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AGORA CENTER
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United Nations
Educational, Scientific and
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UNESCO Chair on
Inclusive Literacy Learning for All
University of Jyväskylä

Niilo Mäki
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# Opening the Mysteries of Dyslexia and Ways to Prevent Problems Faced In the Acquisition of Literacy

*Heikki Lyytinen*
*UNESCO Chair/professor*
*on Inclusive Literacy Learning for All*
*University of Jyväskylä, Finland*

For more, see heikki.lyytinen.info, grapholearn.info & comprehensiongame.info

**5th Global Conference on Neuroscience and Neurological Disorders, Berlin, Germany 04.11.2022**

# Compromised reading skill

**Biological reasons** (% of population)

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

**Educational reasons**

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

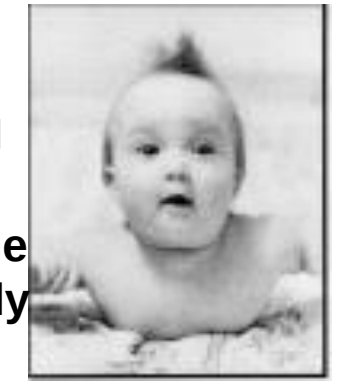
- **>600 million compromised readers!**

# Important facts about reading acquisition

- Reading acquisition = learning to connect items of spoken language to their written forms
- Written languages vary in terms of how this connection-building can be made
- Alphabetic orthographies such as Finnish, German, Spanish and African local languages are relatively **consistent** at grapheme-phoneme level **>no challenges associated with choosing the written items which one had to be able to connect to its spoken form** >>very different in English where none of its letters represents the same phoneme in all contexts of written English – especially difficult concerning vowel items
- Nonalphabetic scripts – the main challenge: large number of connections to be stored for acquiring the reading skill

# Early identification and prevention of problems of children in need of help to acquire literacy

## – results from the Jyväskylä Longitudinal study of Dyslexia (JLD)



an intensive follow-up of children at familial risk for dyslexia from birth to adulthood

**GraphoLearn-technology for the prevention of RDs, helping all in need of support for acquiring the basic reading skill and Comprehensiongame to acquire full literacy in whatever language/writing environment globally**

### > JLD 1994-

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

### > GraphoLearn technology (Ekapeli in Finland, 2004-), the Finnish team members

Ekapeli/Graphogame (ks.www.lukimat.fi / grapholearn.info): Mikko Aro, Jane Erskine, Jarkko Hautala, Riikka Heikkilä, Sini Hintikka (Huemer), Ritva Ketonen, Janne Kujala, Juha-Matti Latvala, **Heikki Lyytinen** Lea Niemelä, Marko Niemelä, Emma Ojanen, Mikko Pitkänen, Suzanne Puhakka, Miia Ronimus, Nina Saine, Paula Salmi, Vesa Rantanen, **Ulla Richardso*n***

*Learning game programmers*: Iivo Kapanen, Ville Mönkkönen, Miika Pekkarinen

### > ComprehensionGame (Tokapeli in Finland, 2022-, see comprehensiongame.info)

Heikki Lyytinen and *programmers*: Kristian Jeskanen, Panu Nummelin, Pyry Lappalainen

JLD supported by EU, Niilo Mäki Foundation, Academy of Finland, Univ. of Jyväskylä, Tekes, RAY, Ministries of Education & Foreign Affairs Finland, Kela, Finnish Cultural Funds, Nokia, Kone, Wärtsilä

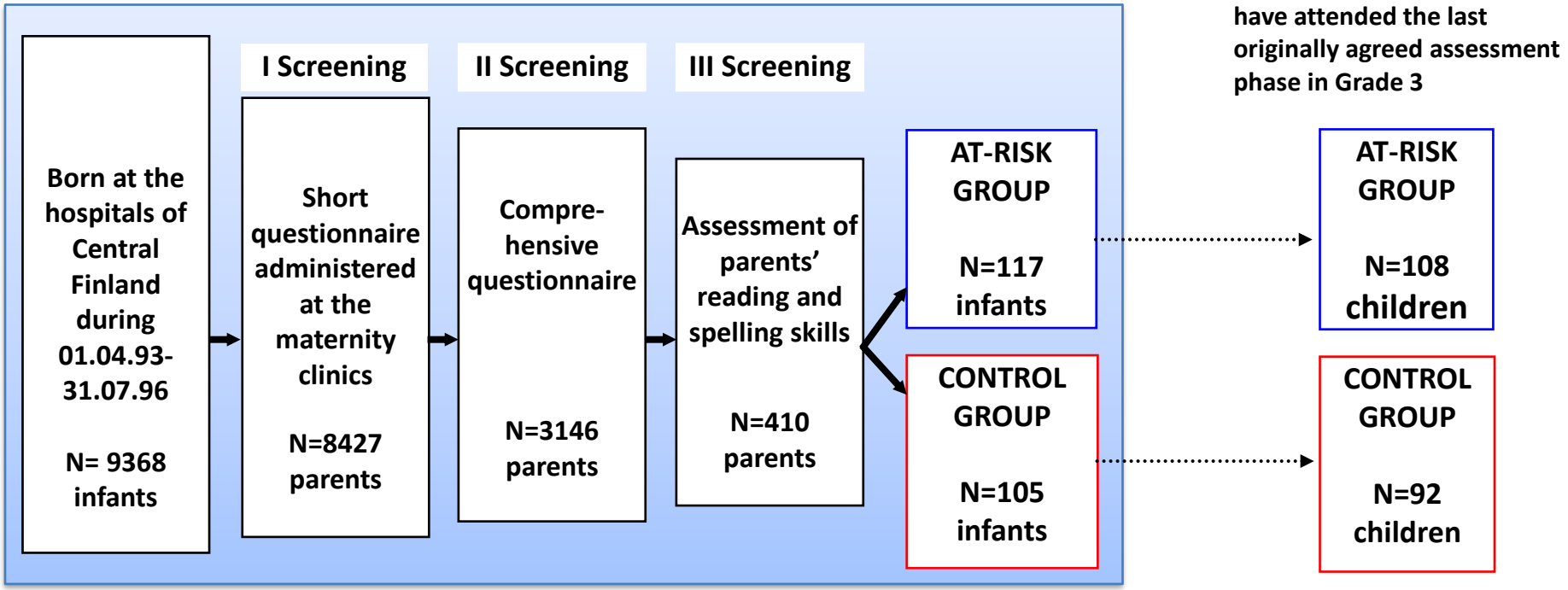
# The goals of the JLD following children with familial risk for dyslexia from birth

**to identify (from children at familial risk for dyslexia)**

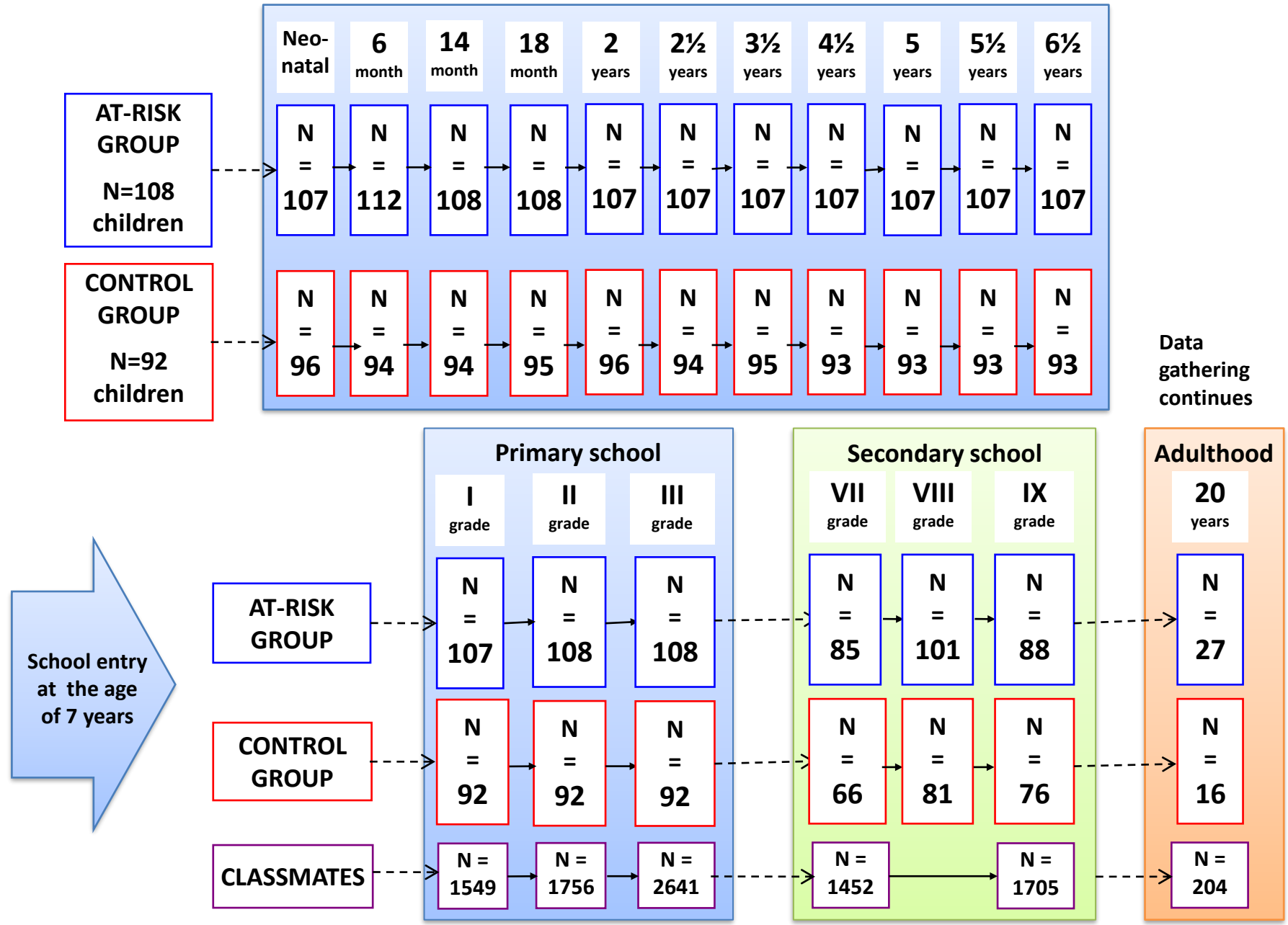
- **precursors of dyslexia**
- **predictors of compromised acquisition**
- **developmental paths leading to dyslexia**

**The last step: the development of preventive measures**

# SCREENING OF THE FAMILIES



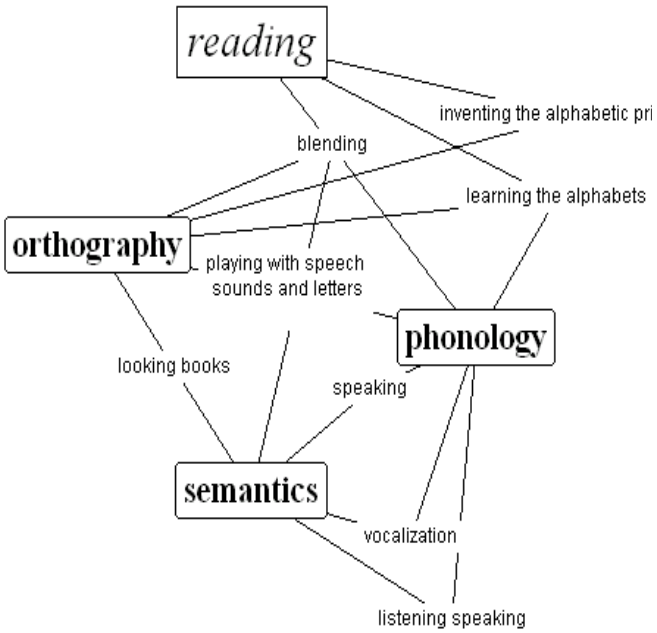
# PHASES OF ASSESSMENTS



# IDENTIFYING & PREDICTING RISK

## Statistically significant predictors of reading acquisition among the children of the Jyväskylä Longitudinal study of Dyslexia

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 |
| 3-5 days | ERP to speech sound | P & D |

3-5 days ERP to sinusoidal sound/pitch differentiates the halves of at risk children who will or will not faces dyslexia

Lyytinen et al., Annals of Dyslexia, 2004; Dyslexia, 2004; Sage Handbook of Dyslexia, 2008; Leppänen et al. Cortex, 2010

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

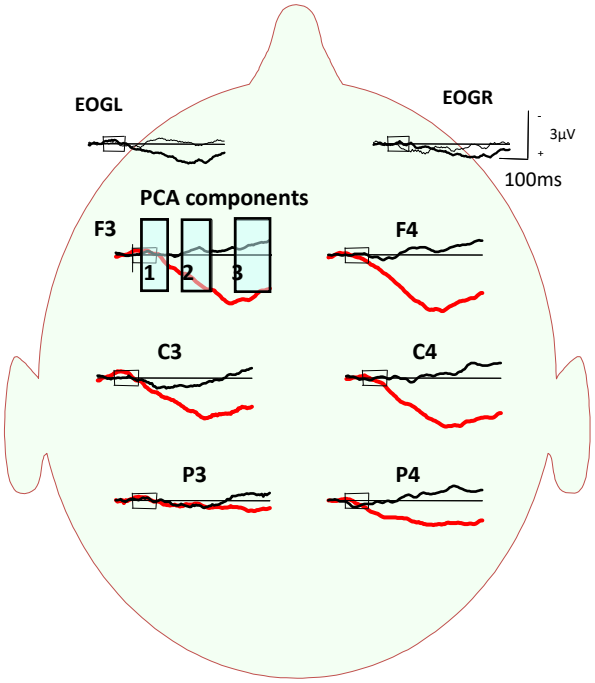
- **Expectation when one parent with dyslexia:**
  - > 1/2 of the children affected
- **The observed result: 42 / 108**
  - compromised initial reading acquisition 38 / 108; in 2.gr. >4x and in 8 gr. 3x compared to controls
  - persistent reading problems 42 / 101

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

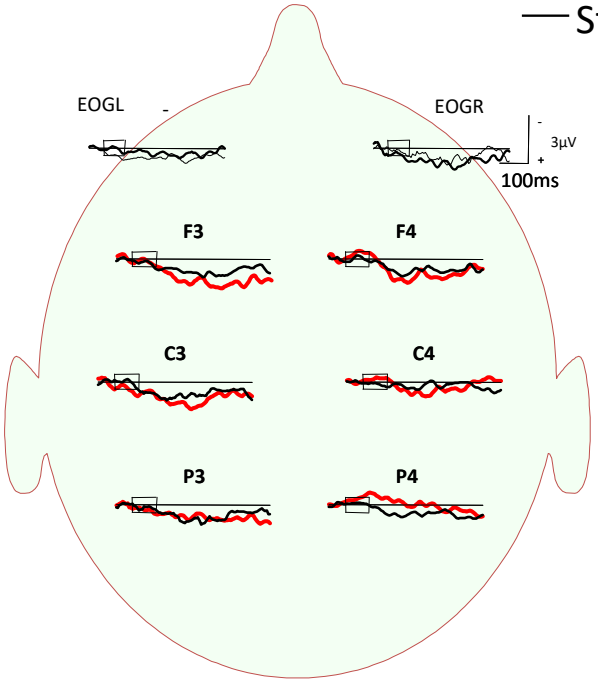
**MMN-paradigm**


Dev 1100Hz, 12 %, SOA 425 ms

Std 1000Hz



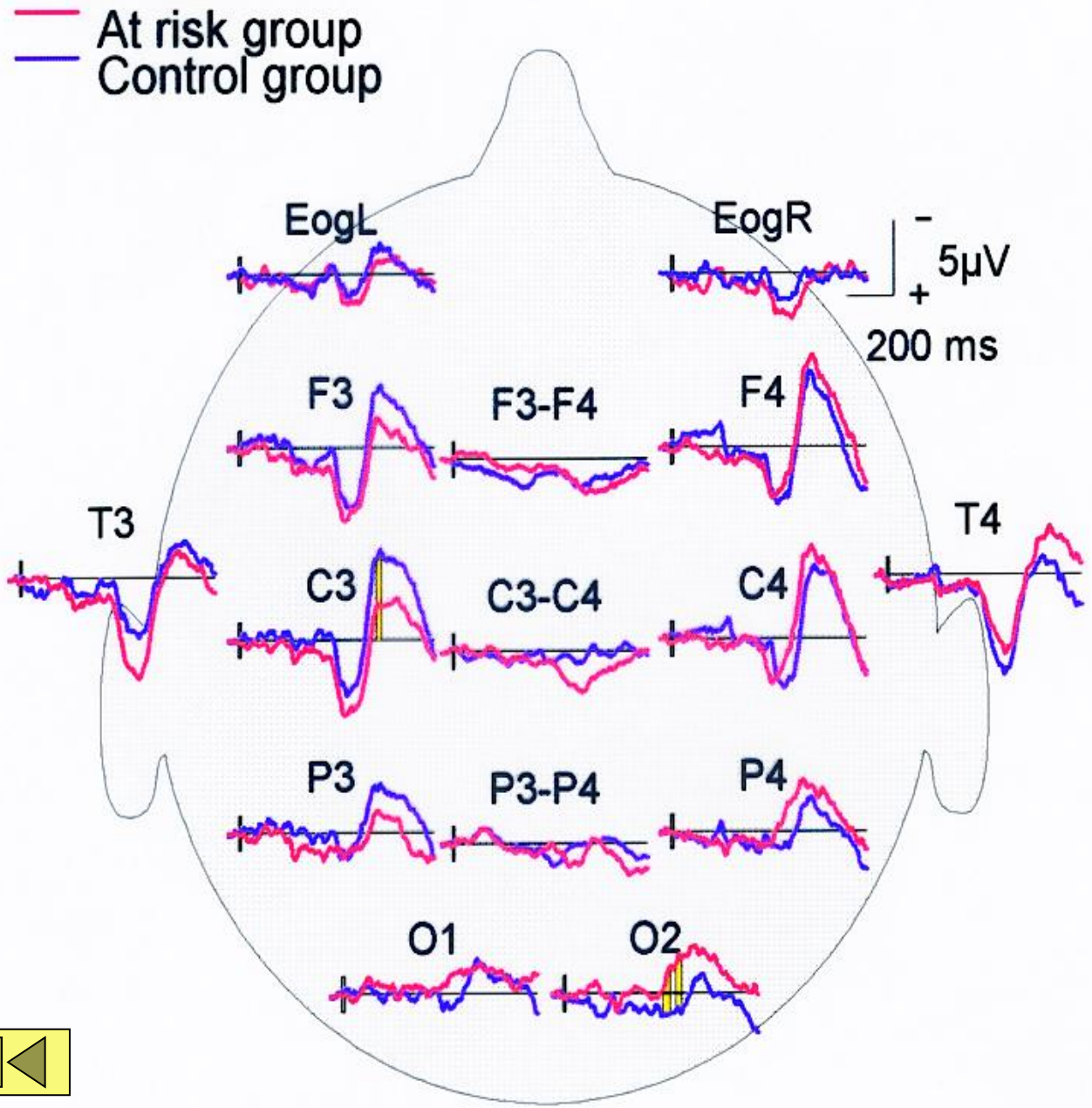

**Controls, typical readers (TRC, N=25)**




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


Quiet sleep

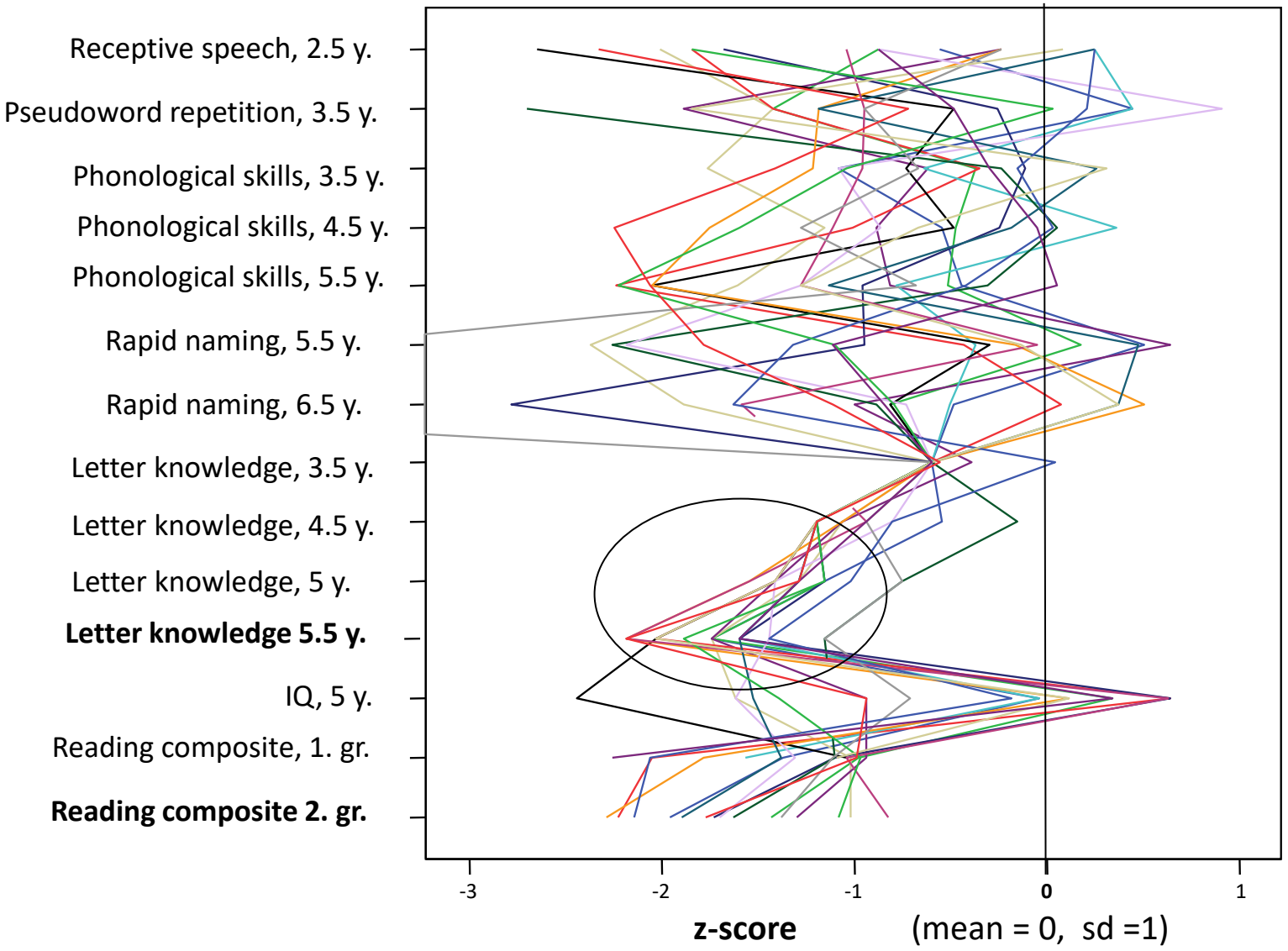
Leppänen et al, *2010*, *Cortex*




**At six months of age** babies of the control group show differential response to the infrequent deviants among /ata/ vs. /atta/ sounds but children of the at-risk group fail to do so on the left side(C3)

(Leppänen & Lyytinen, 1997; Leppänen et al. 2002).

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




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

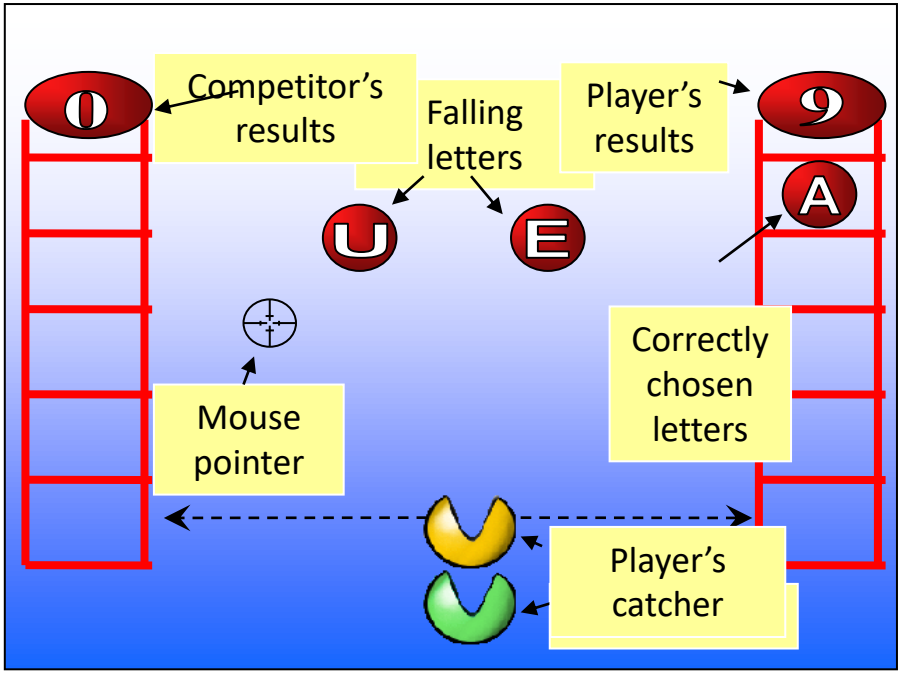
**Individual profiles of** the prediction measures of the JLD **children whose reading acquisition was most severely compromised**

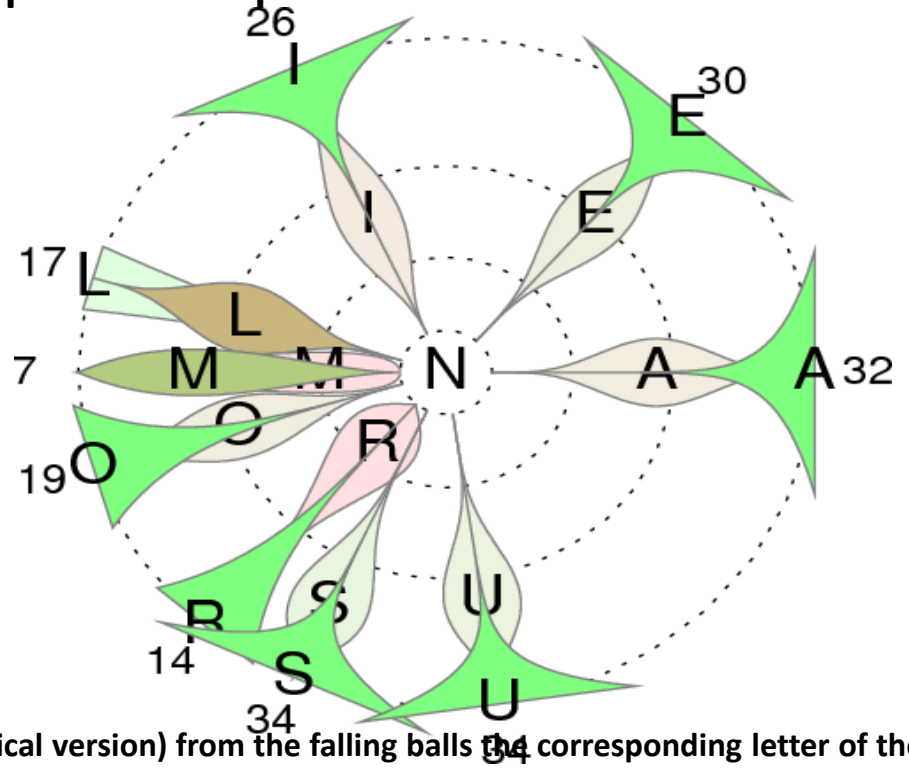
# GraphoLearn technology – digital game supporting learning the basic reading skill and providing its research & dynamic assessment environment

.. based on connections building between spoken and written language

To learn more about GraphoLearn technology, see grapholearn.info

# GraphoGame – an enjoyable digital game (Android/Apple/MS) supporting learning to read: How it helps in overcoming the fuzziness of the phonemic representations of written items

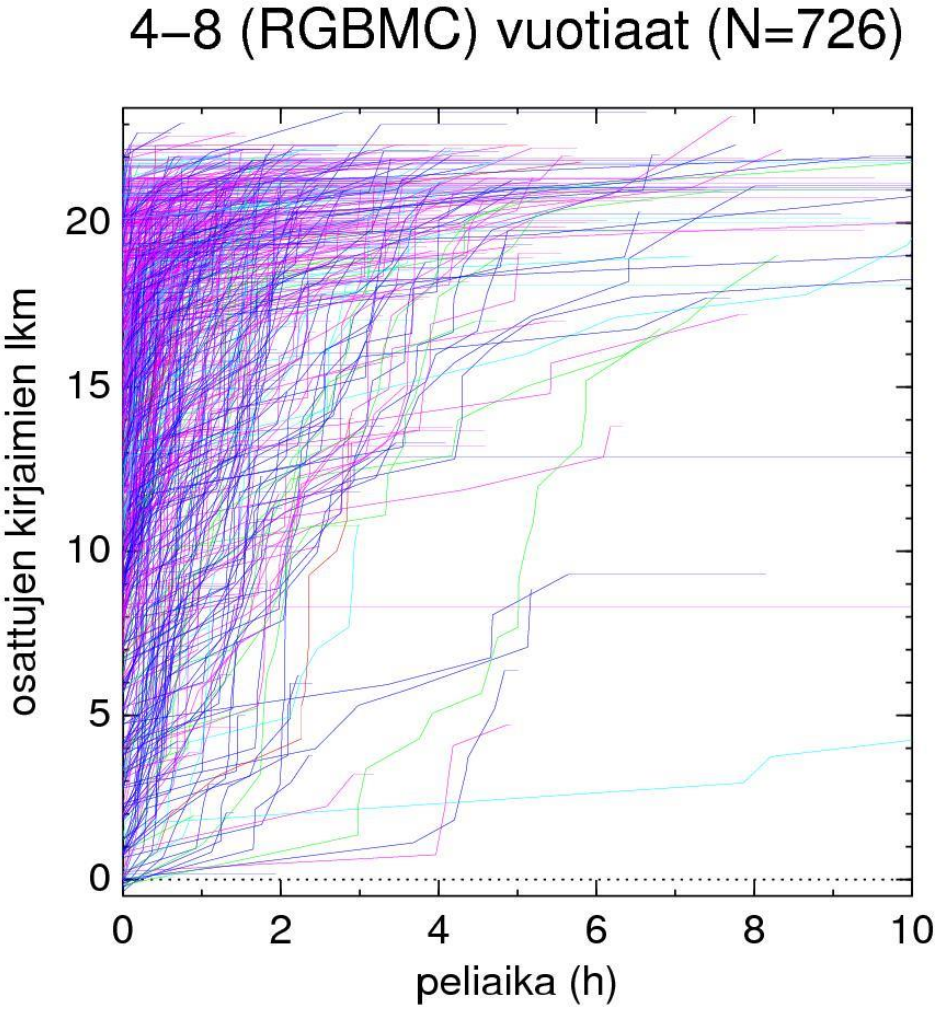



**Description. In the game (left) the learner is choosing (in its classical version) from the falling balls the corresponding letter of the one s/he hears from headphones**. The illustration (right ) shows an example of how results can be followed. Here we follow how /N/ sound (in the centre) which learner 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**.

Exemplary learning curves of GG players showing the time needed for storing the sounds of the letters among Finnish at risk children

The cumulative number of the acquired connections between sounds and letters



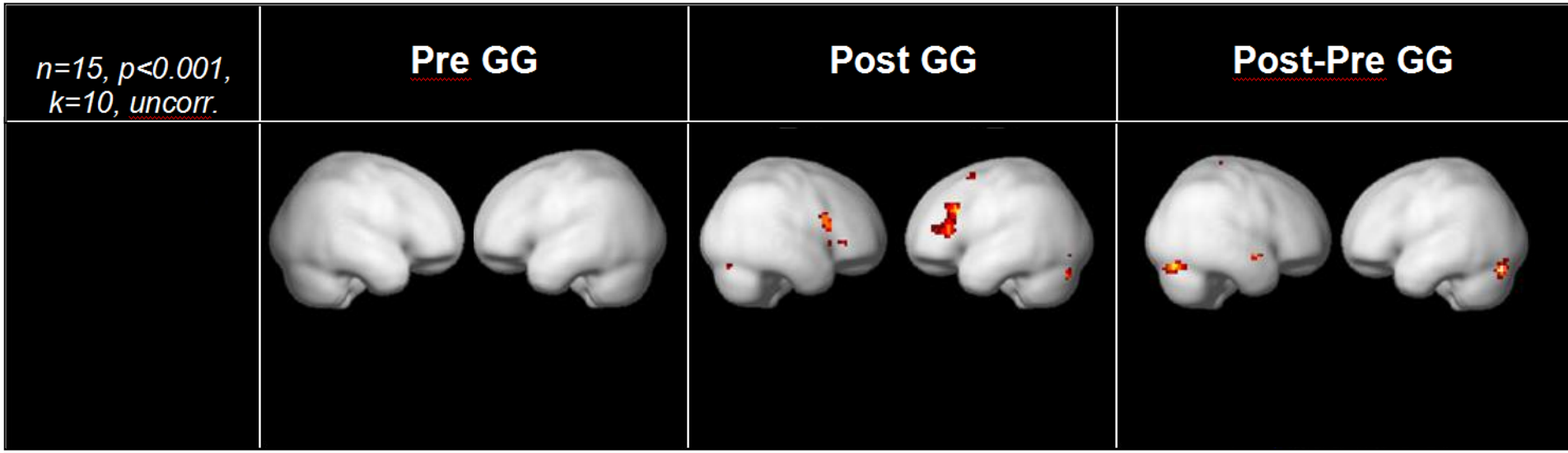

Hours of playing

Modelling: Janne Kujala

# 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 using the Graphogame following optimal phonics strategy helps at risk children most efficiently **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" sounding 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

**The Finnish version (www.lukimat.fi ) of reading and math support has been available for years for Finnish children**

# Evidence -based Educational Game

**GraphoGame™ is**

- **T*heoretically sound, & empirically validated with behavioral and brain measures***
- ***Documented in publication forums, such as Child Development and Proceedings of National Academy of Sciences (PNAS)***

# Practical facts about the game

- Available via net with up-to-date information for teachers and parents about the still actual bottlecks compromising reaching the goal
- 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 Android, Apple, MS phones/tablets
- Used in Finland via a state procurement (made bythe Ministry of Education - at best >20 000 daily Finnish users – from the age cohort of 60 000)
- The GraphoGame English has reached also a great familiarity in Finland today – more than 70 000 users (age cohort=60 000)

# The present Global Network resulting from our GraphoWorld Initiative

# Supporting acquisition of full literacy

- The goal of reading is mediating the meaning from text to mind to reach readiness to learn e.g. knowledge by reading (=learn in the school)
- PISA results in almost all countries have been falling among boys because they do no more read
- We have now a digital learning environment which can support their acquisition of full literacy and also readiness to approach written material with appropriate critics
- This is possible via our new **ComprehensionGame** (see comprehensiongame.info) which had to be used for learning lessons on the side of school books long enough for reaching the goal

# For more.., please,

- Have a look of our research: heikki.lyytinen.info
- Ask for reprint(s): heikki.j.lyytinen@jyu.fi
- For international operations, see grapholearn.info
- The most recent summary of main results of the JLD:
  https://link.springer.com/article/10.1007/s40474-015-0067-1
- A most relevant articles for learning how to use GraphoGame published in Child Development:
  DOI: 10.1111/j.1467-8624.2011.01580.x
- To have an access to GraphoGames: www.graphogame.com
- If you are interested in joining to our validation research of the comprehensiongame, please, contact Heikki.j.lyytinen@jyu.fi
- **Please, find these slides from "news"of Comprehensiongame.info**

**Thank you for your attention!**