# Information searching in learning disabled children: Eye movements reveal reading strategies

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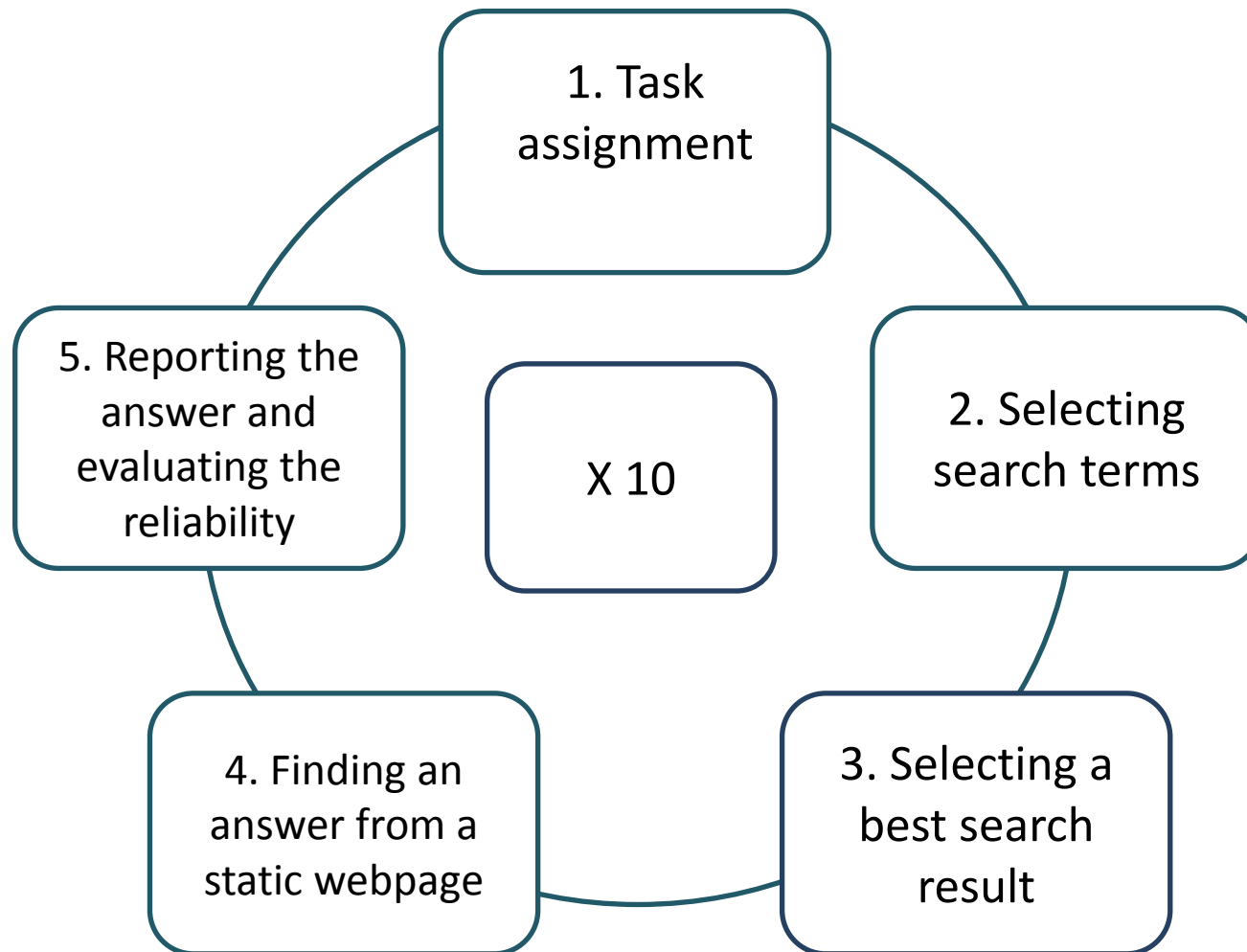
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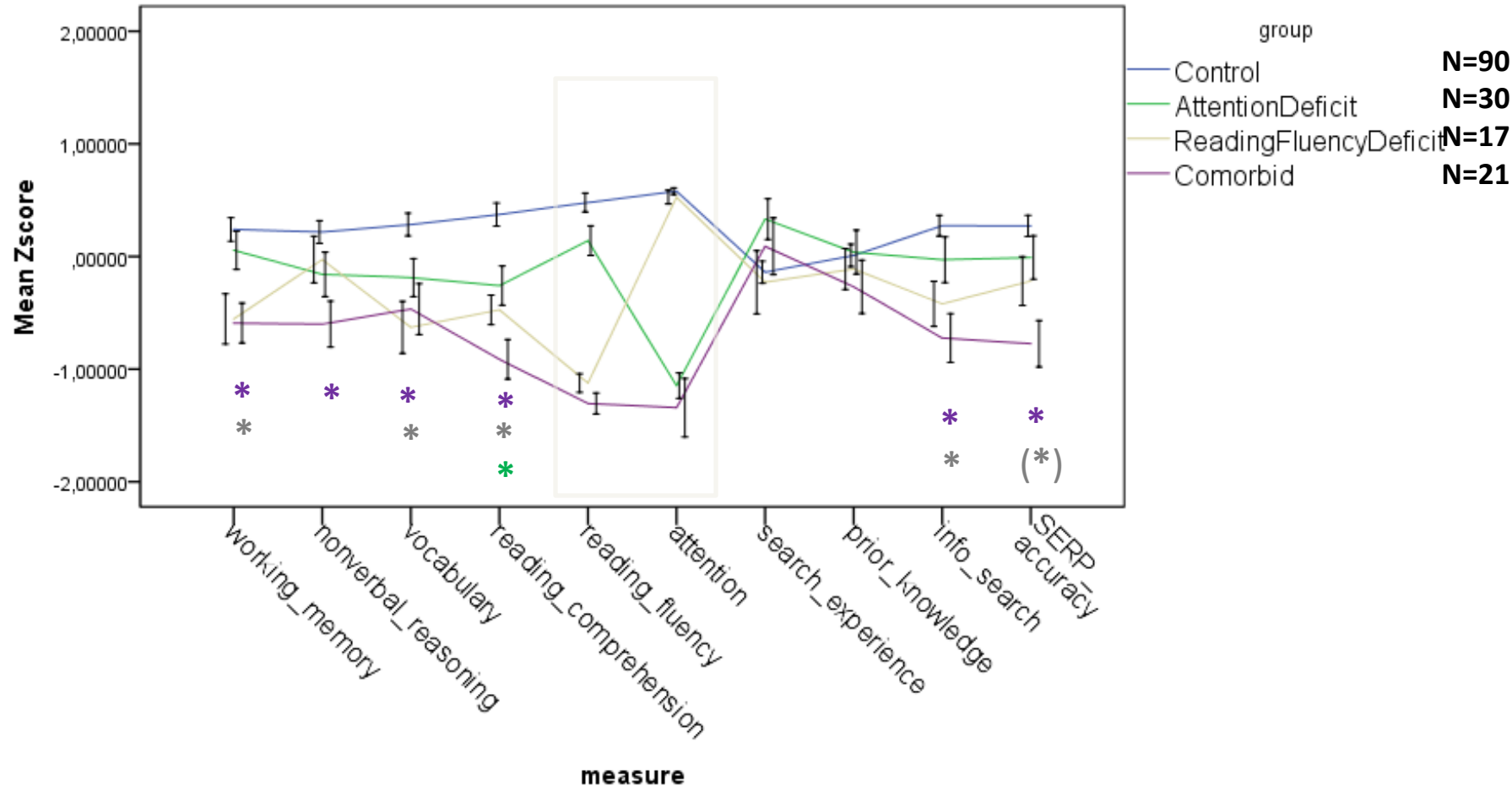www.jyu.fi/ytk/eseek

**NOTE: All of the results are preliminary.**

# Research goals

1) To specify cognitive strategies involved during different phases of Internet search

2) To study how cognitive skills, reading fluency and attentional problems in particular, affect the adoption of these cognitive strategies

# Controlled eye tracking experiment simulating phases of information searching from internet

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1. Task assignment

2. Selecting search terms

3. Selecting a best search result

4. Finding an answer from a static webpage

5. Reporting the answer and evaluating the reliability

X 10

# Participants

N=90
N=30
N=17
N=21

-> reading problem and comorbid groups perform poorly in neuropsychological tests
-> comorbid group perform poorly in the experiment

# Subtask 1: Reading task assignment
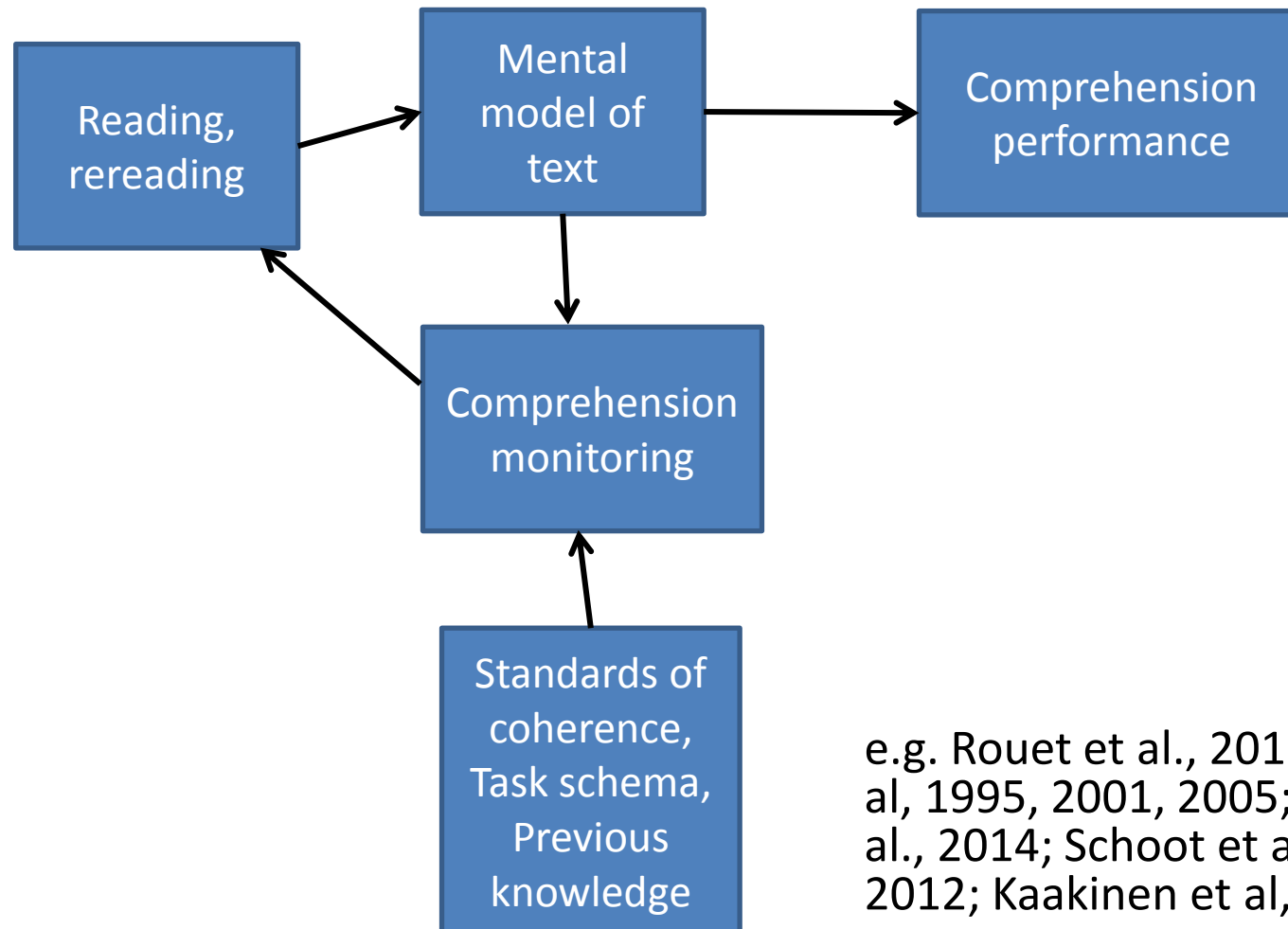


e.g. Rouet et al., 2017; Broeck et al, 1995, 2001, 2005; Kendeou et al., 2014; Schoot et al., 2009, 2012; Kaakinen et al,. 2015.

# Several general cognitive skills involved

- Good reading fluency frees attentional working memory resources for comprehension (Huestegge et al., 2009; Verhoeven et al., 2008).

- Prior knowledge and skills (e.g. McMaster et al., 2014), vocabulary (Calvo et al., 2003), and reasoning abilities (Tiu et al., 2003) facilitates comprehension.

- Executive functions are needed to regulate one's attention over several possible visual objects and lengthened period of time (Locascio et al., 2010).

- The relevant information is stored in working memory (Swanson et al., 2009).

- Word recognition, language and executive function skills all contribute on children's reading comprehension skills (Miller et al., 2014).

# Eye movement measures

Kautta historian kulta on ollut arvostetuimpia maametalleja.

Suomen maaperässä kultaa esiintyy lähinnä Lapin alueella.    Irrelevant

Ota selvää, mistä maailman suurin kultahippu on löydetty.    Relevant

Löytäjä on hädin tuskin jaksanut nostaa niin painavaa hippua.

**Figure 1. Illustration of sentence-specific reading measures.**
Red = Progressive Fixations. Black = Backward Fixations. Green = Look-Backs from last sentence.

First pass reading times reflect both the efficiency of decoding the linguistic information (Rayner, 1998).
Regressive eye movements during first-pass reading reflect initial comprehension processes (Yeari et al., 2015; Kaakinen et al., 2015: Schoot et al., 2008).
Rereading of previously text portions reflect more selectively the reader's conscious and strategic comprehension monitoring processes (Schotter et al., 2014; Hyönä & Nurminen, 2006).

# Covariates

- Prior knowledge (self-rated in four-point scale on each topic)

- Information searching performance (sum score from search query selection, search result selection, and reporting the answer)

- Verbal memory factor score (Digit span forward, backward, vocabulary, word list interference)

- Reading fluency (word recognition, word segmentation, pseudoword reading)

- Attention deficit scale, skewed -> categorized on 25th percentile (Kesky, teacher-rated)

- Linear mixed effects modelling used in most of the analysis presented. Random intercept and slopes of id and item for continuous variables, for dichotomous model only intercepts due to convergence problems.
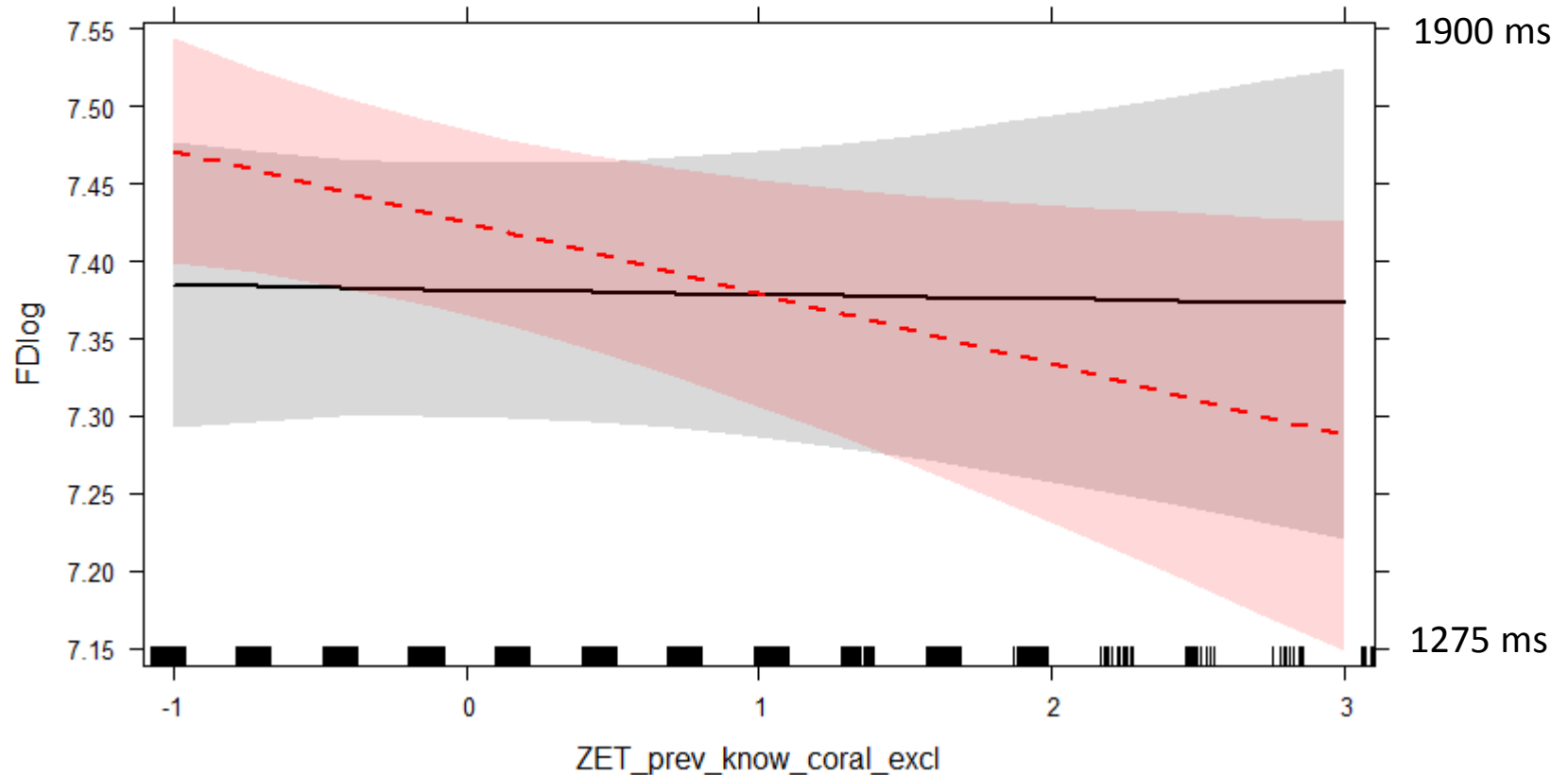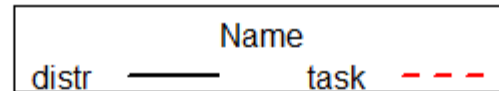
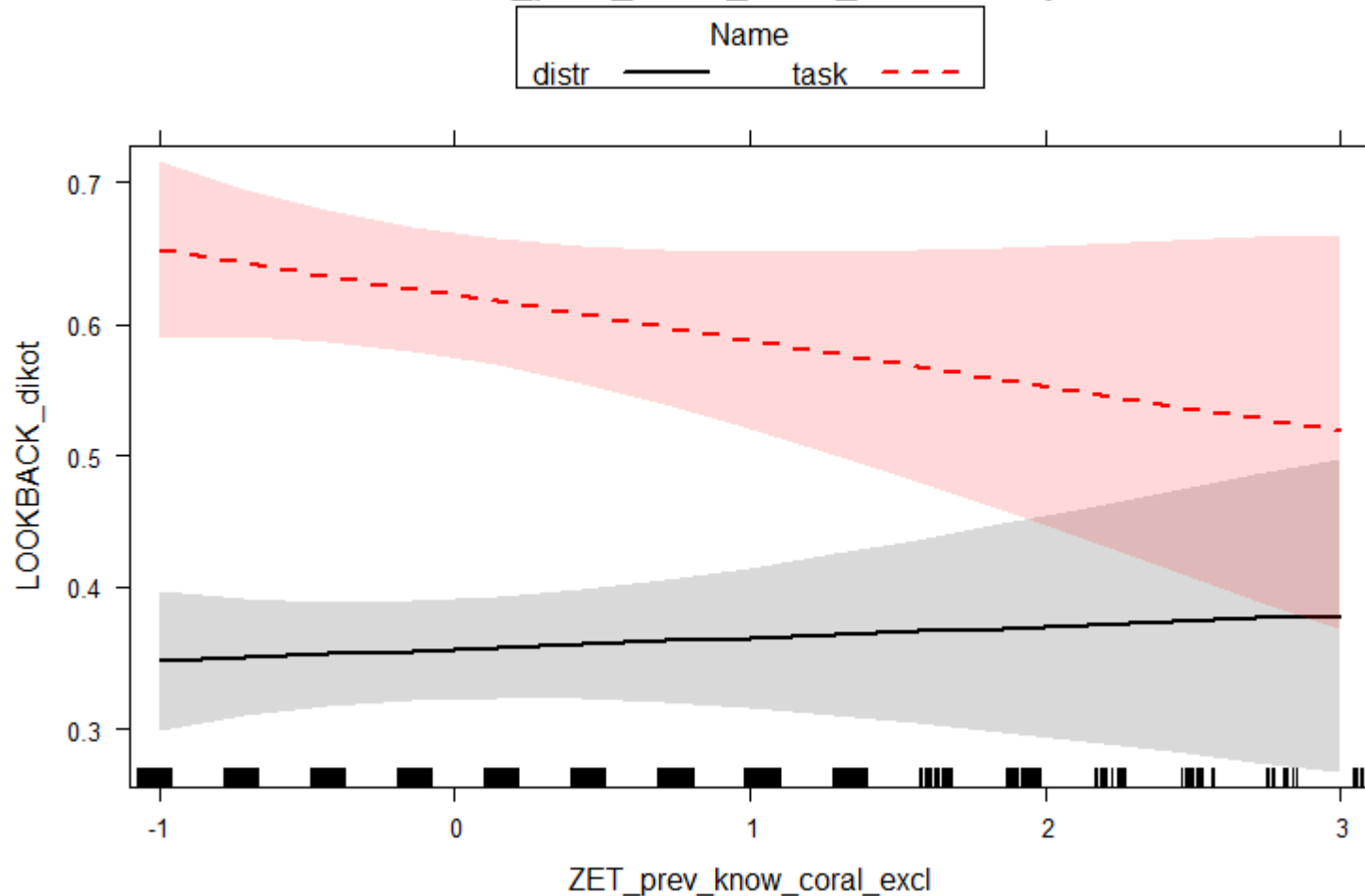# First pass fixation times: Effect of reading fluency



ZZPAF051017 effect plot
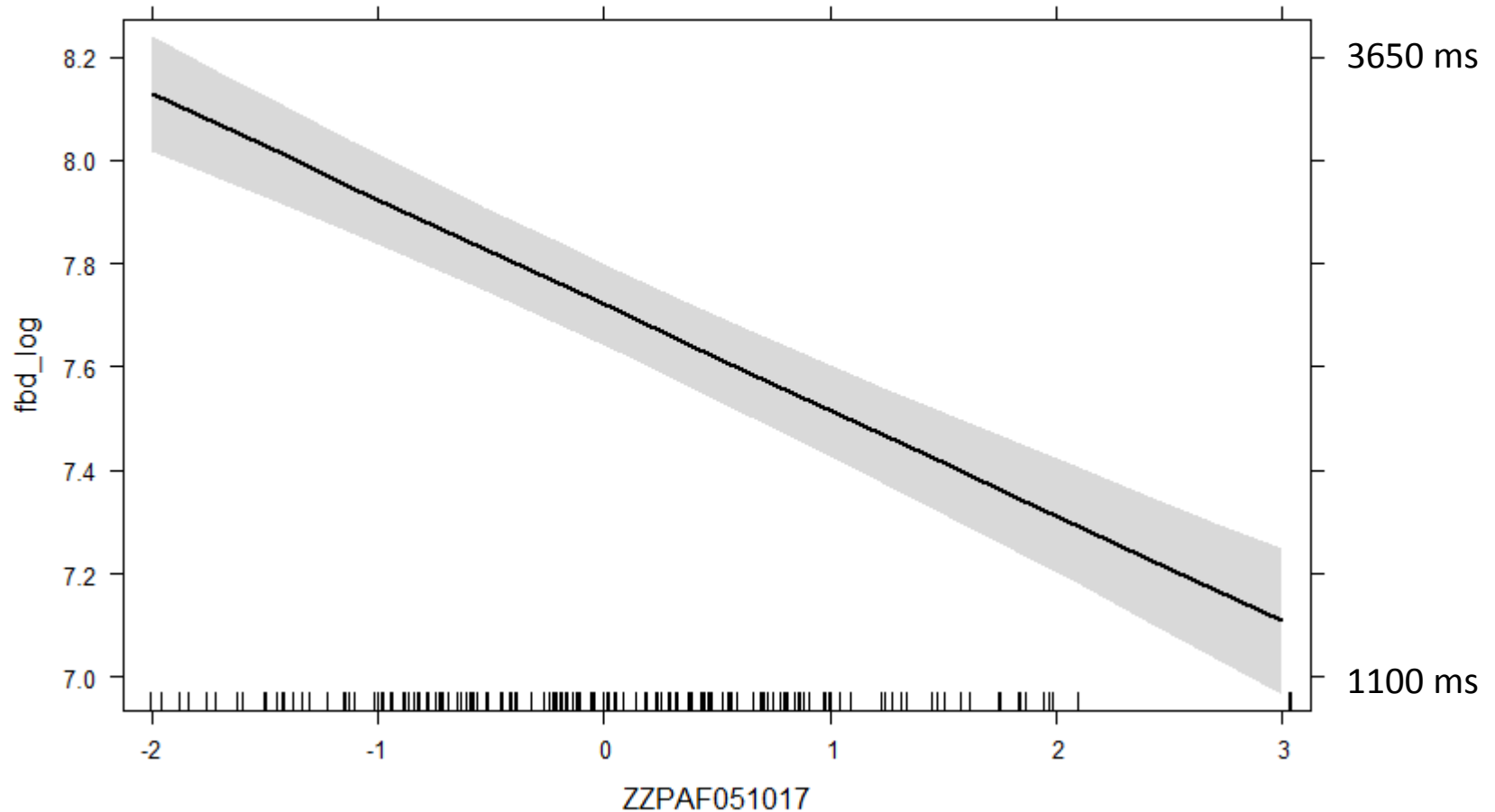
# First pass fixation duration:
# Sentence type x Previous knowledge



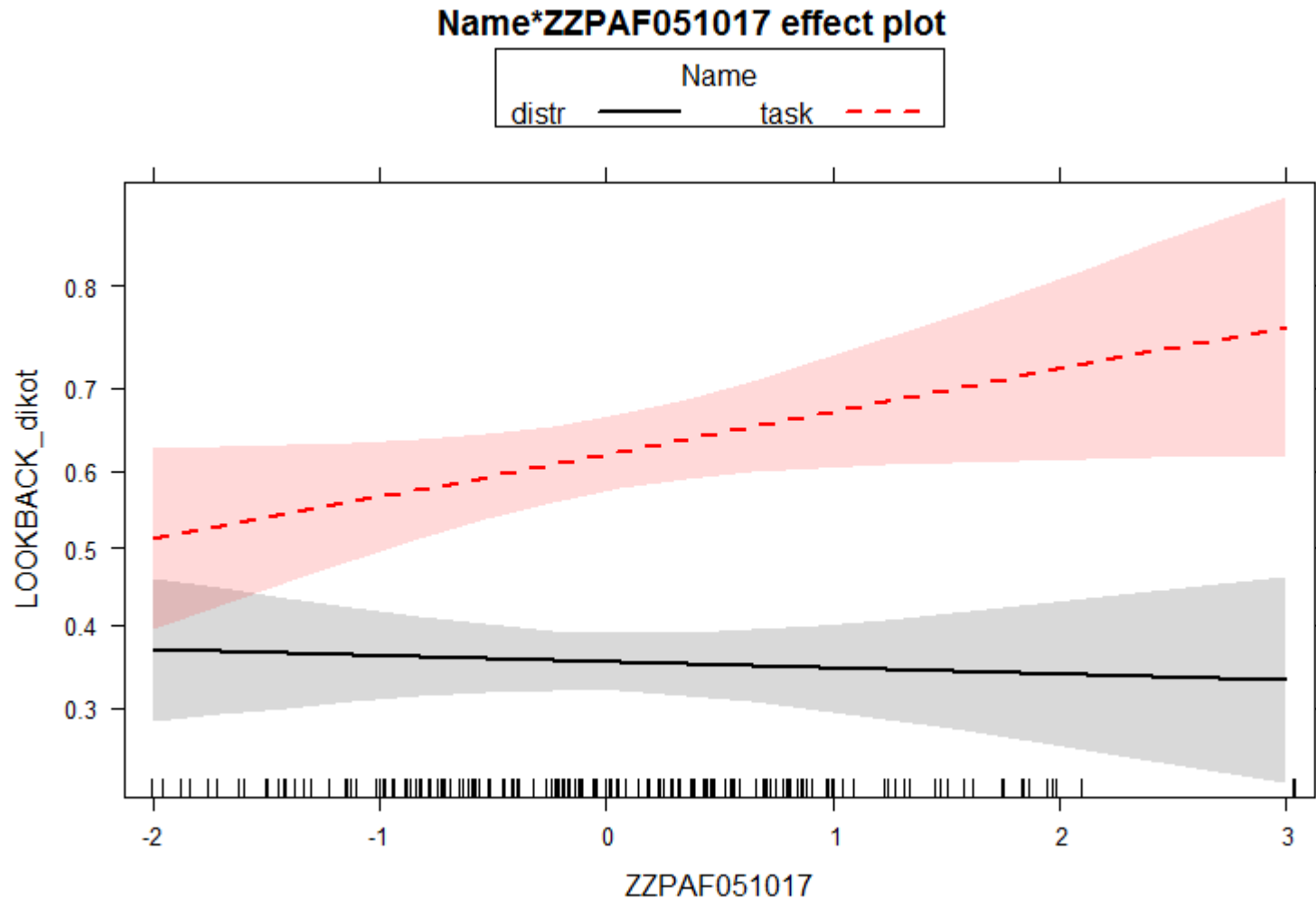Name*ZET_prev_know_coral_excl effect plot

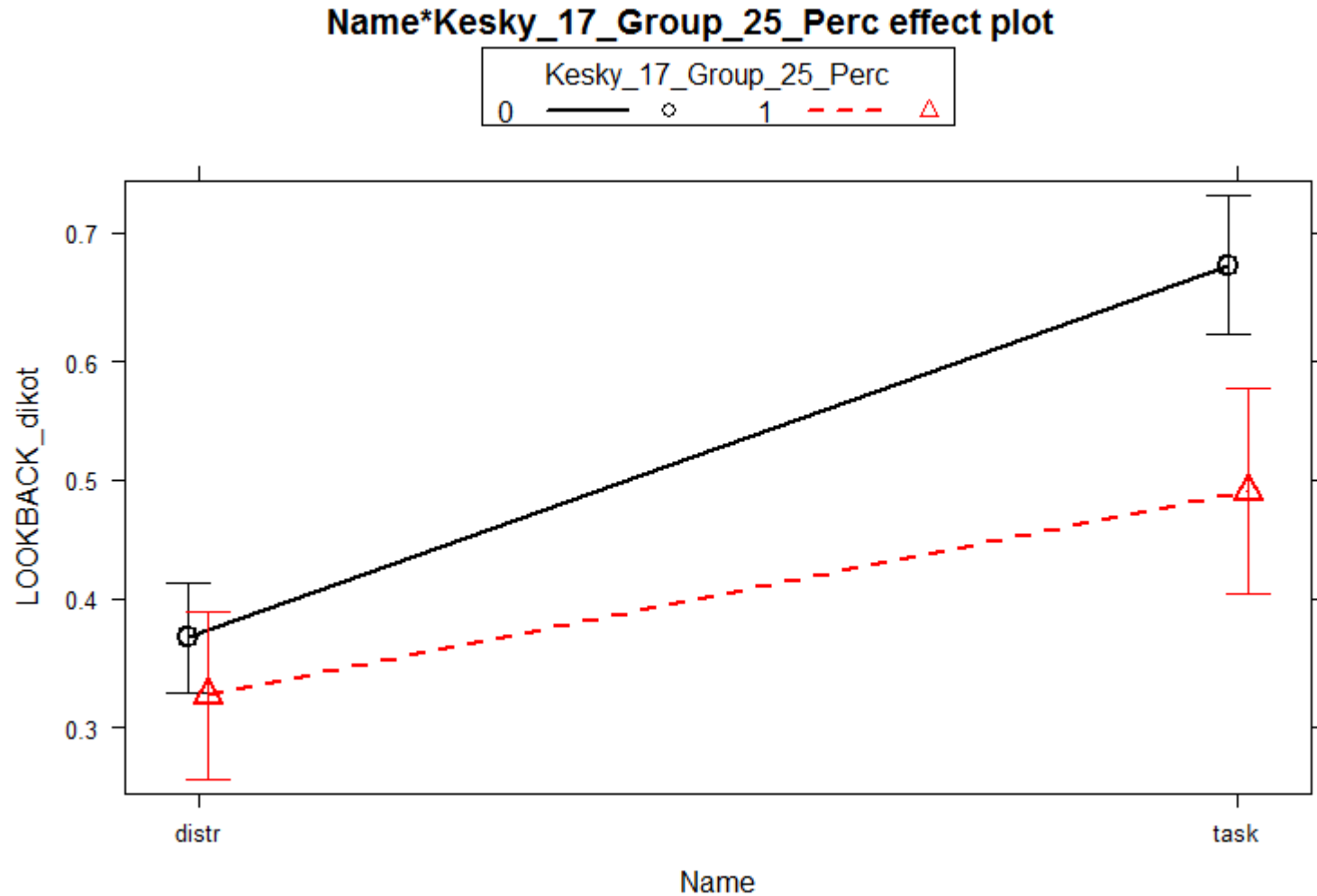# Look back probability:
# Sentence type x Previous knowledge



Name*ZET_prev_know_coral_excl effect plot

# Look back probability:
# Sentence type x Reading fluency



Name*ZZPAF051017 effect plot

# Look back probability:
# Sentence type x Attentional problems



Name*Kesky_17_Group_25_Perc effect plot

# Reading task assignments: Interpretations

- **Why learning disabilities affects one's task assignment reading strategies?**
    - High reading fluency gives more time for strategic look-backs? OR
    - Slow first-pass reading may give more time for comprehension processes, attenuating the need for look-backs?
    - Attentional problems may interfere comprehension monitoring?

# Subtask 2: Search result selection

- An important basic skill of information literacy

- Highly practiced and automatized skill

- Relative to text reading, SERP reading is less linear

- Strategies and heuristics determine what fields are read, as not all search results and fields are read

- However, the strategies are currently underspecified, especially in children populations

# Example task – Why was Gold Rush very harmful for Indians?

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## Learn now about Gold Rush

http://www.historychannel.fi/gold

Alaska Gold Rush is a television program running in Discovery –channel. It shows the life of gold miners as they seek gold all around the Alaska...

**Competitor-Snippet = Irrelevant snippet**

## Gold Rush consequences

http://www.history.fi/goldrush

Gold rush had diverse consequences for the Indians. Many kinds of theories has been suggested about how the Gold Rush affected the life of Indians. These web pages...

**Correct = All components highly relevant**

## Robot's Gold Rush

http://m.player.fi/news/robots

Robot's Gold Rush hits on PlayStation! Started as 3DS -game, Steam World Dig has been slowly but steadily conquering the world...

**Distractor = All components irrelevant (Distractor)**

## History of Gold Rush

http://www.tv-guide.fi/goldrush

Gold Rush was anticipated in May 1848, when a shop-keeper Sam Brannan found a bottle covered with gold dust from ground. It...

**Competitor-Url = Irrelevant URL**

# Search result selections proportions

**Descriptive Statistics**

|  | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| prop.Comp_Snip | 165 | ,00 | ,56 | ,1733 | ,13194 |
| prop.Comp_URL | 165 | ,00 | ,44 | ,1097 | ,11630 |
| prop.Correct | 165 | ,14 | 1,00 | ,7147 | ,19706 |
| prop.Distr | 165 | ,00 | ,13 | ,0022 | ,01616 |
| Valid N (listwise) | 165 |  |  |  |  |

-> Competitor-Snippet items selected more often than Competitor-URL items (Wilcoxon signed rank test, Z=-5.07, p < .001)

-> Error rates:

Reading problems = Comorbid < Attention problems = Controls (Kruskall-Wallis Test, p <= 0,15)

# Looking probabilities reveal that search result evaluation is a two-stage process

During first-pass viewing, search results with irrelevant title are being discarded without even reading its snippet text.

During second-pass viewing, readers focus on confirming the most promising search result by inspecting all of its components.



FirstSecondPass*SearchResult*Field effect plot
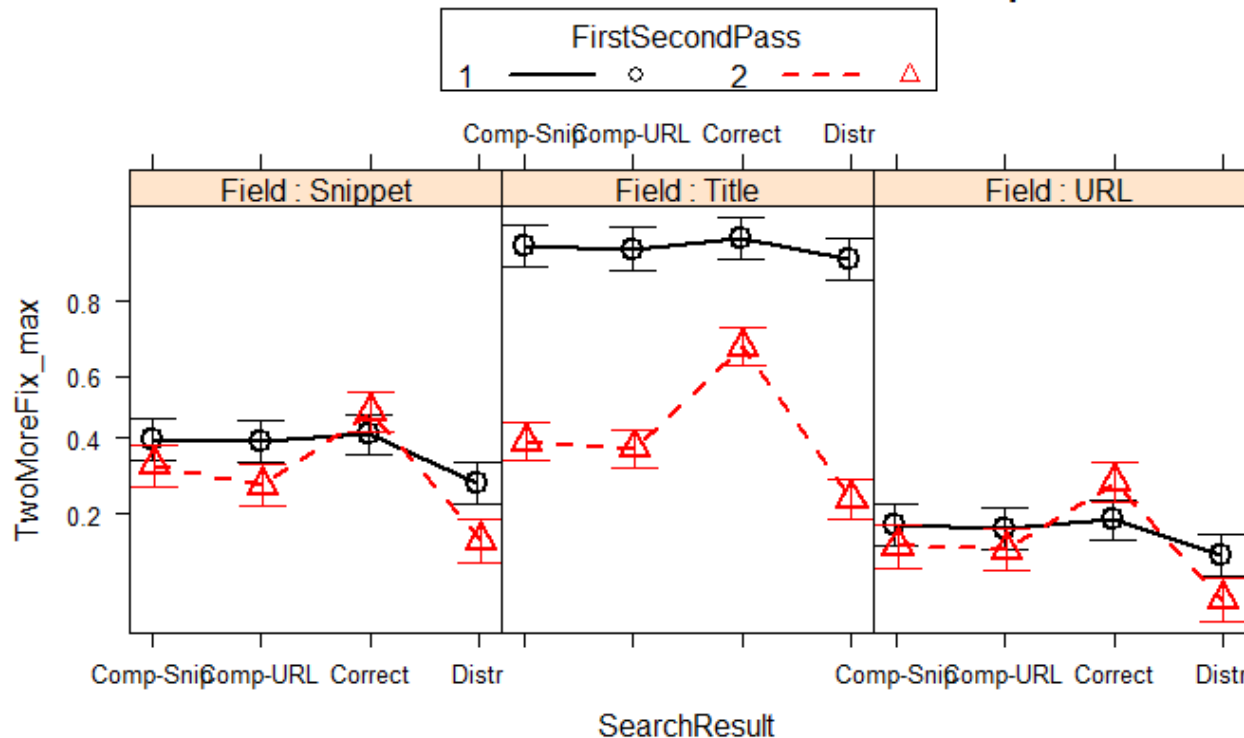
# Skilled info searchers look more probable (and for longer time) snippets and URL fields
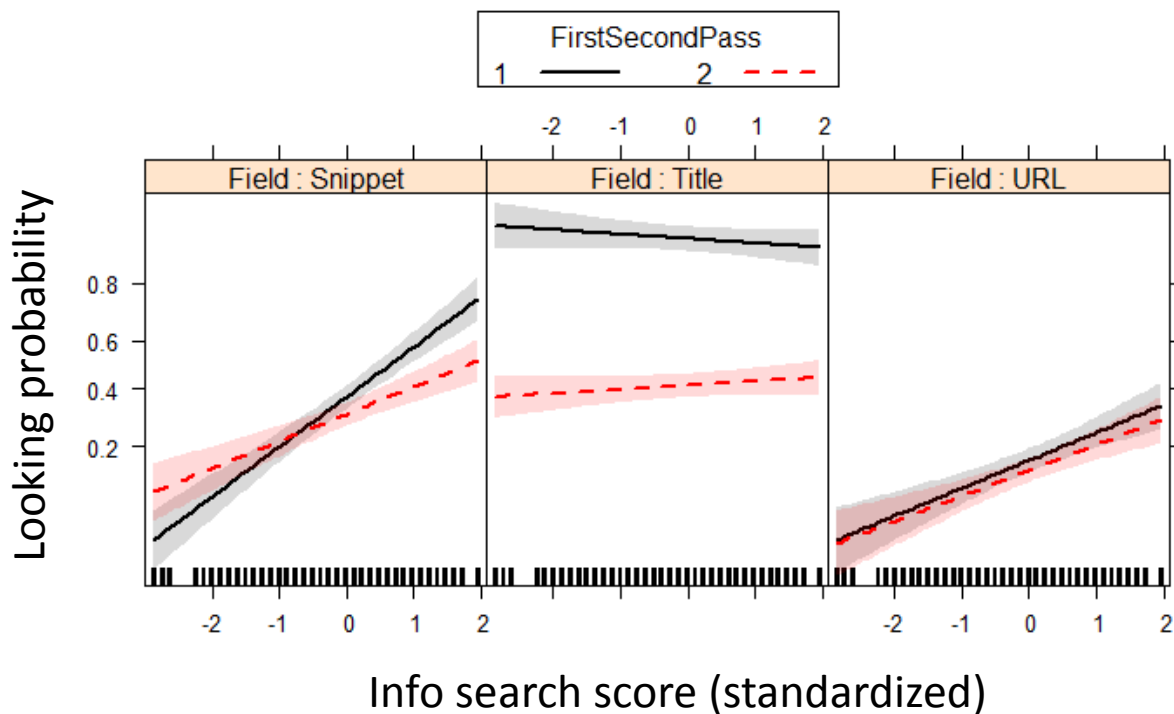
# Search result viewing style clusters

**Students show large variability in how likely they look snippet and URL fields.**

**Learning disabled students are grossly over-represented in title reader group**

## Viewing style x Group

| | | | Group_FL_Att | | | |
|---|---|---|---|---|---|---|
| | | Controls | Attention problems | Reading problems | Comorbid | Total |
| viewing_style | Title only | 10a | 7 | 6a, b | 16b | 39 |
| | | 22,2 | 7,4 | 4,2 | 5,2 | 39,0 |
| | | 11,1% | 23,3% | 35,3% | 76,2% | 24,7% |
| | All fields | 41a | 11 | 3a, b | 1b | 56 |
| | | 31,9 | 10,6 | 6,0 | 7,4 | 56,0 |
| | | 45,6% | 36,7% | 17,6% | 4,8% | 35,4% |
| | No URL | 17a | 4 | 2a | 1a | 24 |
| | | 13,7 | 4,6 | 2,6 | 3,2 | 24,0 |
| | | 18,9% | 13,3% | 11,8% | 4,8% | 15,2% |
| | Intermediate | 22a | 8 | 6a | 3a | 39 |
| | | 22,2 | 7,4 | 4,2 | 5,2 | 39,0 |
| | | 24,4% | 26,7% | 35,3% | 14,3% | 24,7% |

Each subscript letter denotes a subset of Group_FL_Att categories whose column proportions do not differ significantly from each other at the ,05 level.

$\chi^2 (9)= 44.05$, p <= .001

# Selecting a search result: Interpretations

- **Why search results are read in more heuristic fashion than linear texts?**
  - Hierarchically organized search result list
  - The goal is to find a satisfying search result
  - Trust on search engine

- **Why learning disabilities affect search result evaluation?**
  - In this context reading mostly titles may provide a tempting and often a succesfull heuristic to find a good enough search result

# Subtask 3: Finding an answer from a static "Web page"

- Another important information literacy skill is to search specific information from a text or in web-page

- Reading everything is a too slow strategy

- A more efficient strategy would be first skimming through the material, especially the titles (or menus to understand how the information is organized, and then focus on reading the relevant portion of the material (only)

- These selective, goal-oriented reading skills are less studied, both in adults (Hyönä & Lorch, 2004) and children (Kaakinen et al., 2015)

- Information finding efficiency = score / time used

# An inefficient fluent reader finding an answer from a "web page"

# What explains efficiency in finding the answer?

| | | | | | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change |
| Reading fluency | ,489[a] | 0,239 | 0,234 | 0,87 | 0,239 | 48,079 | 1 | 153 | 0,000 |
| + Info search score | ,556[b] | 0,309 | 0,300 | 0,84 | 0,070 | 15,281 | 1 | 152 | 0,000 |
| + Nonverbal reasoning | ,575[c] | 0,331 | 0,318 | 0,83 | 0,022 | 5,027 | 1 | 151 | 0,026 |
| + Verbal working memory | ,592[d] | 0,351 | 0,333 | 0,82 | 0,020 | 4,542 | 1 | 150 | 0,035 |

*Table title: Linear Regression Analysis Model Summary*

Paired Correlations (r) with Efficiency:

Reading fluency              .497
Info finding score           .441
Nonverbal reasoning          .086
Working memory               .384

# Surprisingly many learning disabled students are efficient in finding the answer

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Info finding efficiency percentile

| | | | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|---|
| 0=Control, 1=AttentionDef, 2=ReadingDeficit, 3=Comorbid | ,00 | Count | 8a | 18a, b | 15a, b | 22b | 24b | 87 |
| | | Controls | 9,2% | 20,7% | 17,2% | 25,3% | 27,6% | 100,0% |
| | 1,00 | Count | 4a | 4a | 9a | 6a | 5a | 28 |
| | | Attention deficit | 14,3% | 14,3% | 32,1% | 21,4% | 17,9% | 100,0% |
| | 2,00 | Count | 9a | 4a | 6a | 1a | 2a | 22 |
| | | Reading deficit | 40,9% | 18,2% | 27,3% | 4,5% | 9,1% | 100,0% |
| | 3,00 | Count | 10a | 7a | 3a | 2a | 2a | 24 |
| | | Comorbid | 41,7% | 29,2% | 12,5% | 8,3% | 8,3% | 100,0% |
| Total | | Count | 31 | 33 | 33 | 31 | 33 | 161 |

# Finding the answer: Interpretations

- **What determines ones' efficiency in finding an answer from text?**
    - Focusing on relevant insted of irrelevant paragraph
    - Reading fluency, info score, noverbal reasoning and working memory

- **How learning disabilities affect one's efficiency in finding the answer?**
    - Typical reading skills is no guarantee for efficiency
    - Reading problem is a clear risk for inefficiency
        - A compensatory strategy is to focus solely on the relevant parts of text

# Implications

- Importance of teaching general goal-oriented reading strategies (what is the goal of reading activity, what is relevant or not), and specific information literacy reading strategies (e.g. search result evaluation)

- Reading disabled students and especially those with additional attentional problems are in disadvantaged position to learn basic information literacy skills

- The positive finding is that some reading disabled students have developed efficient compensatory reading strategies

- Research is needed how learning disabled students can learn more efficient online reading strategies