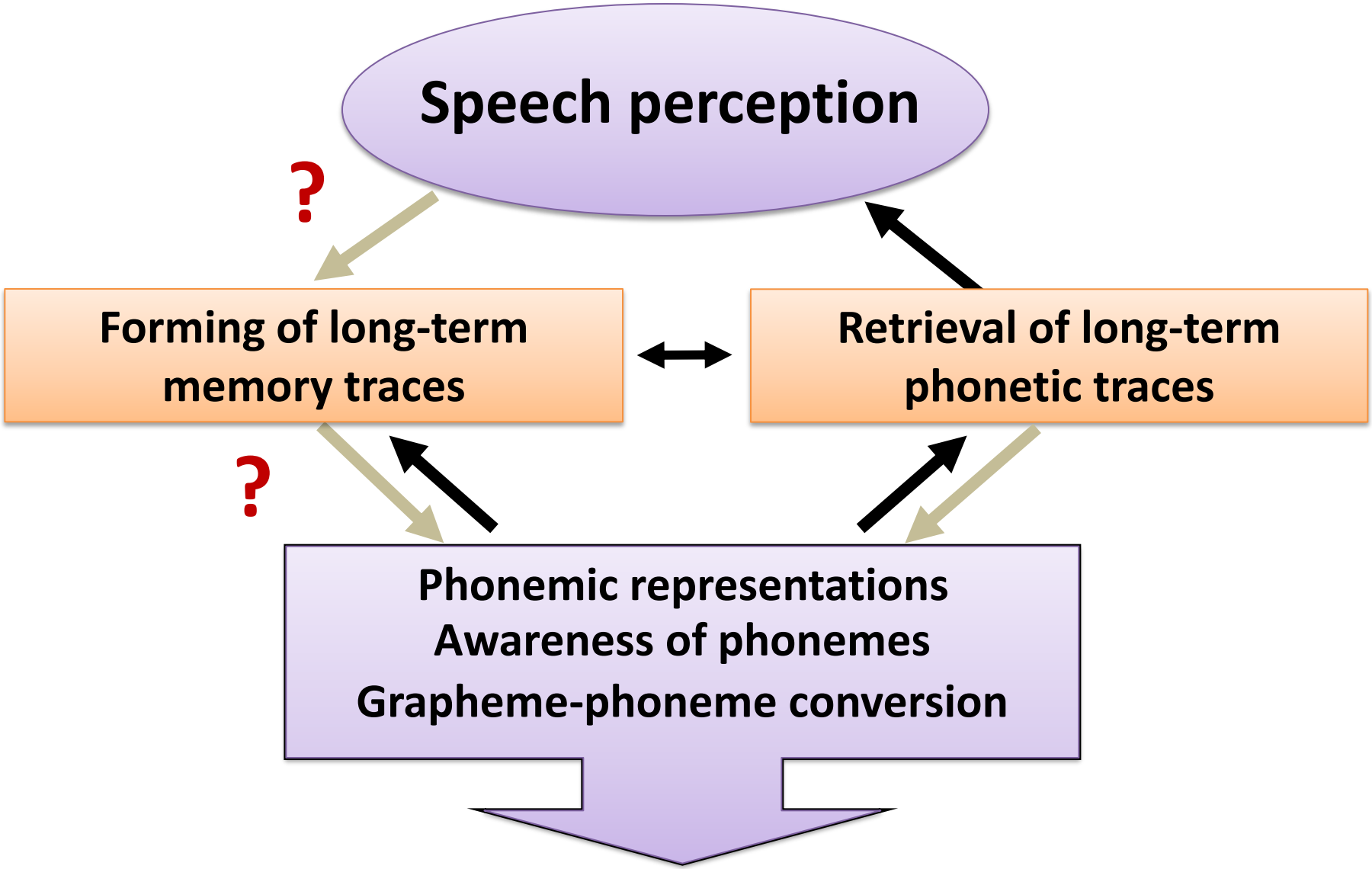
JLD – follow-up phases



Behavioral follow-ups also at:
- 5th, 7th, 8th, and 9th grade

Reviews, Lyytinen et al., eg. 2001; 2004; 2005; 2008

ERP work: Leppänen et al. 1997-2012, Guttorm et al., 2001-2010, Hämäläinen et al., 2005-2013



Learning to decode

Newborn ERPs to tone frequency change differ between 2nd grade typical control and dyslexic at-risk readers

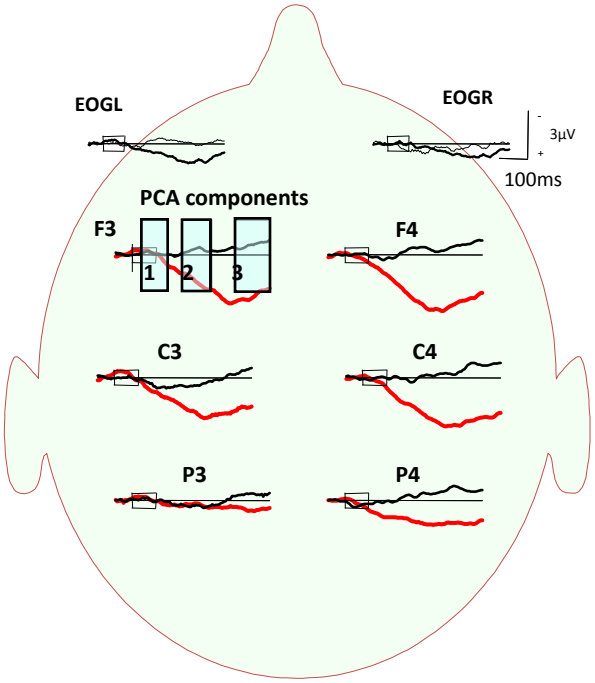
MMN-paradigm

Standard

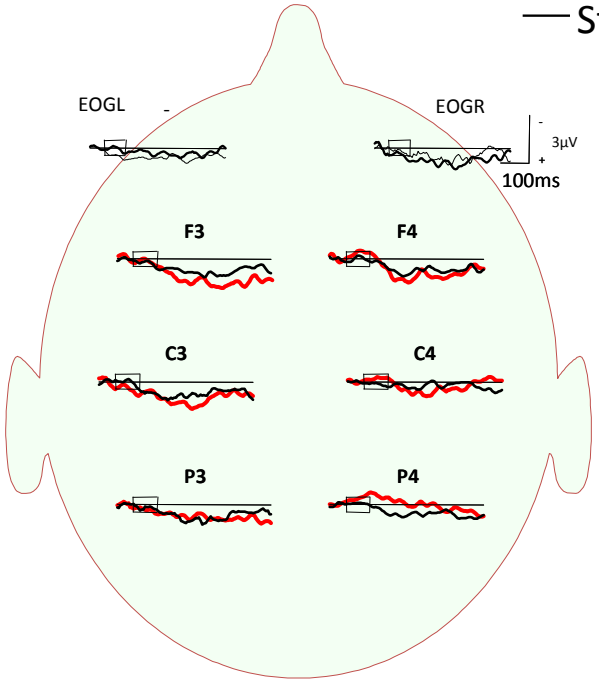
Deviant

Dev 1100Hz, 12 %, SOA 425 ms

Std 1000Hz



Control typical readers (TRC, N=25)



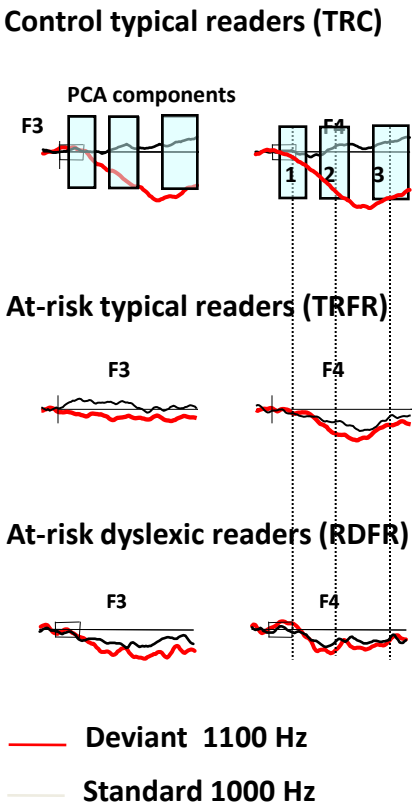
At-risk dyslexic readers (RDFR, N=8)

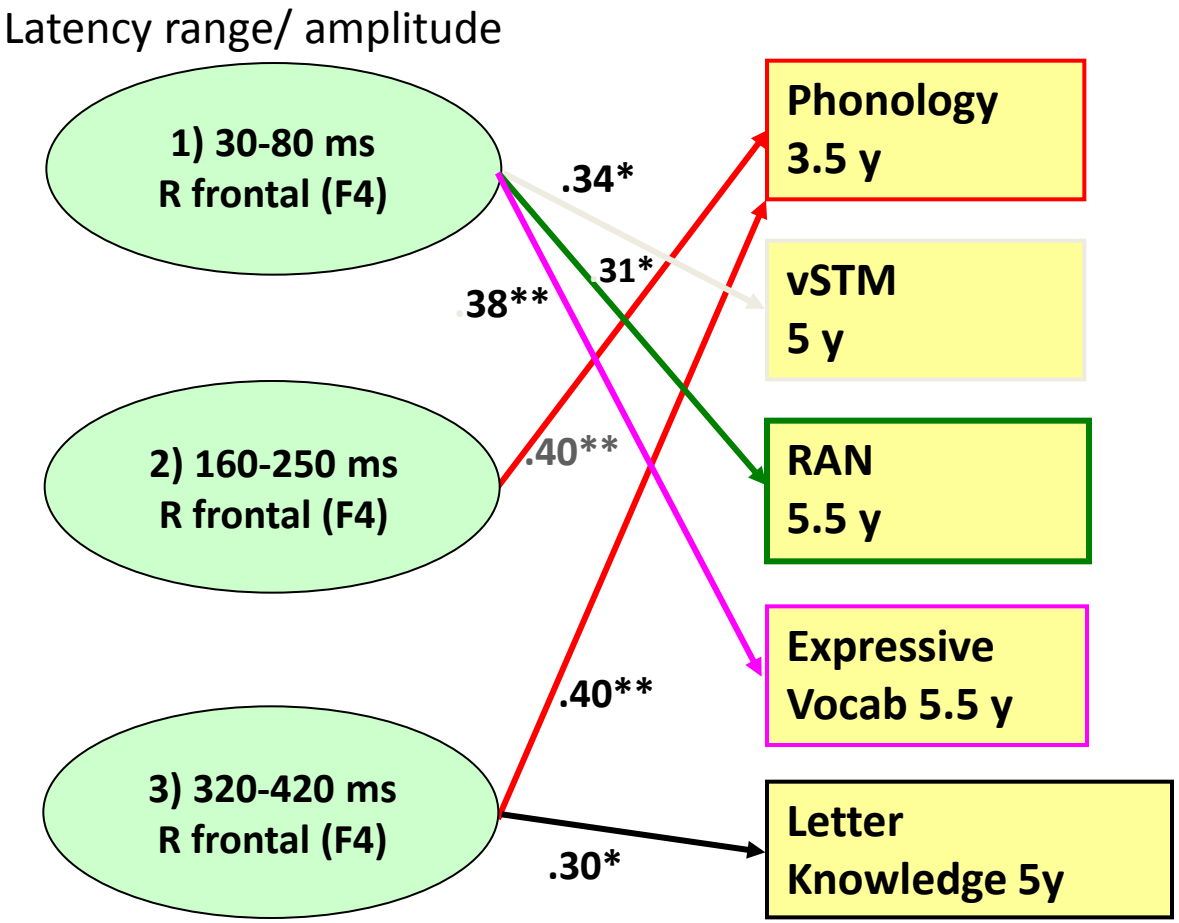
Quiet sleep

Leppänen et al, *2010*, *Cortex*

Newborn ERPs to tone change (deviancy) correlated to later pre-reading skills

across all groups (N= 47, TRC, n=25, TRFR, n=14, and RDFR, n=8)



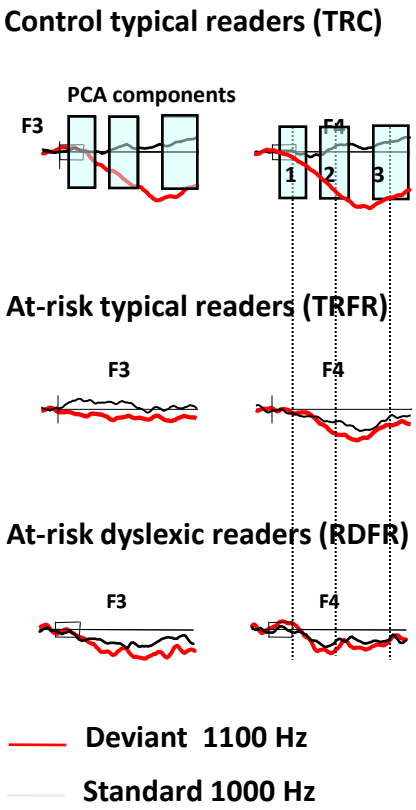


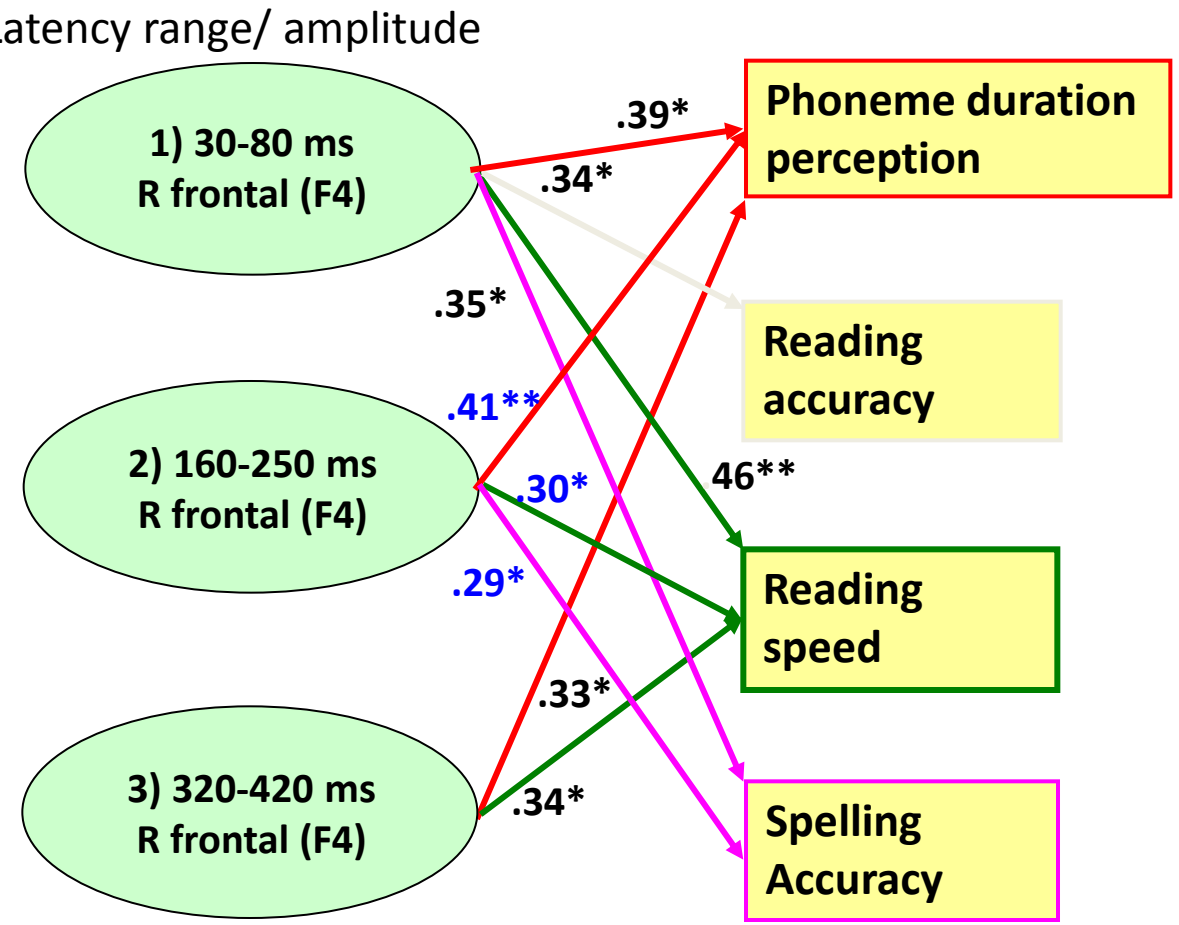
*p < 0.05, **p < 0.01 (2-tailed)

Leppänen et al, *2010*, *Cortex*

Newborn ERPs to tone deviancy correlated to later skills at 2nd gr (9y)

across all groups (N= 47, TRC, n=25, TRFR, n=14, and RDFR, n=8)



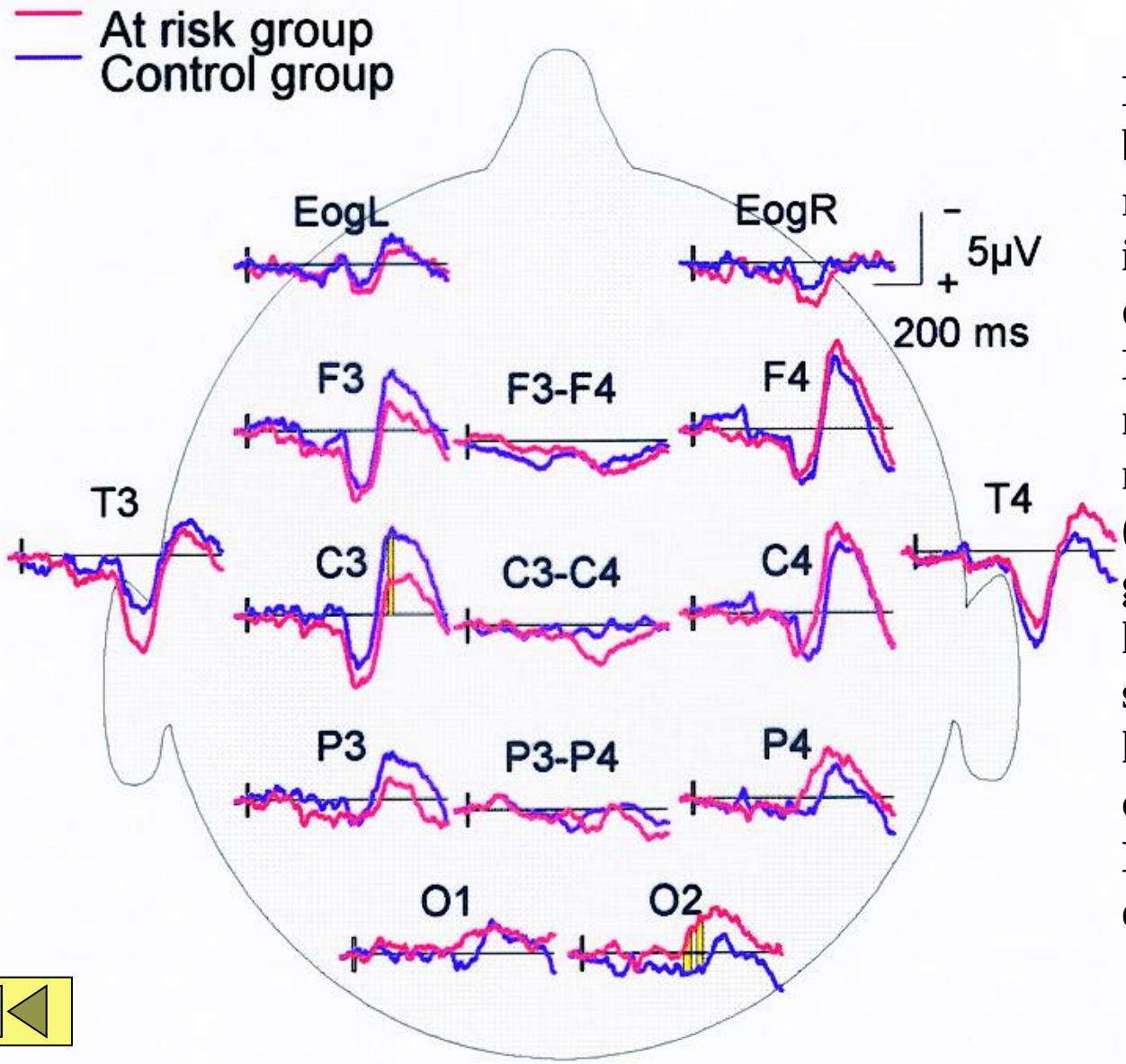


*p < 0.05, **p < 0.01 (2-tailed)

Leppänen et al, *2010*, *Cortex*


1994-03-25 14:00:49 Subj: 23029 Ata-NonVis 2 (5)
Trig: 790 Std: 635 C.Dev:155 Dev1: 77 Dev2: 78

At 6-month of age- ERPs to /ata/ - /atta/



ERP difference waves between responses to repeated standard and infrequently presented deviant /ata/s.
Note that the deflection of negative polarity called mismatch negativity (MMN) is present in both groups in the right hemisphere but is clearly smaller in the left hemisphere among at- risk children (see Leppänen & Lyytinen, 1997; Leppänen et al. 2002).

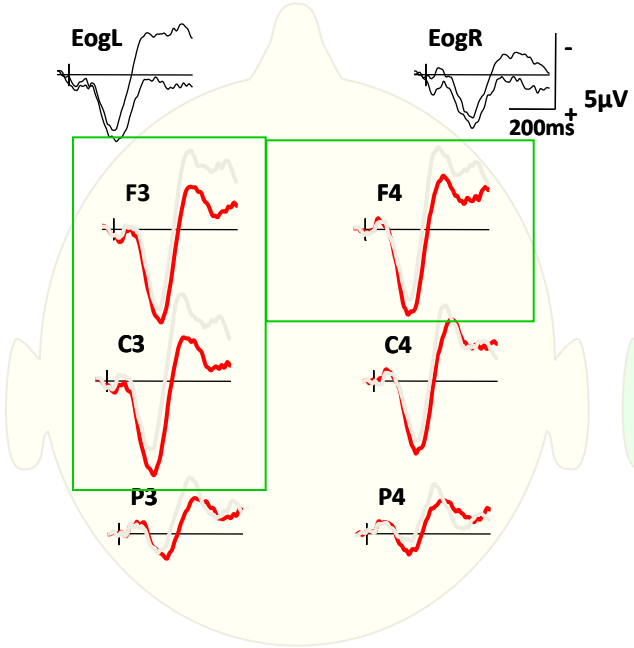
ERPs to vowel duration change – at-risk readers at 2 grade differ already at 6 months

MMN-paradigm

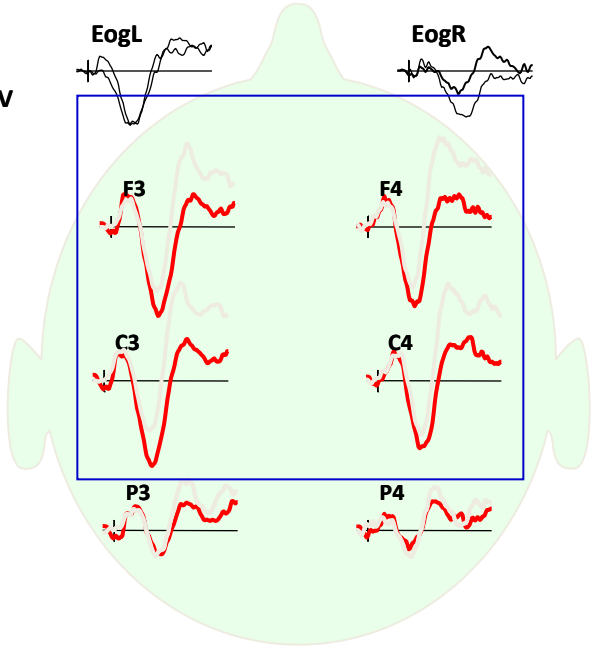
… kaa kaa kaa **ka** … kaa kaa … kaa **ka** kaa … kaa **ka** …

Standard, long /kaa/

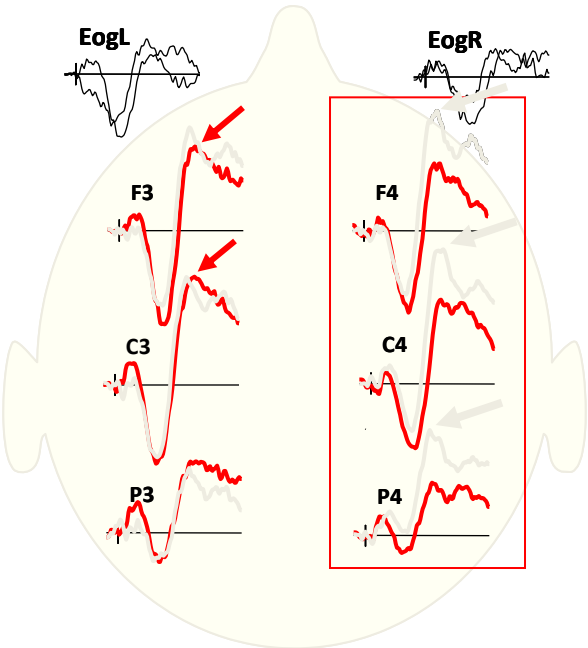
Deviant, short /ka/



Controls (TRC, N=22)



At-risk typical readers (TRFR, N=18)

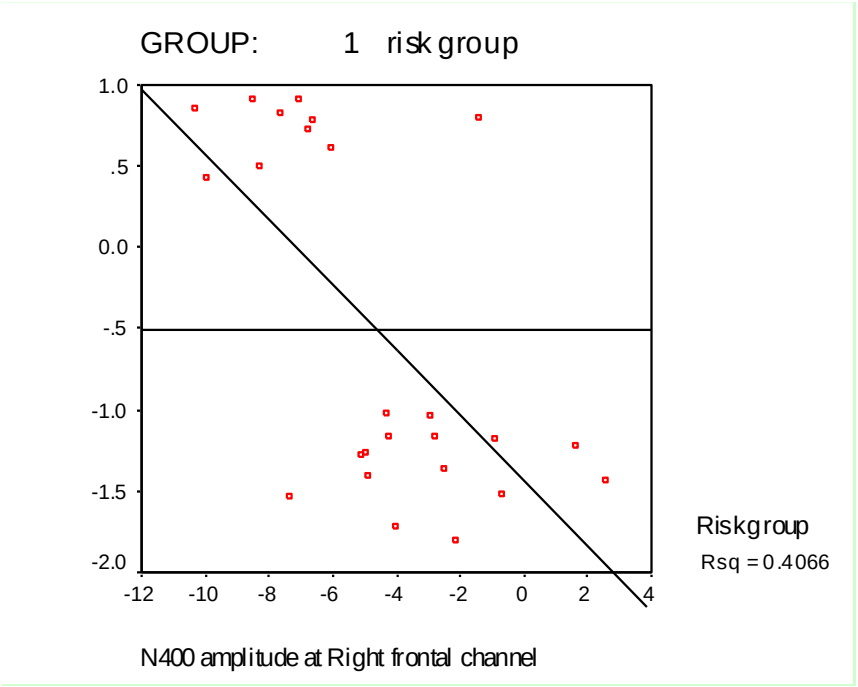


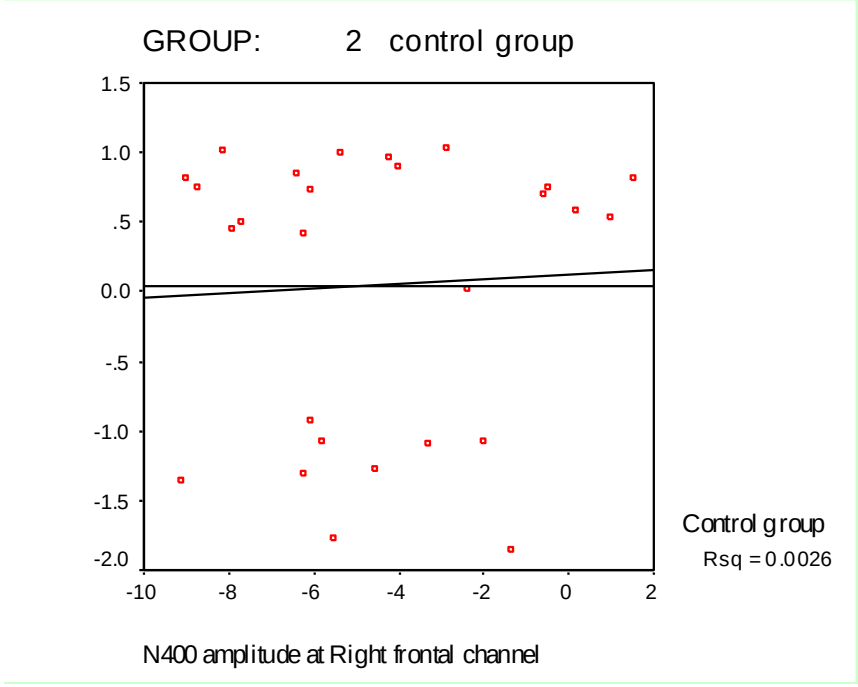
At-risk dyslexic readers (RDFR, N=10)

Leppänen et al., *CNS* 2006

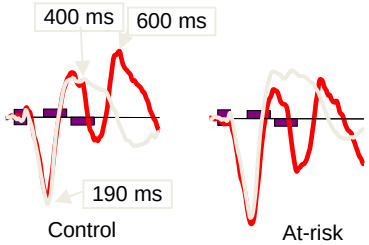
Scatterplot: 6-mo standard-ERP amplitude and early reading before school start

Standard-N400 amplitude at right frontal area





At-risk group (N=25)



Control group (N=27)

Developmental differences between JLD at-risk children with (N=37) and without (N=66) reading impairement

Developmental skill	Observed p's and powers of the differences	
Expressive language 1.5y	.001	.78
Expressive language 2.5y	.027	.61
Verbal short-term memory 3.5y	.010	.74
Verbal short-term memory 5.0y	.016	.68
Verbal short-term memory 6.5y	.001	.92
Morphology 5.0y	.024	.62
Phonology 4.5y	.006	.80
Phonology 5.5y	.001	.93
Phonology 6.5y	.002	.88
Letter knowledge 4.5y	.003	.85
Letter knowledge 5.0y	.000	.98
Letter knolwedge 5.5y	.003	.85
Letter knolwedge 6.5	.000	.98
Rapid naming 5.5y	.000	.97
Rapid naming 6.5y	.000	.99
Verbal IQ 8.5y	.004	.83

Lyytinen et al., 2008

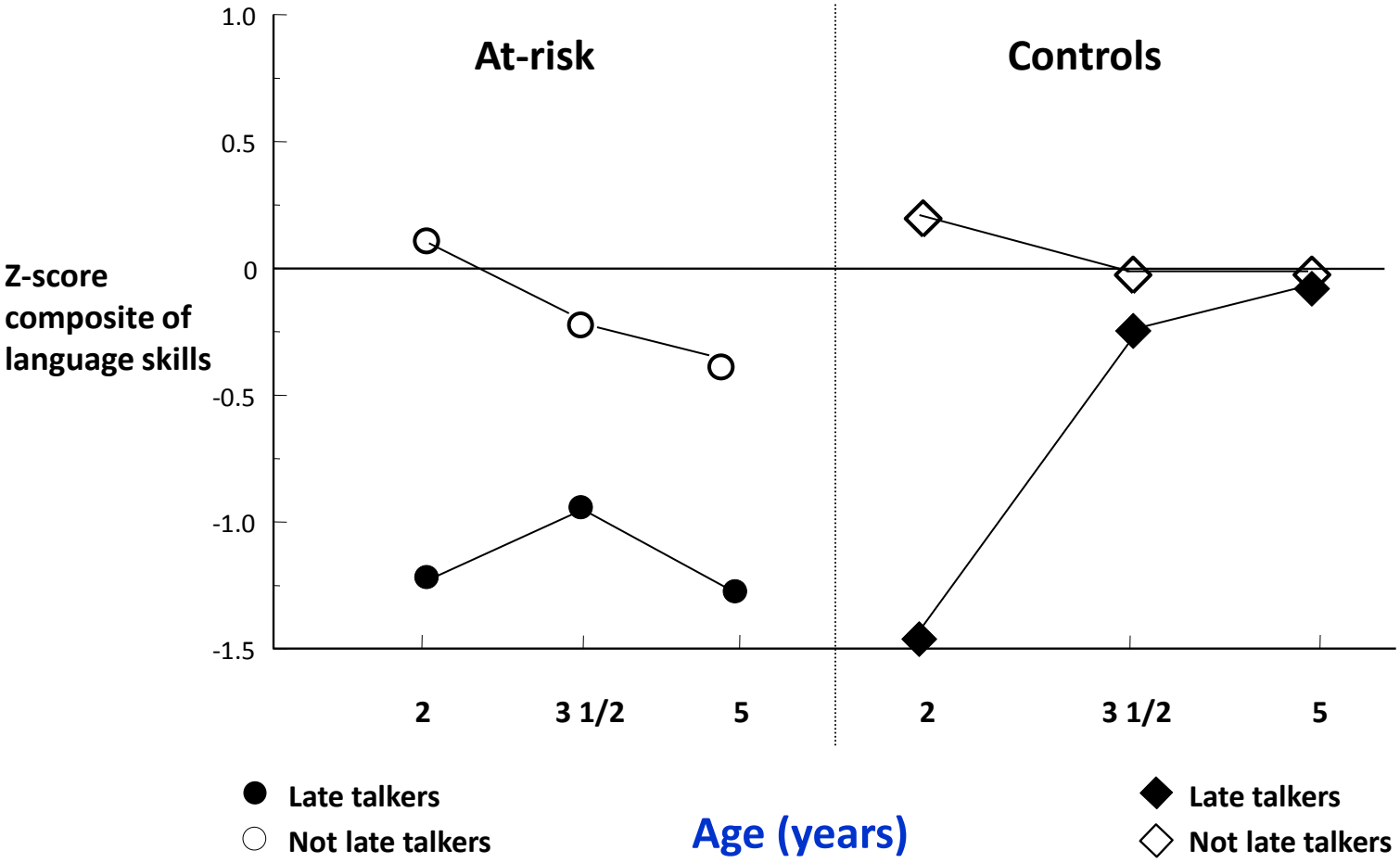
GROUP COMPARISONS IN COGNITIVE DEVELOPMENT

	At-risk with dyslexia	At-risk with NO dyslexia	Controls with NO dyslexia	F	Power
Expressive language 1.5 y	**-.26 (.58)**	**.03 (.90)**	**.05 (.96)**	**1.49**	**.32**
Expressive language 2.5 y	**.03 (.90)**	**-.05 (.94)**	**.09 (.78)**	**.44**	**.12**
Morphology 5 y	**-.66 (.89)**	**-.33 (1.17)**	**.01 (.99)**	**4.56***	**.77**
Verbal short-term memory 5 y	**-.42 (1.04)**	**-.36 (1.08)**	**.06 (1.01)**	**3.88***	**.70**
Verbal short-term memory 6.5 y	**-.18 (1.26)**	**.01 (1.07)**	**.11 (.98)**	**.83**	**.19**
Phonology 5.5 y	**-.76 (.70)**	**-.31 (1.02)**	**.03 (.90)**	**9.89*****	**.98**
Phonology 6.5 y	**-.61 (.85)**	**-.26 (.97)**	**.04 (.89)**	**6.78****	**.92**
Letter knowledge 5-5.5 y	**-.91 (.85)**	**-.26 (1.11)**	**.15 (.92)**	**12.28*****	**1.00**
Letter knowledge 6.5 y	**-.89 (.91)**	**-.34 (1.20)**	**.20 (.82)**	**13.58*****	**1.00**
Rapid naming 5.5 y	**-1.47 (2.02)**	**-.36 (1.48)**	**.08 (.87)**	**13.78*****	**1.00**
Rapid naming 6.5 y	**-1.29 (1.52)**	**-.37 (1.71)**	**.13 (.86)**	**13.13*****	**1.00**

Is reading acquisition associated with early language delays?

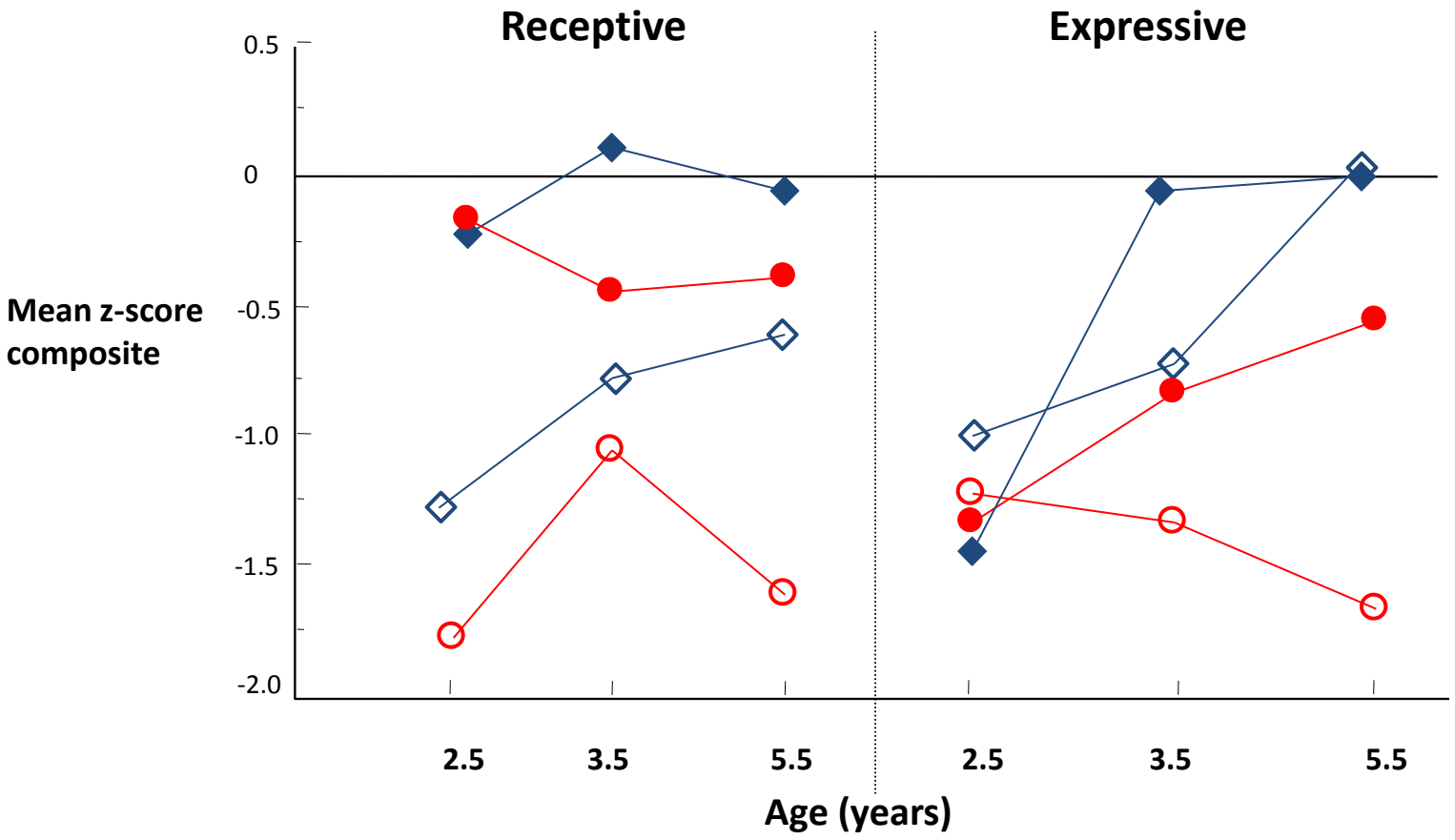
- Late talking – delay in the development of expressive language skills (assessed here at 2 years of age)
  - Similar numbers of children in both groups could be defined as late talkers
  - Do children with normal speaking at 2.5 years age differ from those who start speaking later (after 2.5 y of age) in their later language development?
    - If so how?
  - Is late talking connected to reading acquisition
    - If so how?

Development of language skills among late talkers of the risk and control groups



Lyytinen P. et al., J. of Speech, Language & Hearing Res;2001

LANGUAGE DEVELOPMENT OF "Late talkers"



Delay in **expressive** language

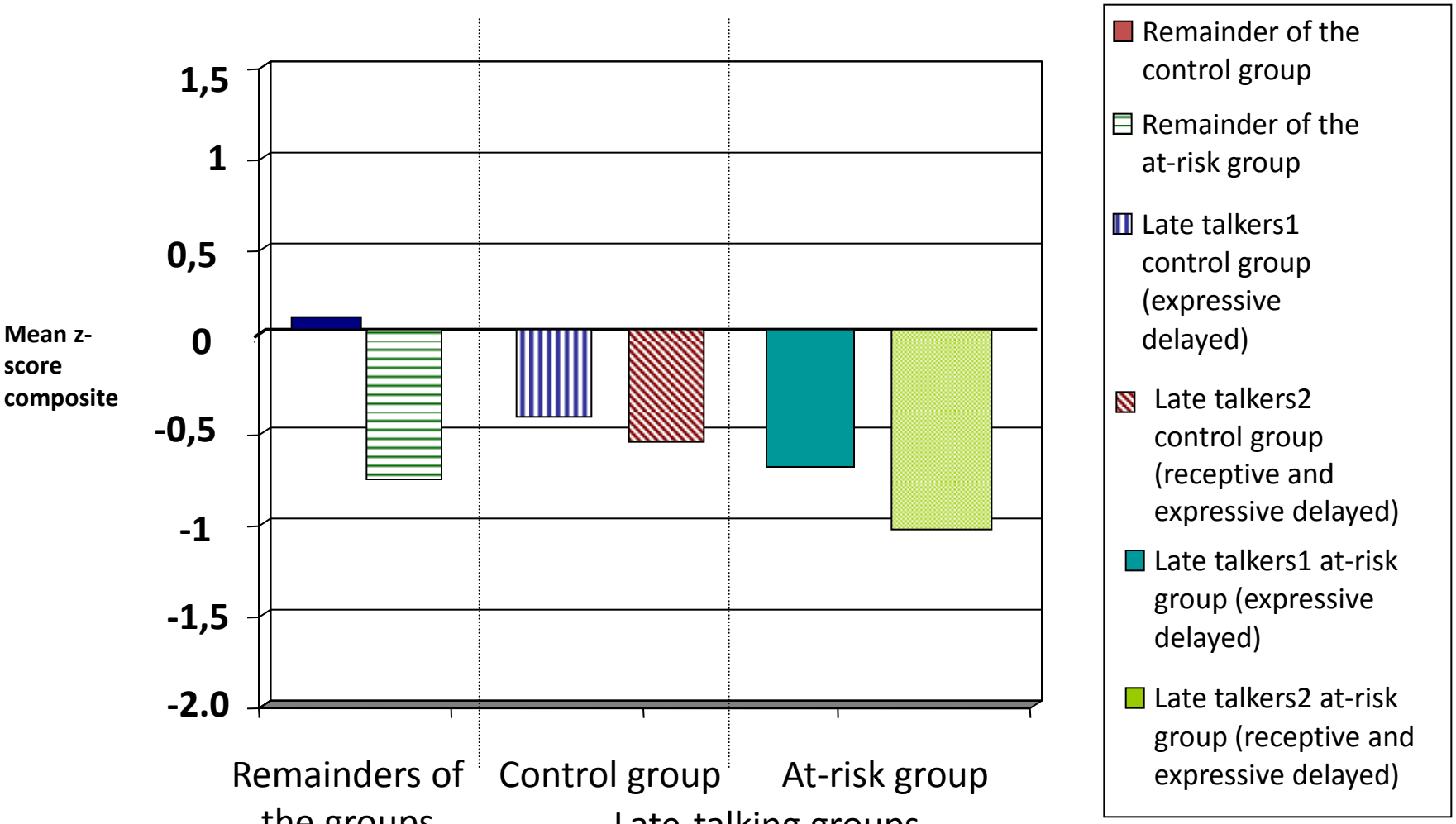
- **At-risk group (N=10)**
- **Control group (N=10)**

Delay in **expressive and receptive** language

- **At-risk group (N=12)**
- **Control group (N=3)**

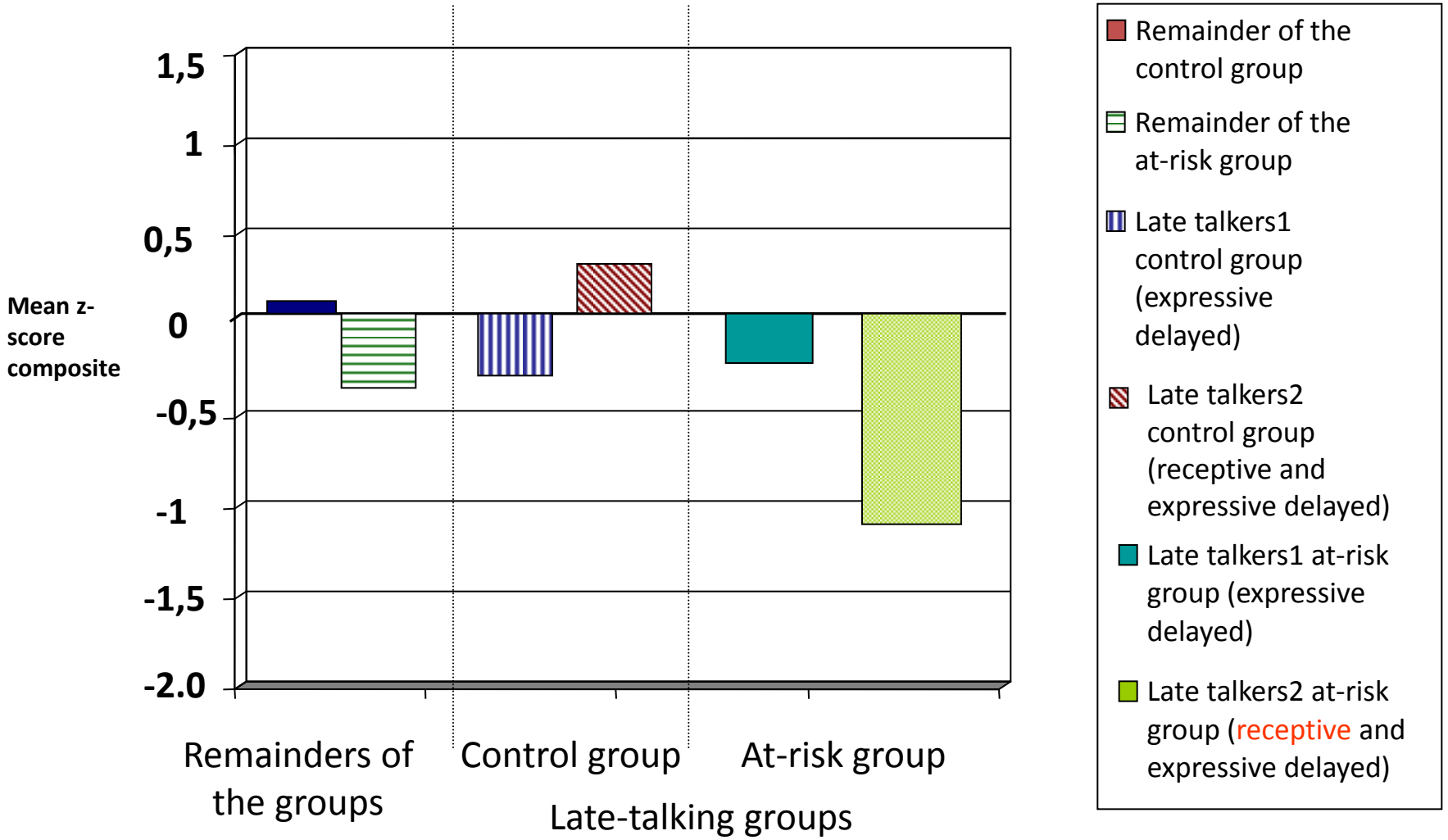
Lyytinen, P. et al.,
Annals of Dyslexia, 2005, 55, 2, 166-192.

Reading accuracy and speed by groups at the end of the first grade



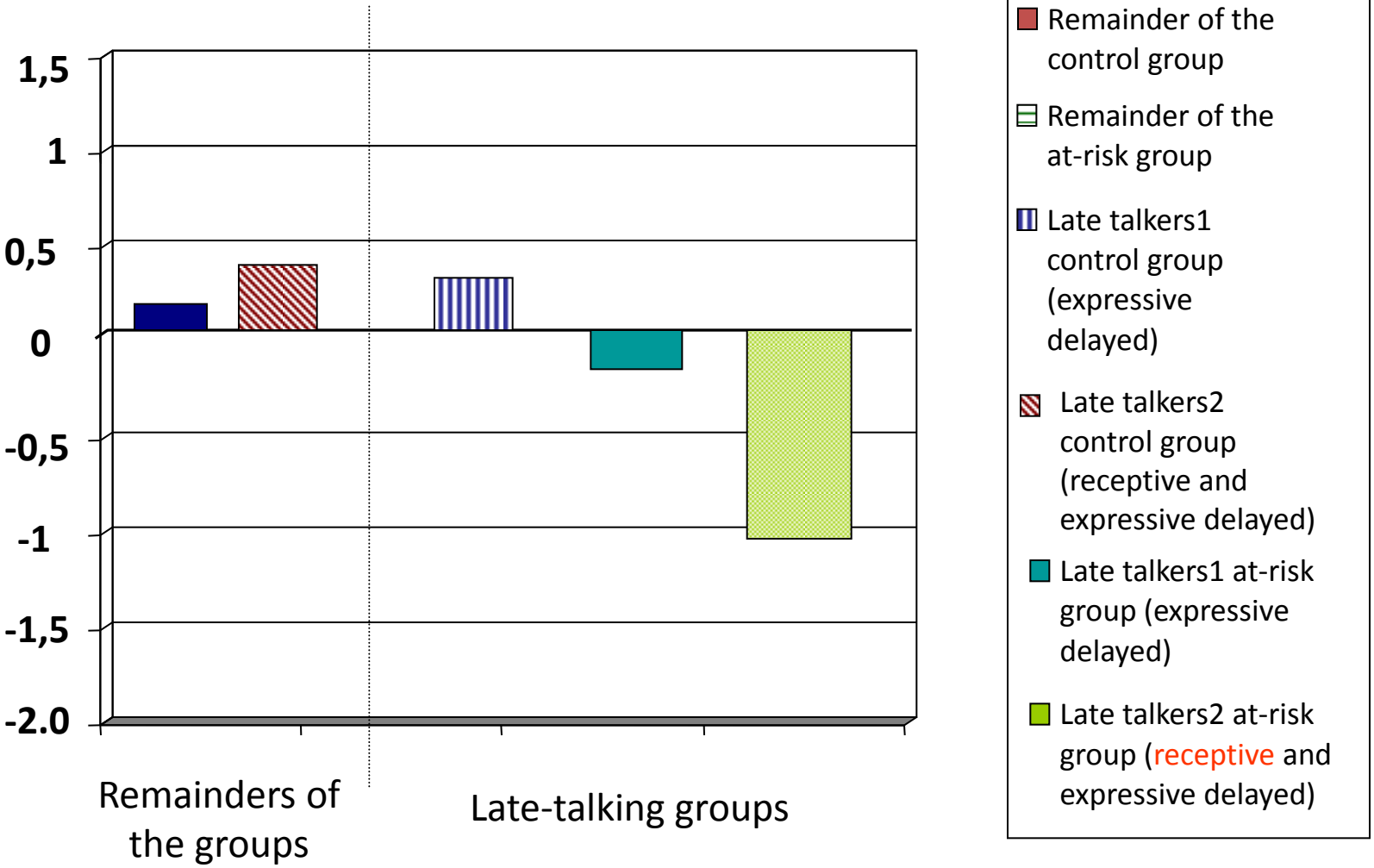
Lyytinen, P. Eklund & Lyytinen, Annals of Dyslexia, 2005, 55, 2, 166-192.

Spelling skills by groups at the end of the first grade



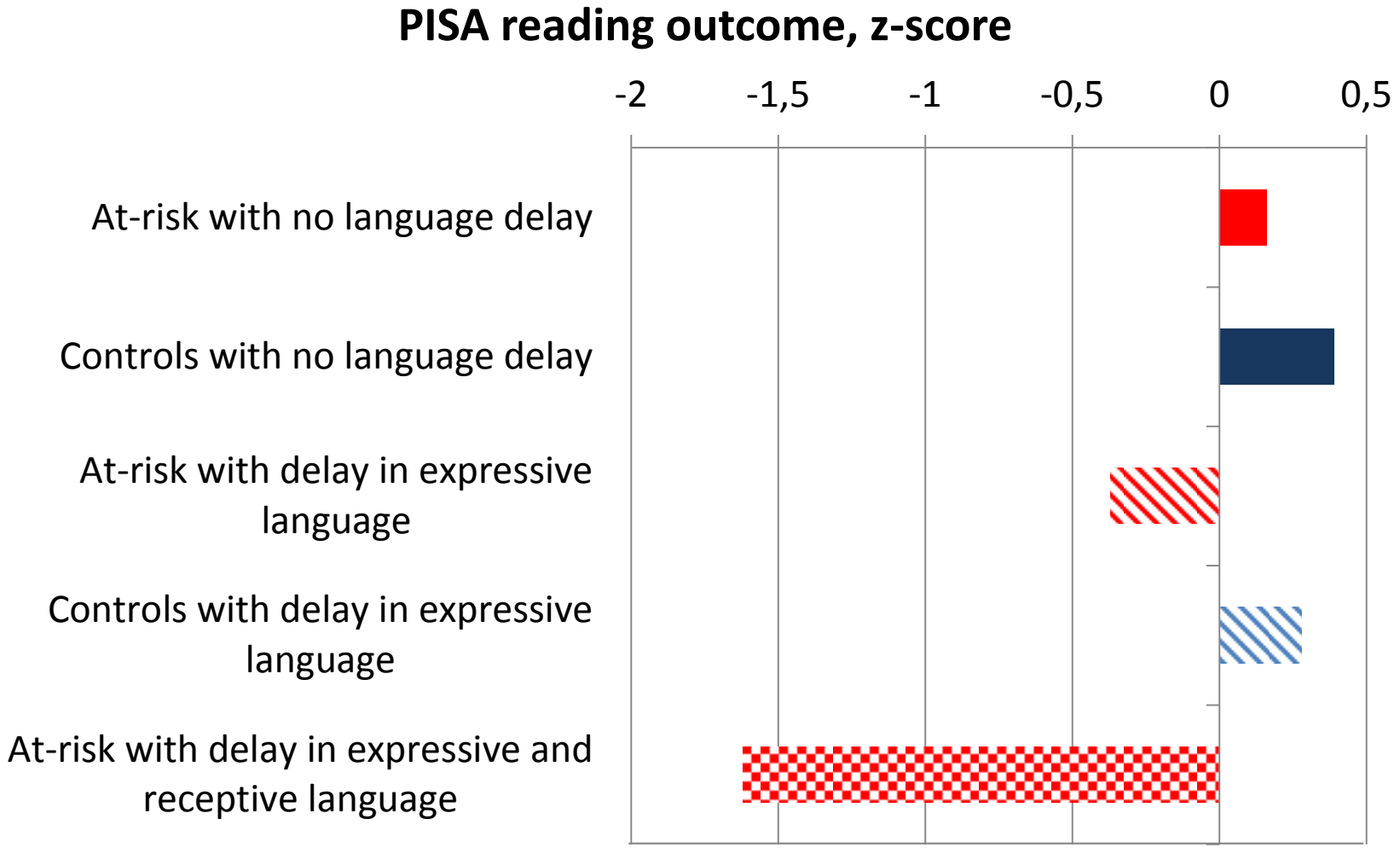
Lyytinen, P. Eklund & Lyytinen, Annals of Dyslexia, 2005, 55, 2, 166-192.

Reading comprehension by groups at the end of the first grade

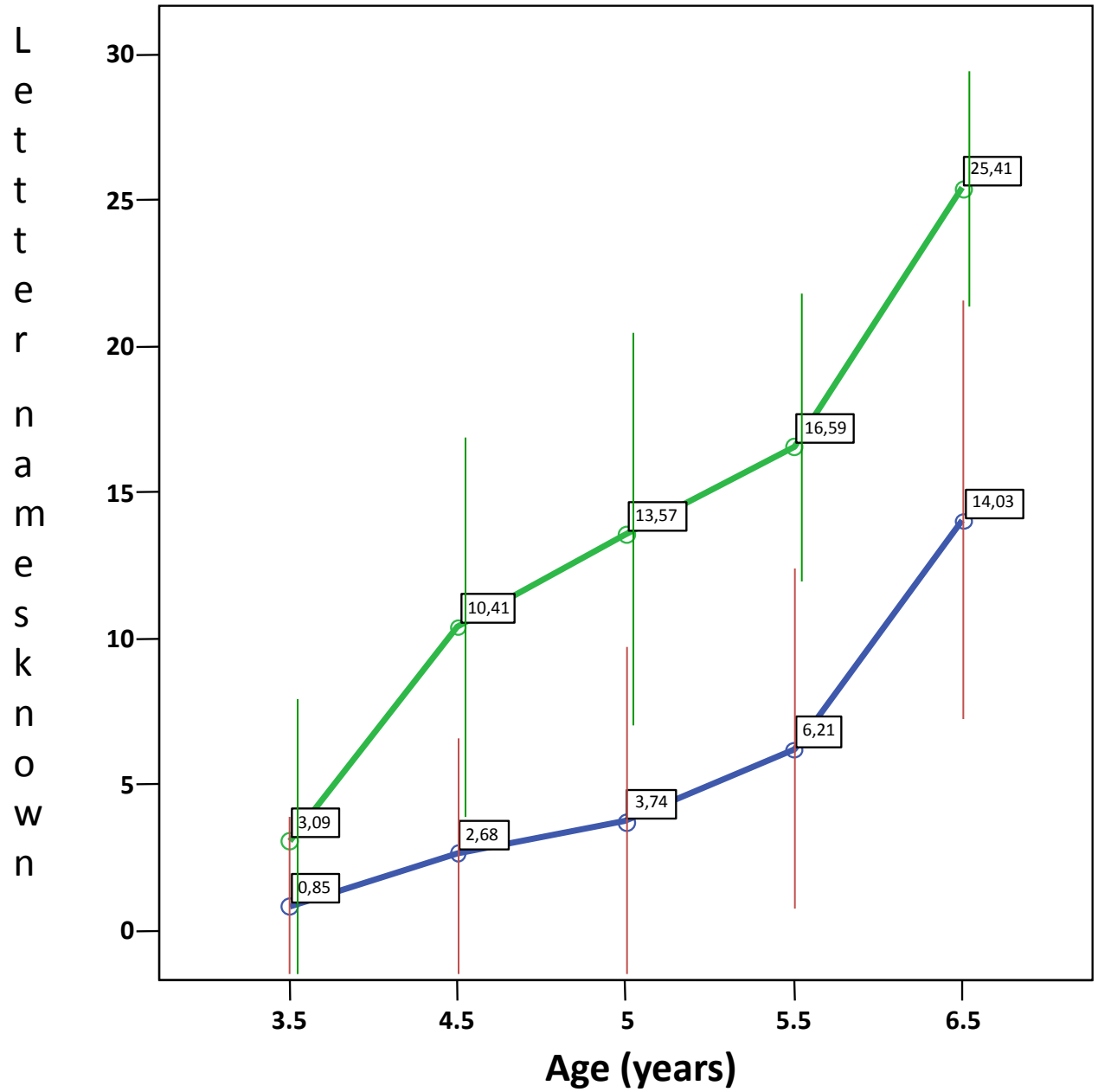


Lyytinen, P. Eklund & Lyytinen, Annals of Dyslexia, 2005, 55, 2, 166-192.

PISA READING PERFORMANCE (age: 15 y) OF "Late talkers"



The letter knowledge of 3.5-6.5 year olds (JLD) and reading acquisition

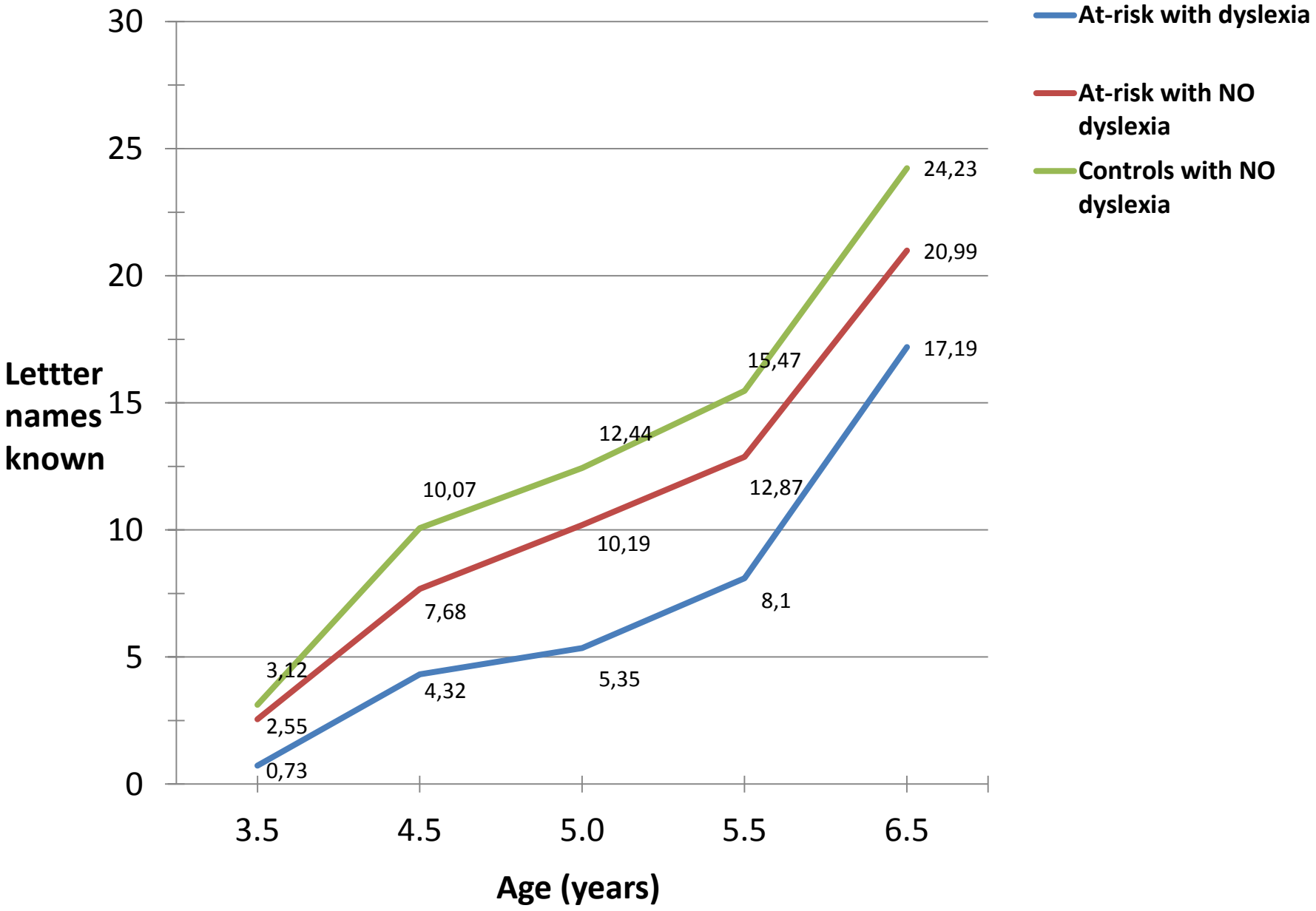


Reading acquisition fails during 1. grade

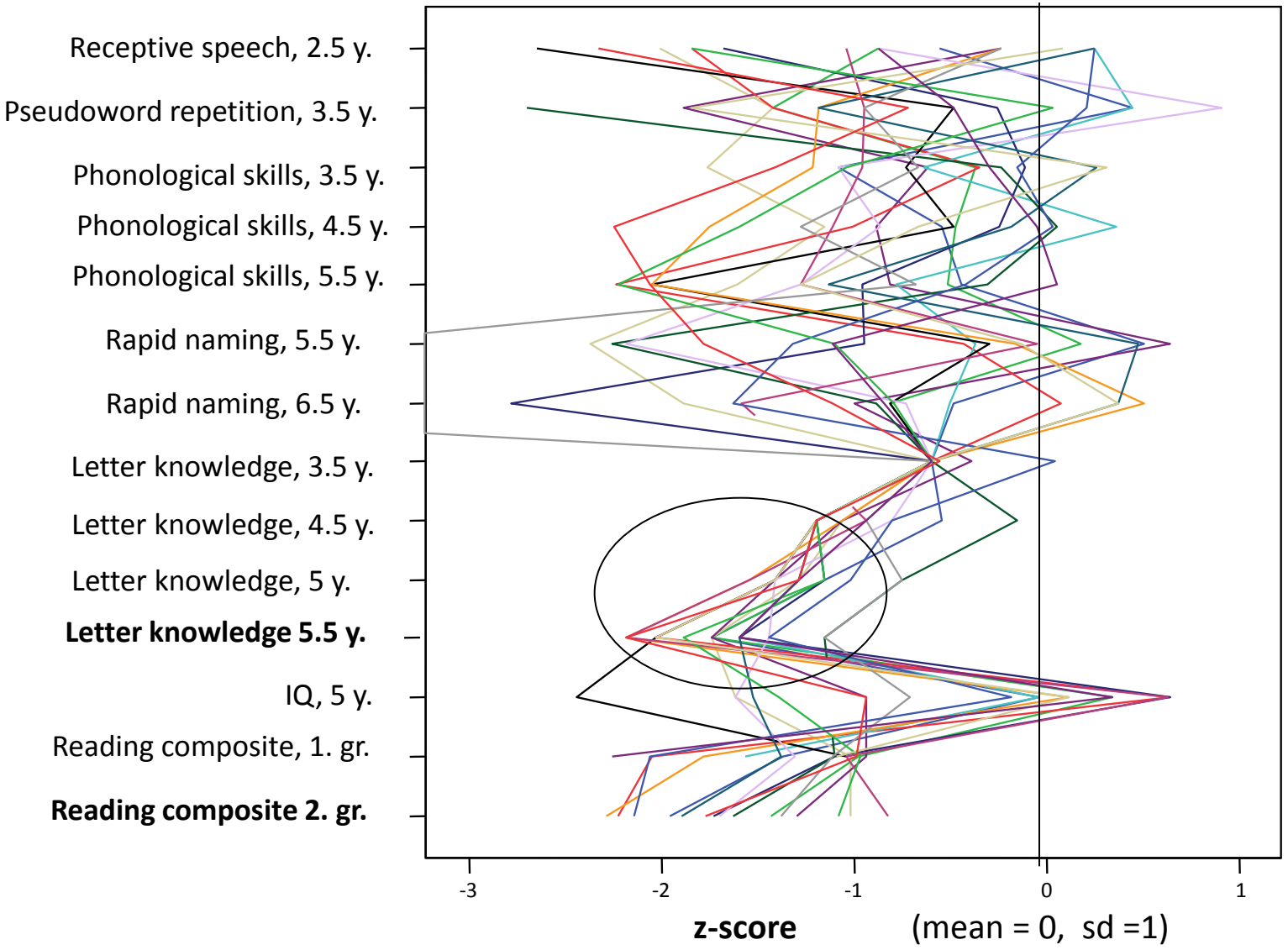
Reading acquisition normal during 1. grade

Lyytinen et al., (2007)
Nordic Psychology

DEVELOPMENT OF LETTER KNOWLEDGE



The JLD-follow-up from birth to school age of reading-related development

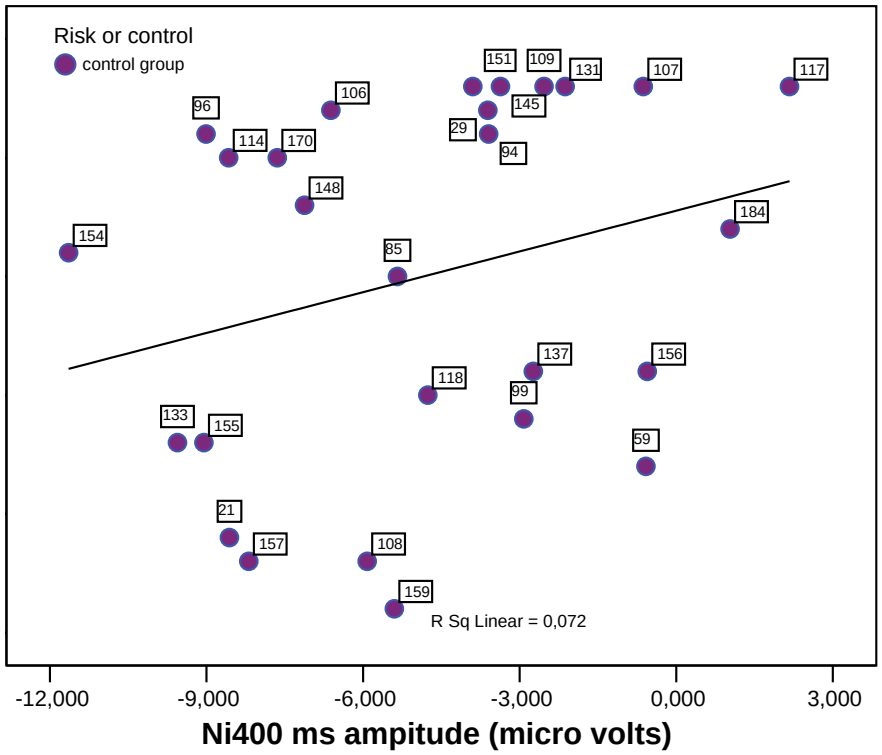


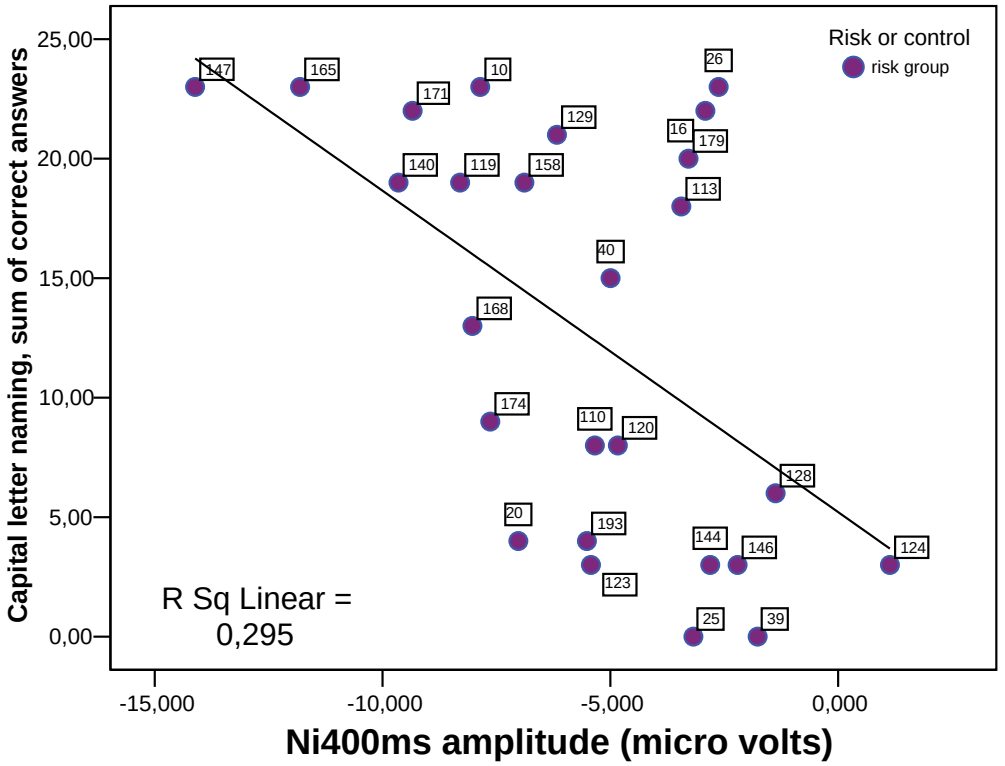
Lyytinen, et al. Scand. J. of Psychology, 2009.

Individual profiles of the prediction measures of the JLD children whose reading acquisition was most severely compromised

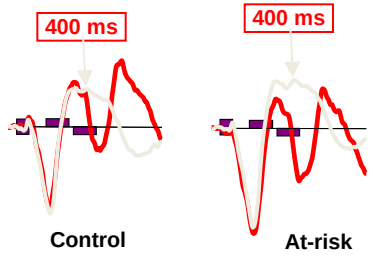
6-month-ERPs are related to letter naming skills at 5.5 years

ERP at the left hemisphere (C3)



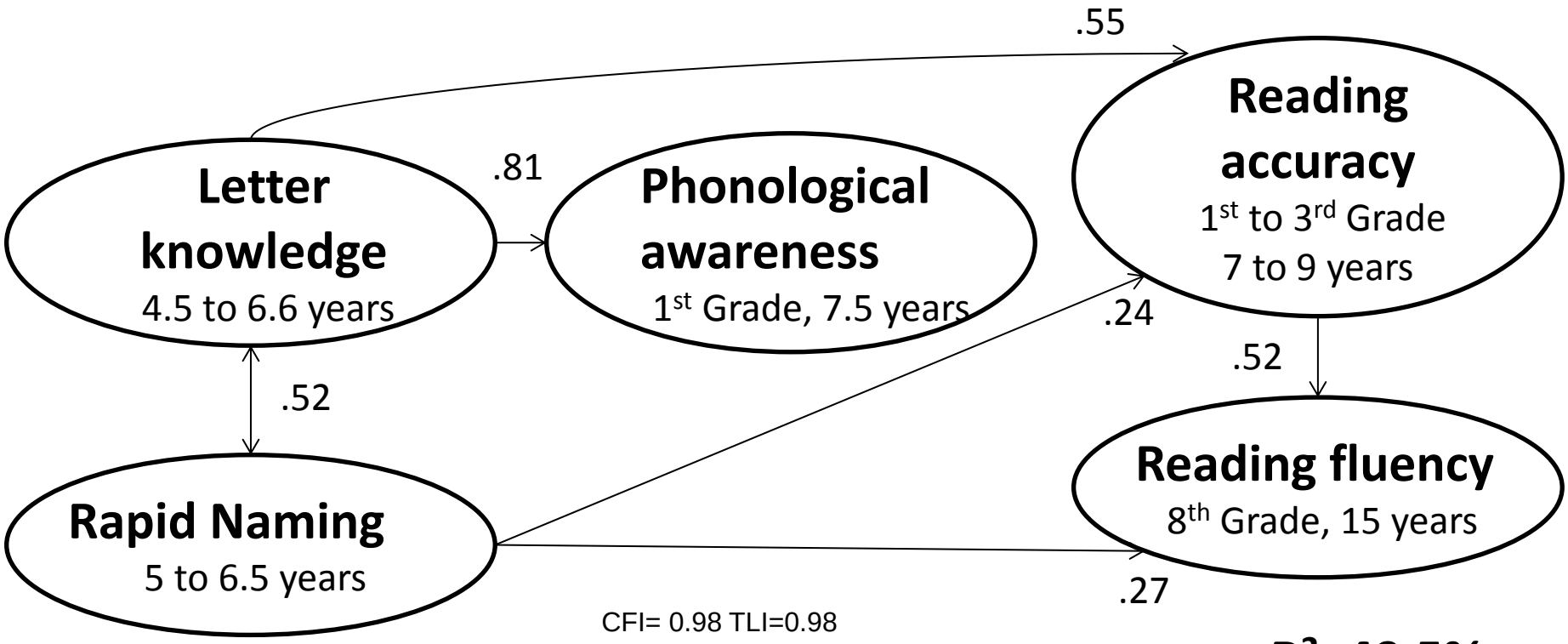


Control group (N=27)



At-risk group (N=27)

Predicting reading fluency



CFI= 0.98 TLI=0.98

RMSEA=.043, SRMR=.036

chi= 112.063 (df=82), p=.004

N=200

R^2=49.5%

Observing developmental routes to dyslexia

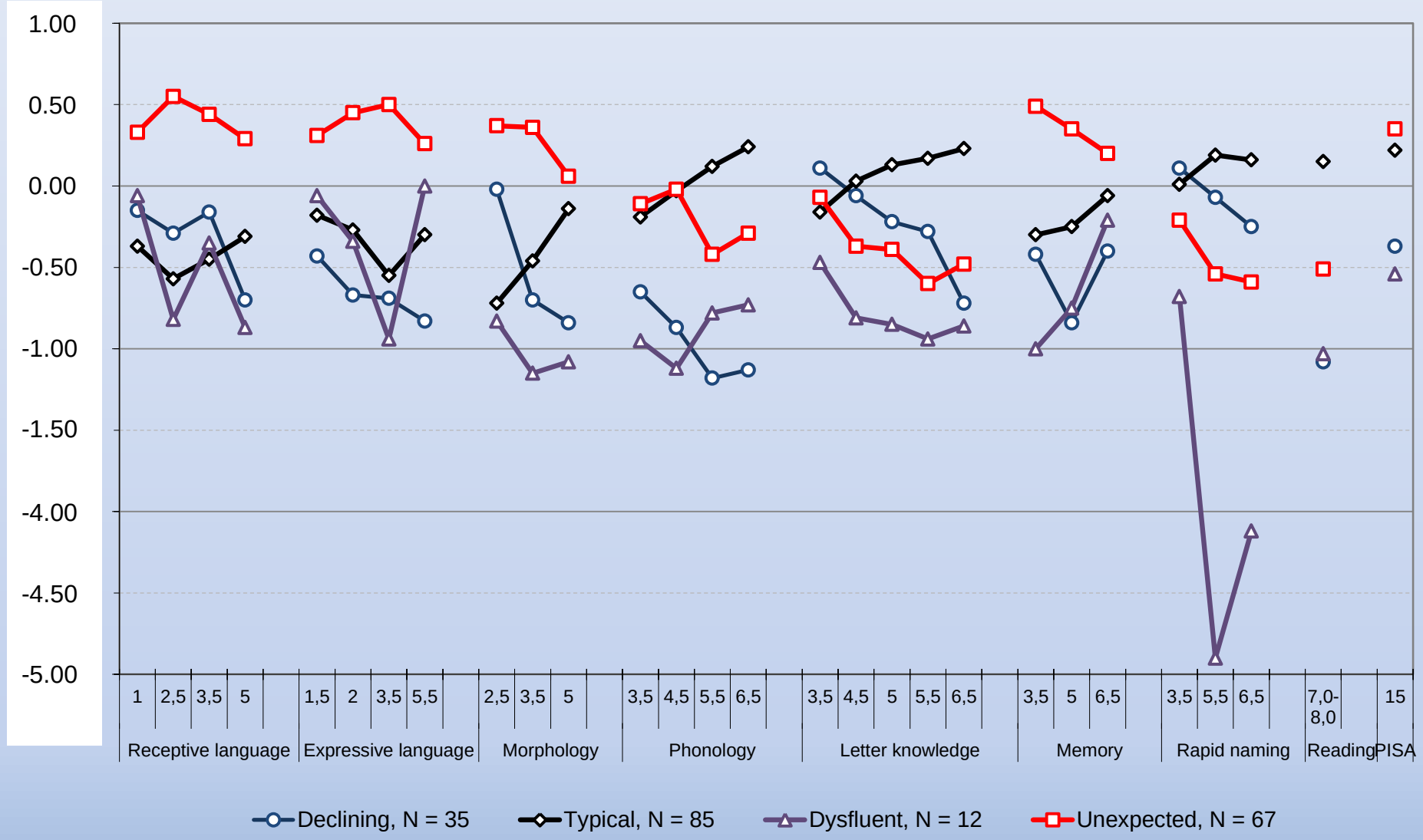
- Predictive domains, assessment ages from 1-6.5 y Alpha*
  - Receptive lang. 12,14,18mo, 2.5, 3.5, 5.0 y .78
  - Expressive lang.12,14,18 mo,2.0, 2.5, 3.5, 5.5 y .93
  - Morphology 2.5, 3.5, 5.0 y .76
  - Verbal short term memory 3.5, 5.0, 5.5, 6,5 y .75
  - Rapid serial naming 3.5, 5.5, 6.5 y .89
  - Letter knowledge 3.5, 4.5,5.0, 6.5 y .72
  - Phonological skills 3.5, 4.5, 5.5, 6.5 y .82
  - IQ 5.0
- Outcome measures used as a composite of the following measures:

  Reading accuracy (Aug.,Jan.,May), Fluency (Aug.,Dec.,April,May/1 gr, Nov/2.gr), Spelling (Dec., Apr,/1.gr Nov/2.gr) and Comprehension (Apr./1gr. And Nov/2.gr)

Lyytinen et al., Merrill-Palmer Quarterly, 2006

Profiling of the subgroups of the reading related developmental differences

- Method: Latent profile analysis – variances set as equal between groups
- Program: MPLUS (including imputing the missing data)
- Estimation method: Maximum likelihood parameters estimates with robust standard error
- Criterion: Bayesian information criterion
- N=199

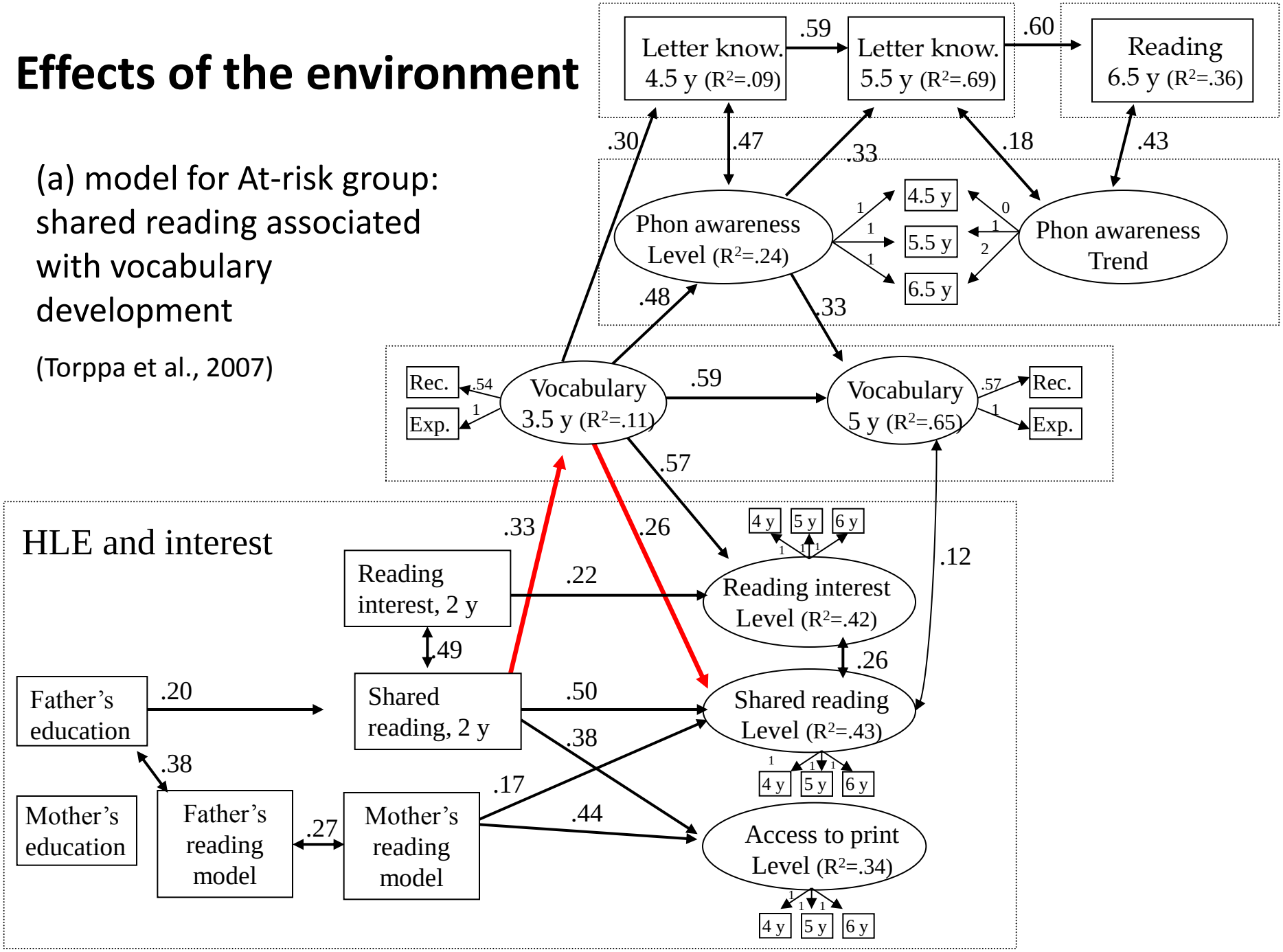


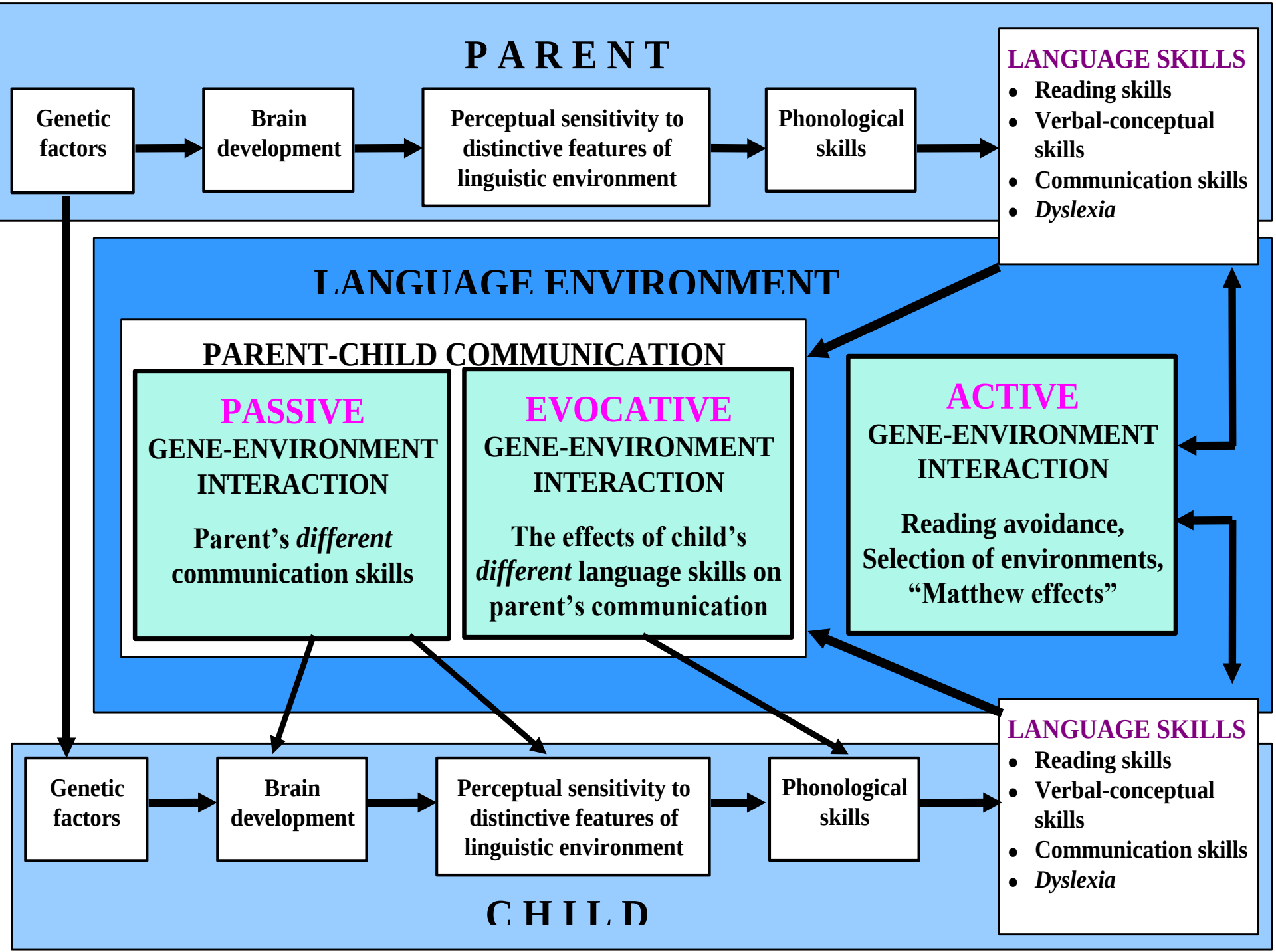
Profiles of early cognitive skills for different subgroups across ages 1 to 6.5 years, their average performance in reading and writing composite score across Grade 1 and 2, and PISA reading composite at 15 years of age. (Modified from Figure 1 in Lyytinen et al., Merrill-Palmer Quarterly, 2006)

Effects of the environment

(a) model for At-risk group: shared reading associated with vocabulary development

(Torppa et al., 2007)




PARENT
Genetic factors
Brain development
Perceptual sensitivity to distinctive features of linguistic environment
Phonological skills
LANGUAGE SKILLS
Reading skills
Verbal-conceptual skills
Communication skills
Dyslexia
LANGUAGE ENVIRONMENT
PARENT-CHILD COMMUNICATION
PASSIVE
GENE-ENVIRONMENT INTERACTION
Parent's different communication skills
EVOCATIVE
GENE-ENVIRONMENT INTERACTION
The effects of child's different language skills on parent's communication
ACTIVE
GENE-ENVIRONMENT INTERACTION
Reading avoidance, Selection of environments, "Matthew effects"
Genetic factors
Brain development
Perceptual sensitivity to distinctive features of linguistic environment
Phonological skills
LANGUAGE SKILLS
Reading skills
Verbal-conceptual skills
Communication skills
Dyslexia
CHILD

For more details, please, see..

Torppa, M., Poikkeus, A.-M., Laakso, M.-L., Leskinen, E., Tolvanen, A., Leppänen, P. H. T., Puolakanaho, A., Lyytinen, H. (2007). Modeling the early paths of phonological awareness and factors supporting its development in children with and without familial risk for dyslexia. *Scientific Studies of Reading*, 11(2), 73-103.

Torppa, M., Poikkeus, A.-M., Laakso, M.-L., Eklund, K., and Lyytinen, H. (2006). Predicting delayed letter name knowledge and its relation to grade 1 reading achievement in children with and without familial risk for dyslexia. *Developmental Psychology*, 42(6), 1128-1142.

Torppa, M., Tolvanen, A., Poikkeus, A-M. Eklund, K., Lerkkanen, M-K., Leskinen, E., & Lyytinen, H. (2007). Reading Development Subtypes and Their Early Characteristics. *Annals of Dyslexia*, 57, 3-52.

Eklund, K.M., Torppa, M., & Lyytinen, H. (2013). Predicting reading disability: early cognitive risk and protective factors. *Dyslexia, 19 (1),* 1-10. doi: 10.1002/dys.1447

Eklund, K., Torppa, M., & Lyytinen, H. (2013). Early cognitive risk and protective factors in predicting dyslexia. In A. Fawcett, & K. Saunders (Ed.), *The Dyslexia Handbook 2013*, (pp. 60-68). Great Britain: British Dyslexia Association.

PREVENTION …

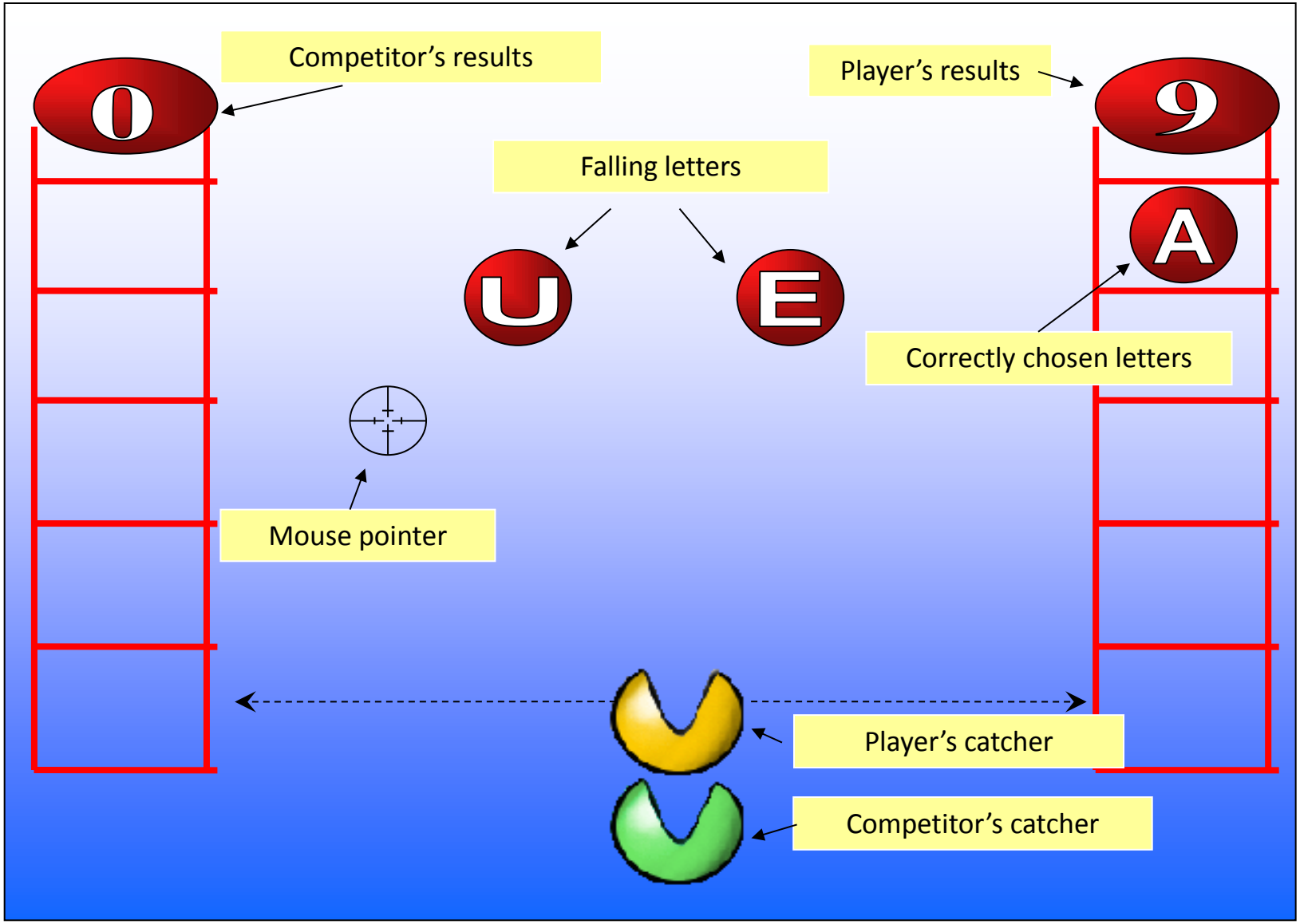
Learning game and research environment for the acquisition of the basic reading skill: Graphogame

helps

learning the connections between spoken and written language

Graphogame

The task: Catch the letter that matches the sound you hear!



For description of the Graphogame , see Lyytinen et al. Scand.J.of Psychol. 2009, 50, 668-675.

A learning environment for L1 and L2 spoken and written languages: Graphogame

Introduces reading skill of any wanted language

Teaches the phonetic basis of language with the help of written language

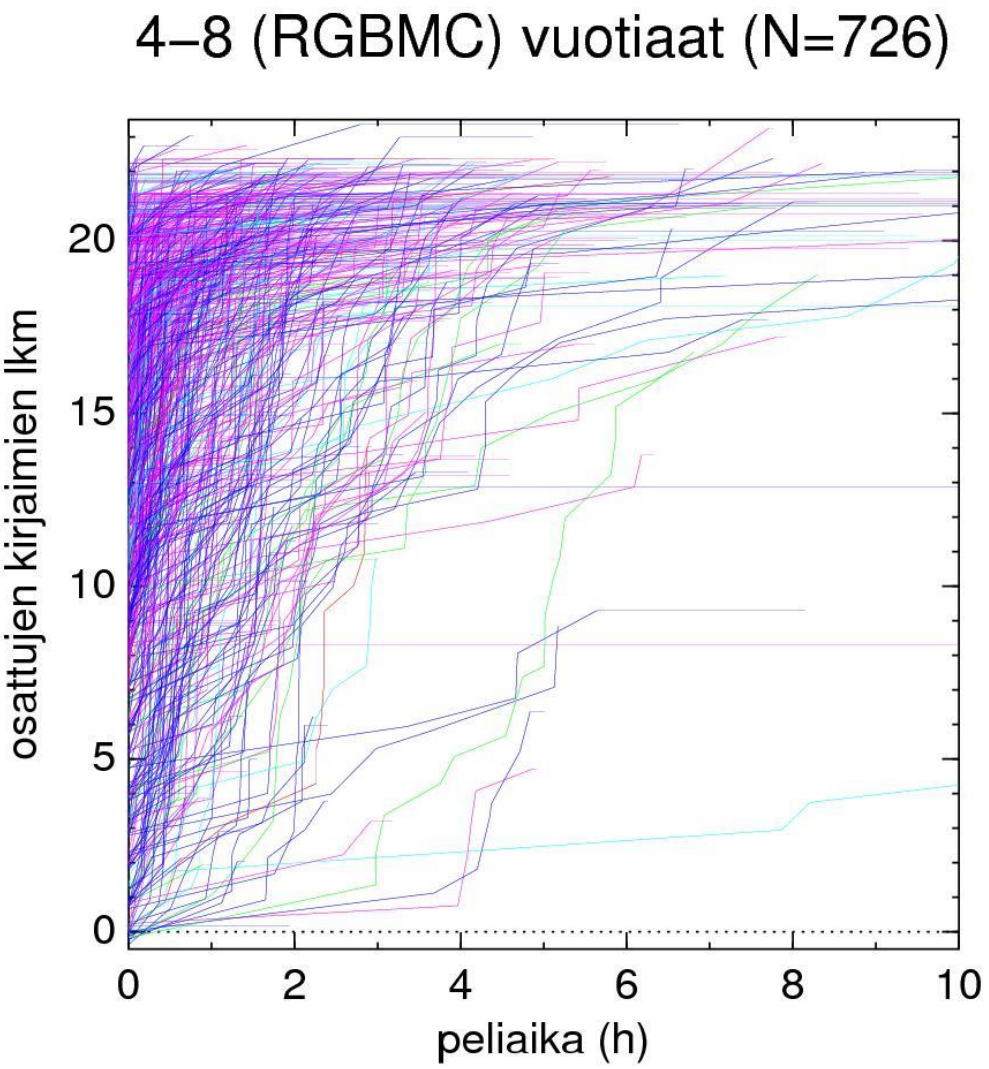
- Tunes the speech perception for the use of a wanted language
- Helps in training correct pronunciation of the sounds of a language
- Introduces spoken words (vocabulary) via drawn pictures and/or written language

How and where Graphogame works

- Applies phonics by drilling connections between spoken and written items; the written item representing the spoken target is chosen from 2-8 alternatives
- Proceeds from small to larger units, from letter-sounds to written and spoken words
- Adapts automatically to individual skills level
- Its use is most uncomplicated in transparent orthographies such as Finnish and African writing systems which have regular letter-sound connections, 1 sound <=>1 letter

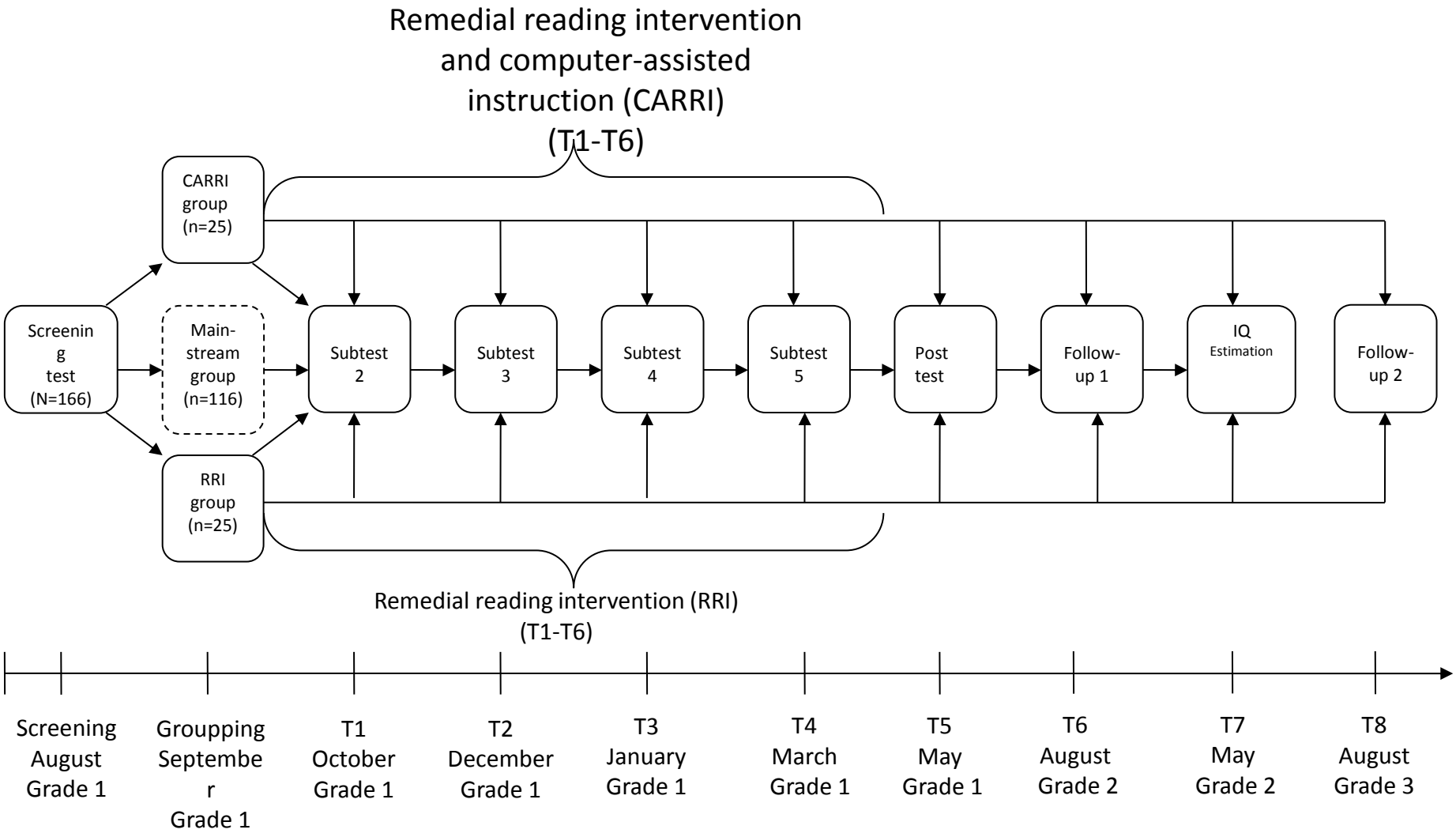
Exemplary learning curves of 4-8 year olds (N=726)

The cumulative number of learned items



Hours of playing

Modelling: Janne Kujala

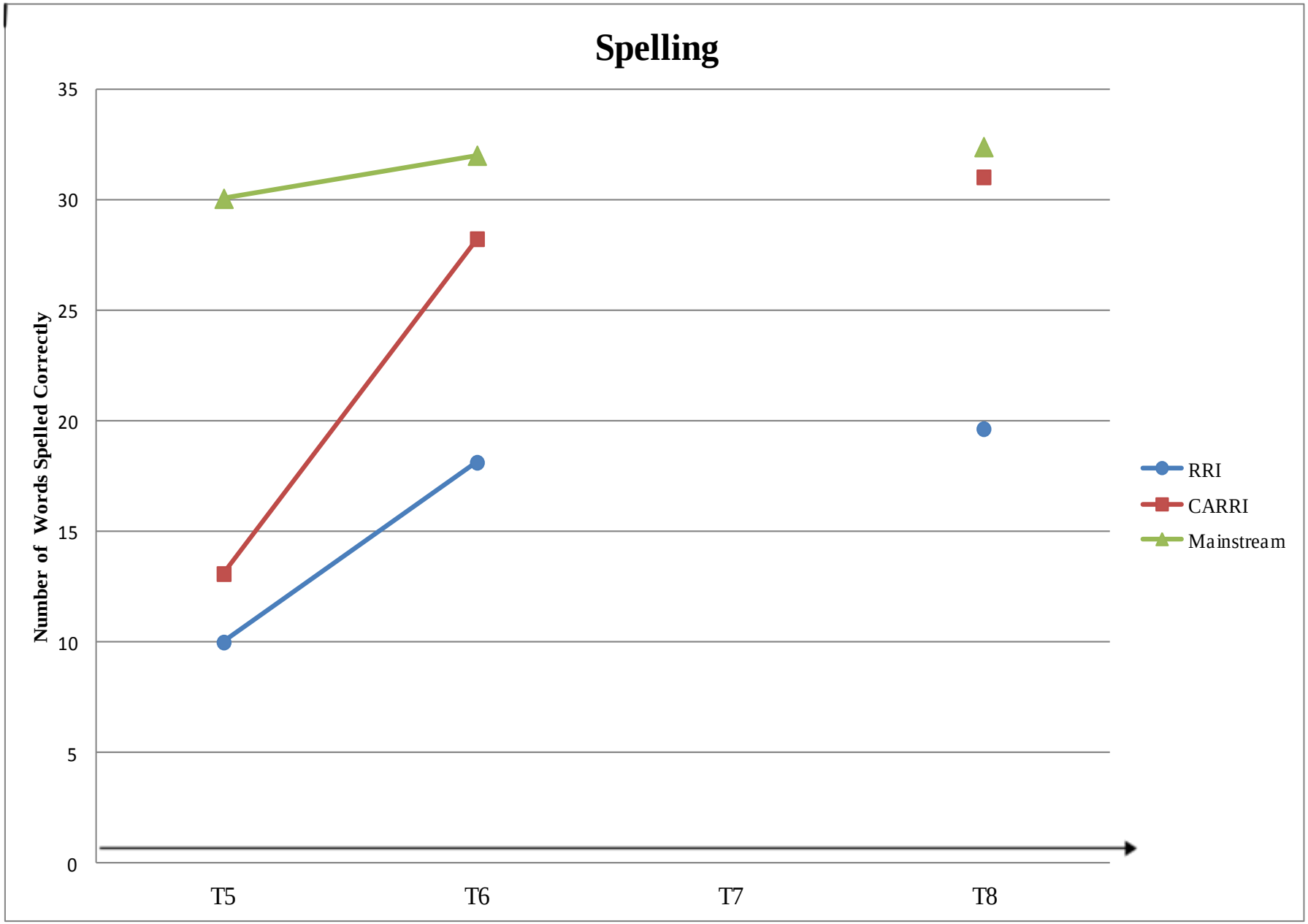


CARRI group = Computer assisted remedial reading intervention group
Mainstream group = Mainstream reading instruction group
RRI group = Remedial reading intervention group

(=1/4 of the remedial reading support session)

Saine et al., (2011) Child Development, 2011, 82, 1013-1028.

Saine et al., 2011, Child Development

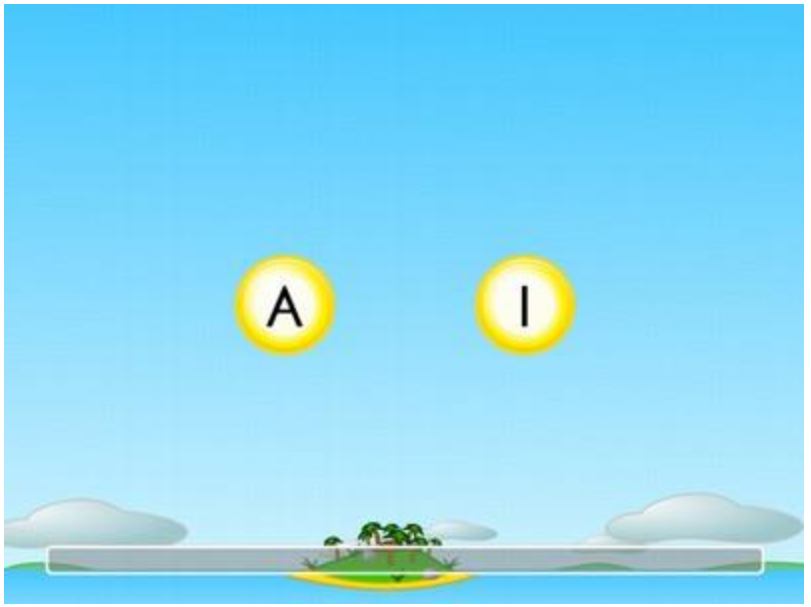


Saine et al., Child Development, 2011, 82, 1013-1028

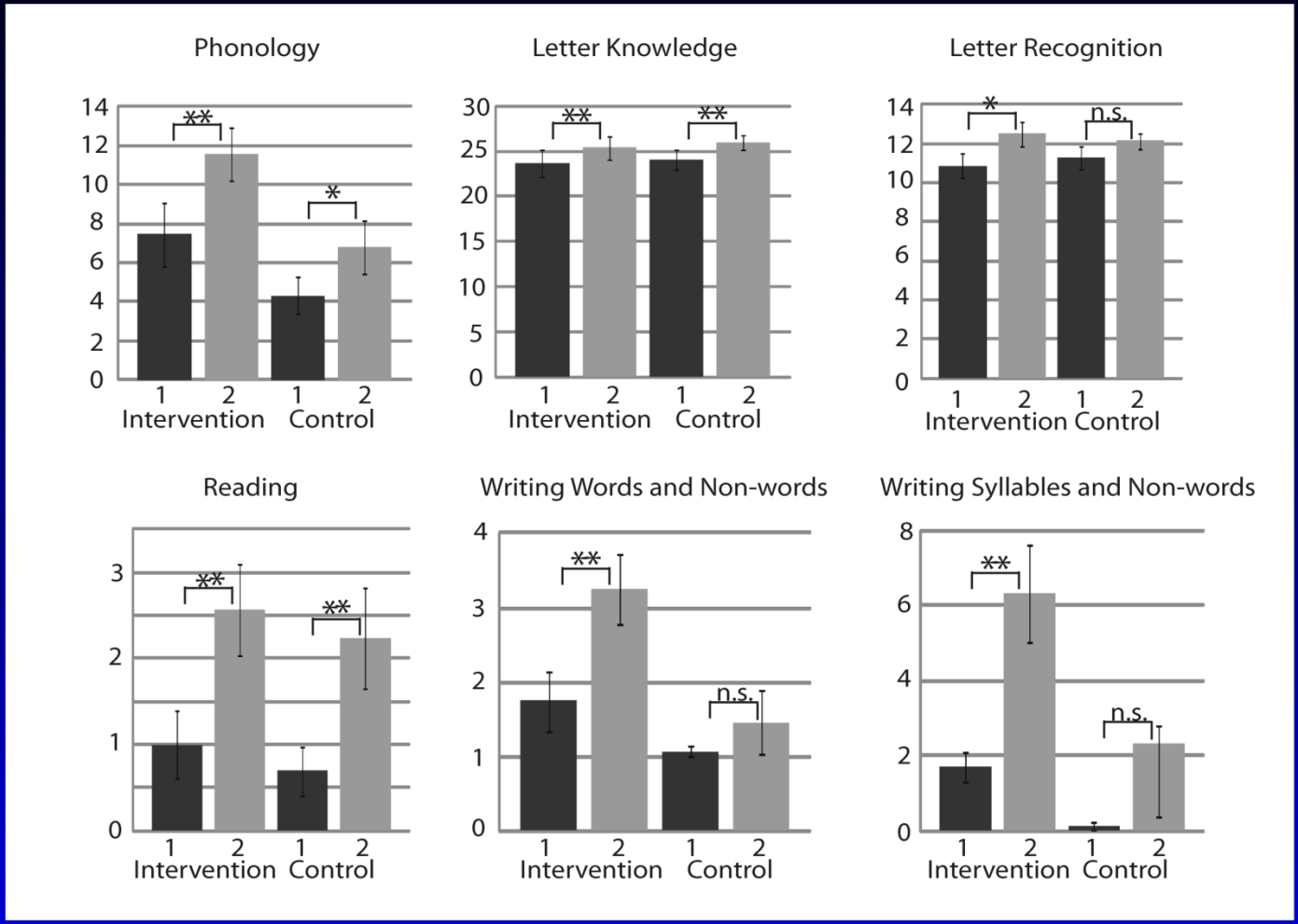
Training pre-schoolers at risk for dyslexia

(from Lovio et al. Brain Research, 2012)

- 3 hours of training of 6.5 year old kindergarten children at risk (in short ~10 mins sessions):
  - Graphogame (GG) training group: matching speech sounds with letters
  - Control group: GG calculation exercises
- Comparison and follow up of:
  - Pre-reading skills
  - MMN responses for vowel and vowel duration changes



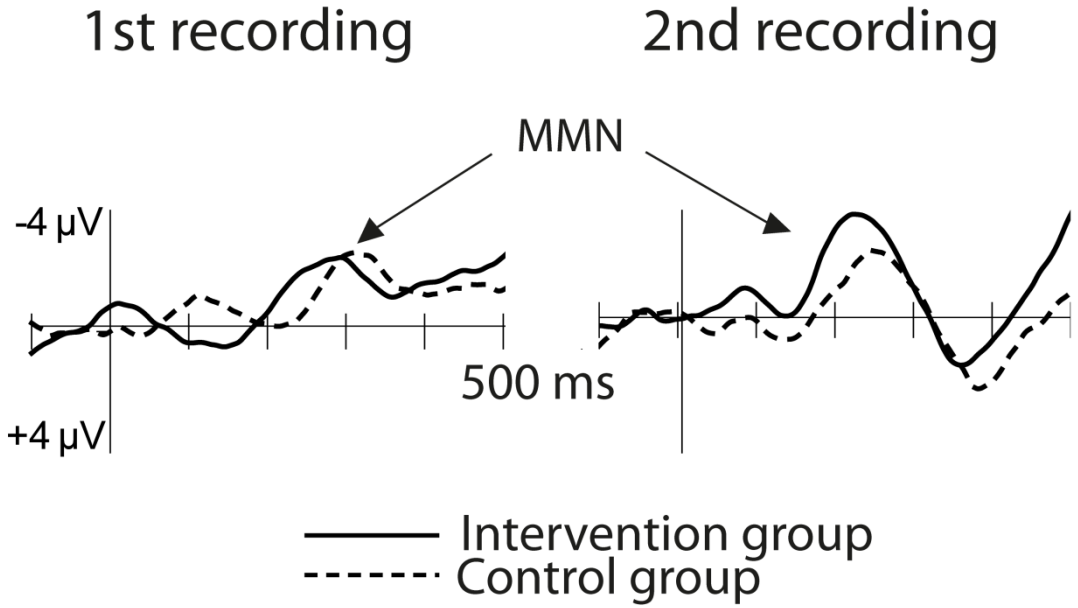
Intervention effects on pre-schoolers at risk for dyslexia



Before training: no group differences
After training: Intervention group better in phonological processing and in writing words and non-words

Lovio et al., *Brain Res.*, 2012

Intervention effects on preschoolers at risk for dyslexia

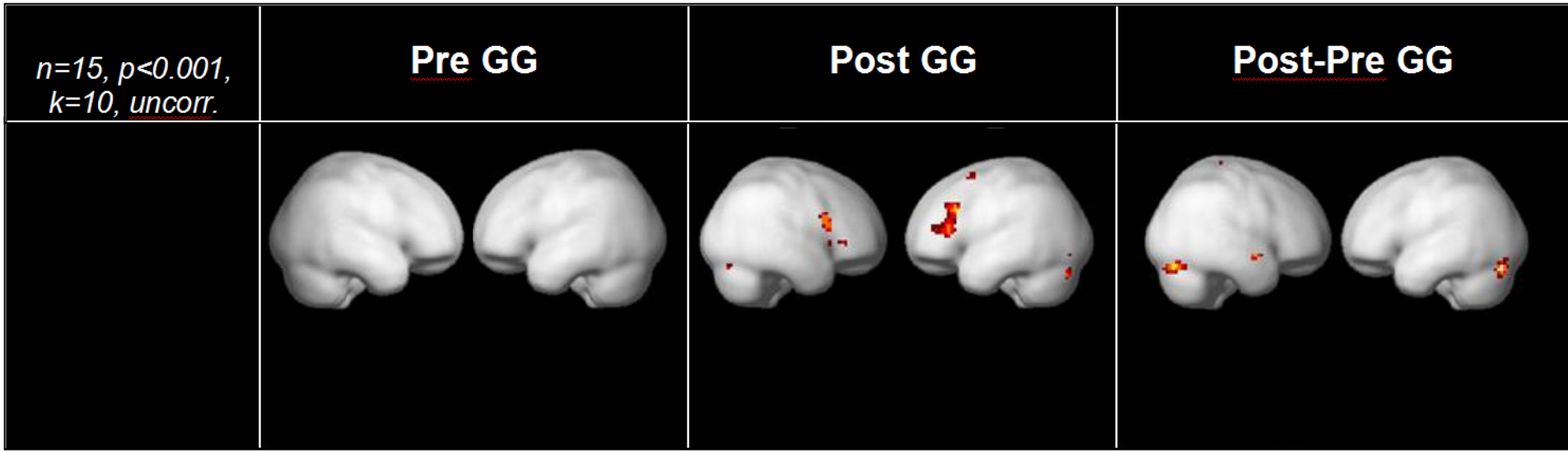


Lovio et al., Brain Res., 2012

GG training of <5 hours affects brain

HL and UR in collaboration with Swiss colleagues Daniel Brandeis, Sylvia Brehm

Pre-Post GG: Children (n=15) before and after playing with Graphogame



Post-pre interaction between groups playing Graphogame vs Mathgame (same with numbers): ***p<0.005***

Brem et al., PNAS, 2010, 107(17), 7939-7944.

Successful preventive practice

Massed practice following optimal phonics strategy helps

at risk children **when started at >6.5y of age**

>>**played >1 x per day in subsequent days until the goal is reached**

- motivated to be used in an as ”active” form as possible
- motivation to continue is guaranteed by rewarding via experience of success (~80% correct trials)
- the role of parents: they show they very much like child plays GG

See: www.lukimat.fi (where Finnish children play) or

graphogame.com for description and

demo in English

Challenges

- Works without complications in consistent (gr>=<ph) orthographies
  - Warning: may ”condition” the stimulus-response connections too deeply to allow easy relearning of different associations when there are alternative connections.
  - Therefore, only consistent relations can be drilled without any risk of losing the necessary flexibility (alternation of associations) typical of inconsistent orthographies.

An example of the statistical approach to illustrate the problems associated with consistency (or the paucity of it)

A mimimun set of single letter-sounds selected to a version of the game – list of their sounds present in > 5% of the occurrence of the letter in English text (Cedex databasis, among 17 million words)

Letter	% of different / all words			(exemplary word)
i	62.3	24076	3471217	I (in)
	19.4	4386	1083446	aI (i)
	5.1	2519	283459	(social)
l	95.4	22272	2934160	l (all)
d	94.4	14990	2844232	d (and)
m	100.0	11176	1817206	m (from)
b	99.0	7726	1169525	b (be)

Computation: J.Kujala

Connection building of written and spoken units of English

Alternative approaches:

- Small unit game: teaches graphemes of the most prototypical vowels, blends of CV and VC digraphs and combines into CVC words etc.
- Larger unit game: phoneme approach+large rime units, blends learned small set of ph/gr in CV rime units starting from most dense neigbourhoods with consistent spelling etc.

Results of the English Graphogame

with Usha Goswami and Fiona Kyle, Cambridge University

- Reading gains in standard scores (SS) per hour of playing:
  - Phoneme game 0.47 SS points
  - Rime game 0.68 SS points

  Note: ~0.3 in the most promising earlier interventions (Hatcher et al. 2006)

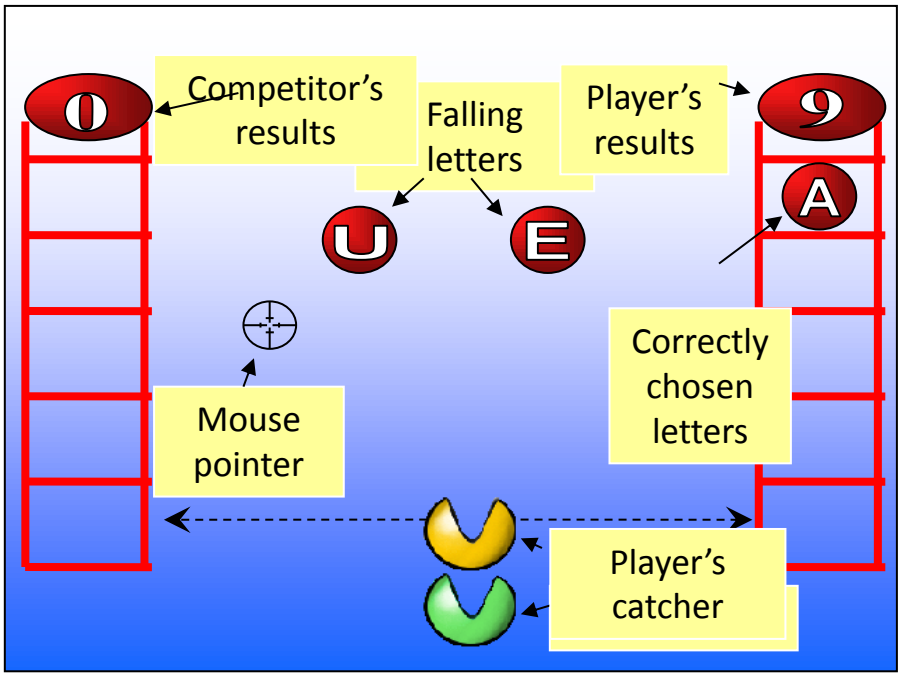
  Only rime game elevated significantly the spelling skill

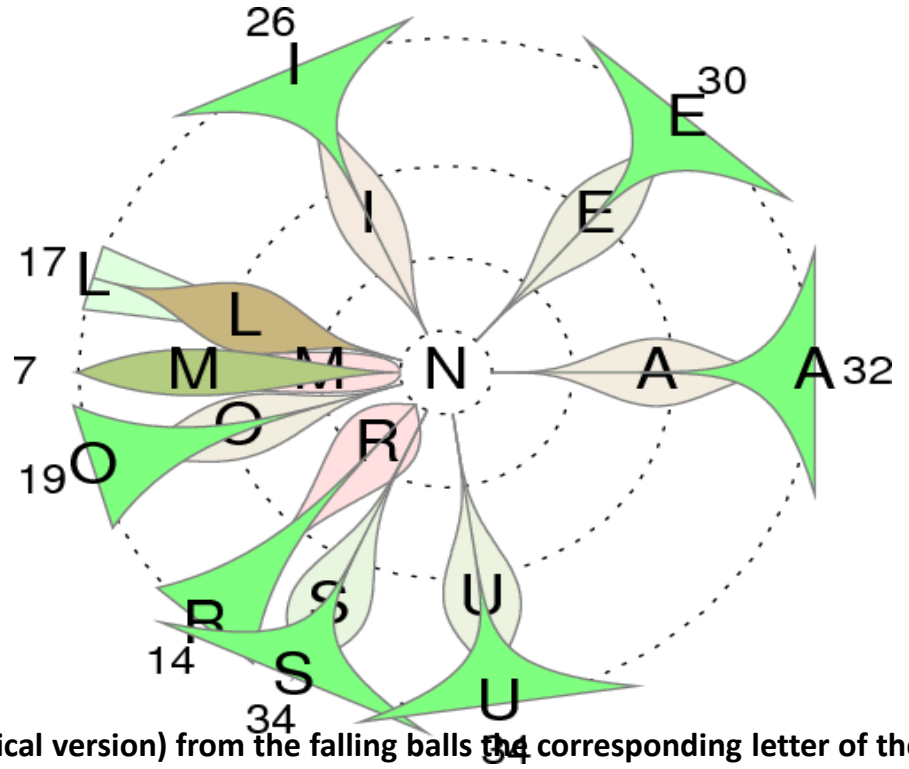
Kyle, Goswami et al., Reading Res. Q. 2012, 48, 61-76

Practical facts about the game

- Available for free to all Finnish children
  - Playing via net with up-to-date information for teachers and parents about learning difficulties
- Very easy to use – children learn within minutes and can use without adults
  - 4-10 hours of playing helps most at risk for dyslexia
- Works also in Symbian & Android mobile phones
- Used in Finland also for learning L2 pronunciations

Graphogame – an enjoyable mobile or computer game for learning to read: How it helps at risk children to overcome the fuzziness of the phonemic representations with letters





Description. In the game (left) the learner is choosing (in its classical version) from the falling balls the corresponding letter of the one s/he hears from headphones. The illustration (right) shows an example of how results can be followed. Here we follow how /N/ sound (in the centre) which learner has heard in the game more than 100 trials at the moment this picture is printed from the game logs has made him/her to choose incorrect alternative letters (shown with the number of times these have occurred with the correct N-letter). The red distributions reveal that the learner has had difficulties in **not** to choose R and M during the first fourth of such trials, but became able to learn during the last fourth (with green distribution) that e.g.R does not represent the /N/ sound. For this learner acquiring that the /N/ sound is **not** represented by M-letter has been a real challenge as shown by the red and darker green distributions which reveal that most of the choices during the first and second fourths of trials (respectively) have ended up to this mistake. The learner has failed to learn to identify the correspondence of the /N/ sound during the whole session in trials where M has occurred (7 times) as an alternative. On the other hand s/he has not chosen e.g. S to represent the /N/ sound any more during the last fourth of the trials (no misidentifications during the 9 last of the 34 trials with S as an alternative). For more details, see Lyytinen et al., Scand.J.Psychol., 2009, 50, 668-675 and for documentation of the efficiency of the game in supporting learning among at risk children, see eg. Saine et.al., Child Development , 82,3,1013-1028.

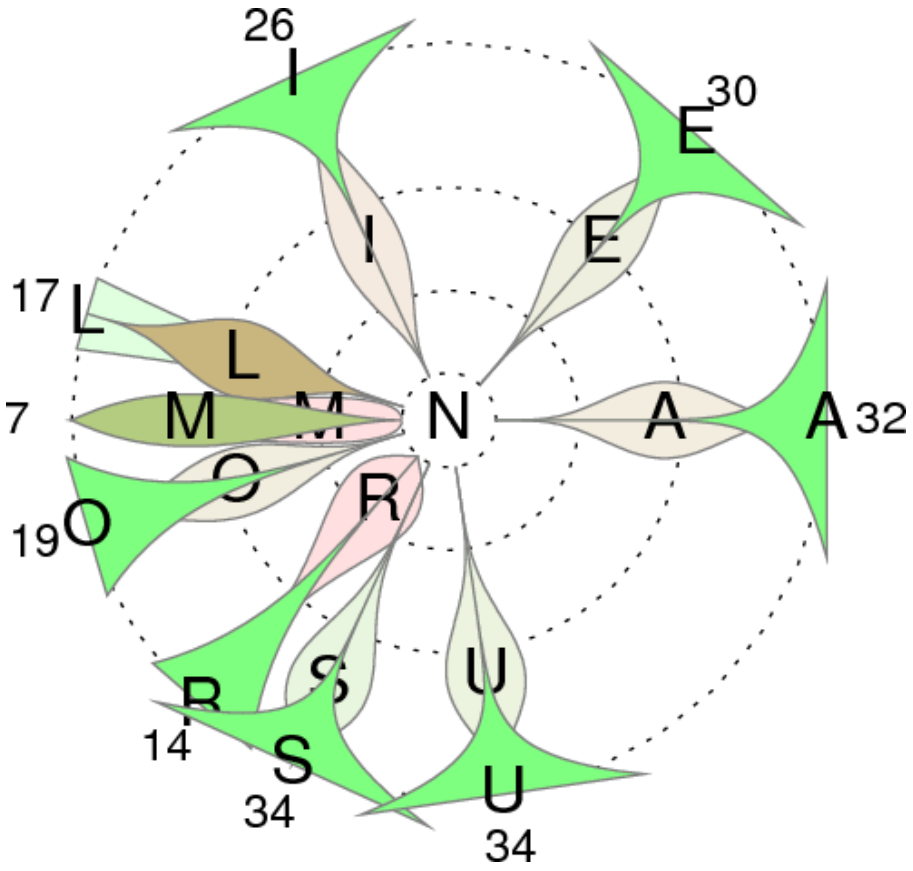


Illustration of the game developed by Janne Kujala

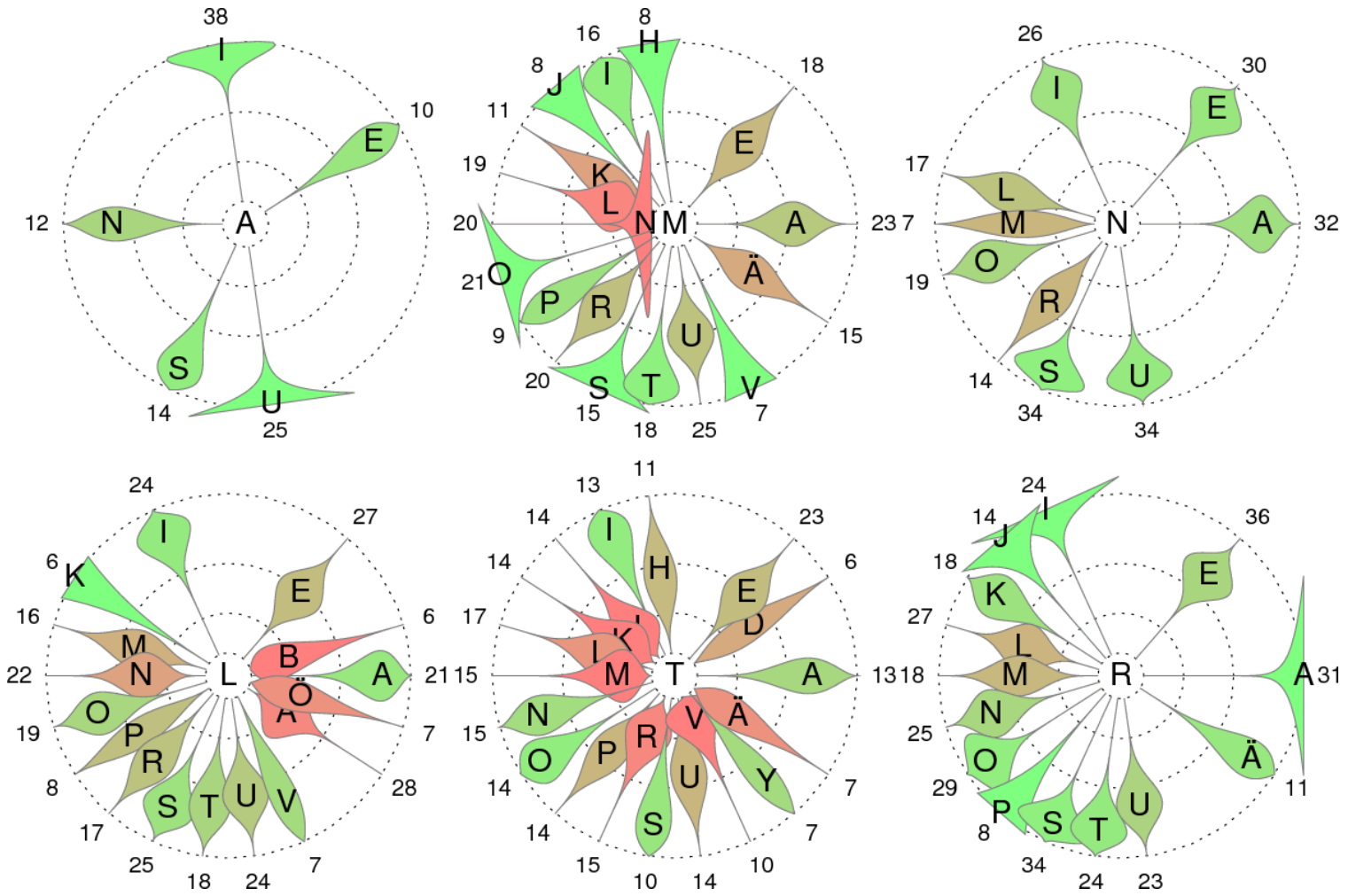


Illustration of the game developed by Janne Kujala

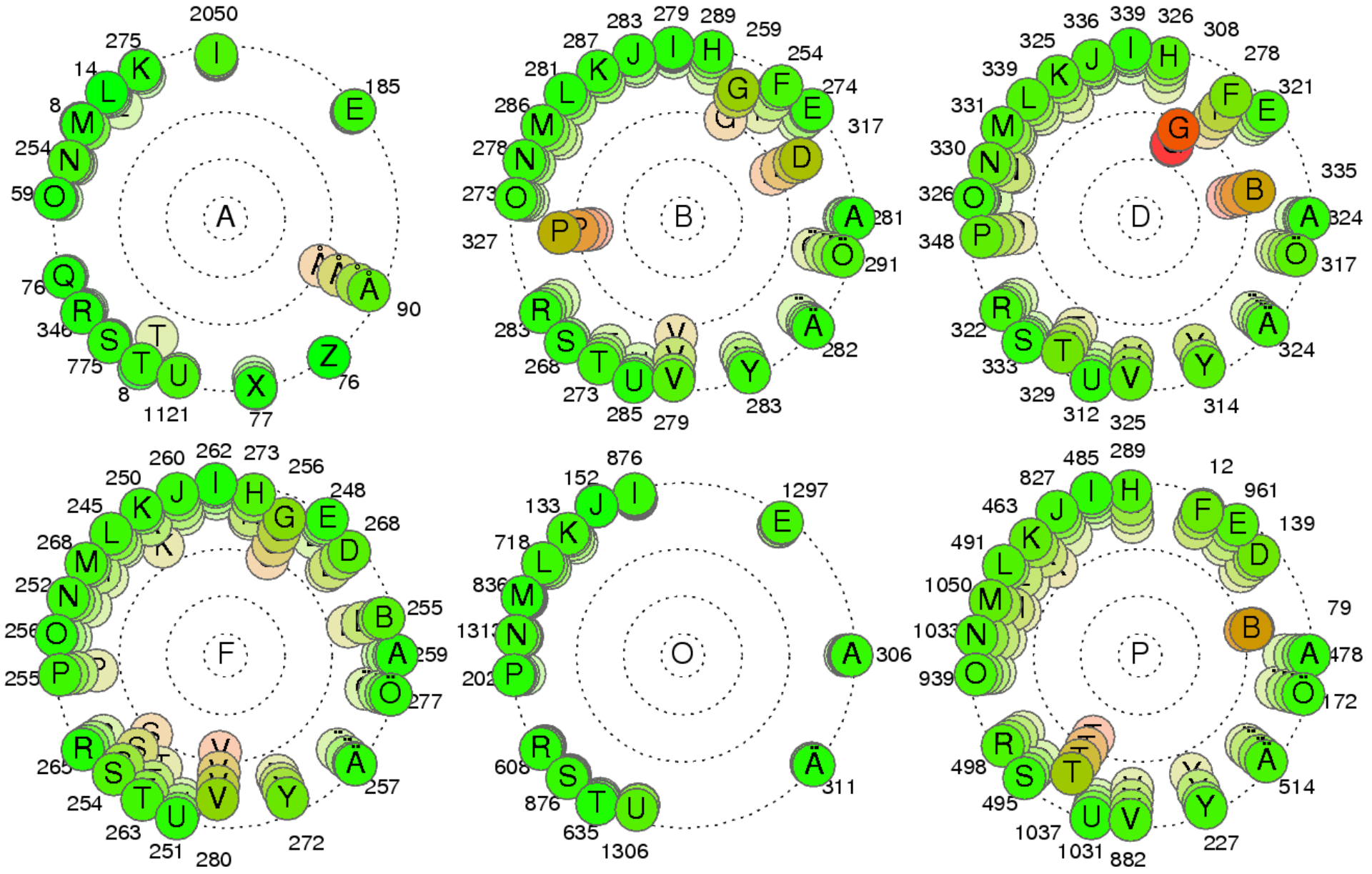


Illustration of the game developed byJanne Kujala

Graphogame as an assessment tool

- Dynamic assessment:
  - Online follow-up of the results of learning connections between spoken and written items
  - Immediate application of the observed results to guiding the training to bottleneck areas

  i.e. integrating assessment and intervention as made in the response-to-intervention model with the exception that the cycle of refocussing intervention can happen in seconds

GRAPHOGAME model

- In Finland today – at best 20 000 daily users
- Ekapeli/Graphogame used under the responsibility and funding of the Ministry of Education
- Centralized monitoring and feedback from Agora
- Could work as main model for implementations elsewhere as well

Grapho Learning Initiative

Our vision is

to **help millions of people**,

who otherwise would not have access

to a **basic skills**, such as **reading**,

and be able to launch themselves

to a sustainable **learning** curve

and a **road to prosperity**.

www.graphogame.com

Compromised reading skill

Biological reasons (% of population)

- **Global > 5%**
- **Finland > 3%** (and other transparent languages)

Educational reasons

- **Global - up to 90%** (in developing countries)
- **Finland – 0%**

Globally 780 000 000 people are illiterate

- Biologic, educational and social problems

Learn to read with a fun mobile game

- Research evidence on learning the alphabets in a few hours of learning with the help of the GraphoGame™ methodology.

Low cost solution for developing countries

- Schools are the best place to learn for most children, but low cost tablet devices and mobile games are able to reach the homes also in Africa within next not so many years.
-
- Ministries of Education: training, learning, analytics.

The basic principles of Graphogame development for a new writing system see, grapholearn.info

- Careful study of the written language environment with local experts for developing appropriate content
- Evidence based documentation of the efficiency of the game after a new implementation of content for a new context
- Distribution and use under the responsibility of the local Ministry of Education after research has shown its efficiency in an orthographic environment

Global Network

Research And Development Partners
GraphoWorld Network of Excellence

GraphoGame® as a Service

Learning

Analytics

GraphoGame® Cloud

Dynamic assessment, analysis and adaptation to learners skills.

GraphoGame® as download and/or online

Online learning material, videos, ebooks and guides

Teacher training, Classroom and/or GraphoGame® Club support.

Gamelogs
Database
Big Data

Training

Who needs GraphoGame™ and how to get it?

- Children learning to read
  - 1.-2. grades of school – most appropriate age - 7y
  - all in need of effective help in learning to read
- Download from our server www.graphogame.com or graphogame.info
  - Play at school or at home
  - Access via pc, tablet, mobile

Note: language versions are pending.

GraphoGame™
Pre-releases, for testing

- Studies initiated in Europe (outside Finland)
  - Austria, Cyprus, Denmark, Estonia, France, Hungary, Ireland, Israel, Netherlands, Norway, Poland, Portugal, Sweden, Switzerland, UK
- Studies running in Africa
  - Kenya, Namibia, Tanzania and Namibia
- Elsewhere (at least beginnings)
  - Canada, Chile, China, Taiwan and US

Jyväskylä Longitudinal study of Dyslexia (JLD) & Graphogame – our tool for the prevention of RDs

The Jyväskylä Longitudinal study of Dyslexia (JLD):

An intensive follow-up of children at familial risk for dyslexia from birth

> JLD 1994-

*Mikko Aro, *Timo Ahonen, Kenneth Eklund, Tomi Guttorm, *Leena Holopainen, Jarmo Hämäläinen, Ritva Ketonen, *Marja-Leena Laakso, Seija Leinonen, *Paavo Leppänen, ^Matti Leiwo, *Marja-Kristiina Lerkkanen, Kaisa Lohvansuu, ^Paula Lyytinen, Anna-Maija Oksanen, Kurt Muller, *Anna-Maija Poikkeus, Anne Puolakanaho, *Ulla Richardson, Paula Salmi, *Asko Tolvanen, *Minna Torppa, Helena Viholainen

> Graphogame (in Finland)

Ekapeli/Graphogame (ks.www.lukimat.fi; www.graphogame.com): Mikko Aro, Jane Erskine, Riikka Heikkilä, Sini Hintikka (Huemer), Ritva Ketonen, Janne Kujala, Emma Ojanen, Mikko Pitkänen, Miia Ronimus, Niina Saine, **Ulla Richardson**
Learning game programmers: Iivo Kapanen, Ville Mönkkönen, Miika Pekkarinen

Supported by EU,Niilo Mäki Foundation,The Academy of Finland,Univ.of Jyväskylä ,Tekes, RAY, Ministries of Education & Foreign Affairs Finland, NokiaOy,KoneOy, WärtsiläOy, Kela,The Finnish Cultural Funds

For more.., please,

- Call: +358 50 552 4892
- See for Unesco Chair: www.jyu.fi/unescochair
- Have a look of our research: heikki.lyytinen.info
- Ask for reprint(s): heikki.lyytinen@psyka.jyu.fi
- The game pages in Finnish: http://www.lukimat.fi/
- ..in English: http://www.graphogame.com
- See also graphogame.info for the whole approach
- Open access summary: Human Technology, May 2014

Thank you for attention!