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Modelling L2 reading proficiency using eye-tracking measures

Eye tracking research day CRELLA-LU, 18th June 2015

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Looking into reading proficiency

Reading in one's first language

- Long research tradition in Psychology
- Research using eye-tracking, e.g.
  - Lexical ambiguity resolution (e.g., Binder, 2003, Duffy Morris &Rayner)
  - Morphological processing (e.g., Andrews Millar & Rayner, 2004)
  - Discourse processing (e.g. Cook & Myers, 2004)

Looking into reading proficiency

Reading in a second/foreign language

- Research in SLA and Language Testing (e.g., Bernhardt, 2010; Grabe, 2009; Kado, 2005; Khalifa & Weir, 2009)
- Research using eye-tracking, e.g.

  In SLA & bilingualism:

  - Task complexity (e.g., Révész, Sachs & Hama, 2014)
  - Lexical access (e.g., Van Assche et al., 2009, 2011)
  - Syntactic ambiguity resolution (e.g., Dussias & Sagarra, 2007)

  In testing L2 reading:

  - CAE multiple-choice items (Bax & Weir, 2012)
  - practice IELTS sentence completion & matching tasks (Bax, 2013)
  - PTE Academic banked-gap fill items (McCray, Alderson & Brunfaut, 2012; McCray, 201
  - APTIS test (Brunfaut & McCray, 2015)

Looking into reading proficiency

→ Evidence that eye-tracking provides insights into L2 reading processing

E.g., Brunfaut, T., & McCray, G. (2015). Looking into test- takers' cognitive processing whilst completing reading tasks: A mixed-methods eye-tracking and stimulated recall study. *ARAGs Research Reports Online*, AR/2015/01. London: British Council. ISSN 2057-5203. http://www.research.lancs.ac.uk/portal/files/84736502/Brunfaut_and_McCray_final_report_FINAL.pdf

→ Evidence of relationship with L2 reading product?

Looking into reading proficiency

Aim

Initial statistical modelling L2 reading proficiency with various eye-tracking measures

- Exploring how people read in L2
- Exploring how to analyse eye-tracking data to gain further insights into L2 reading

Needed

- L2 readers
- A measure of their L2 reading ability *(dependent variable)*
- Eye-tracking measures, which are thought to relate to the skill of the reader *(independent variables)*

Methodology

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50 ESL speakers

- *Asian-L1*:

  51% Chinese, 4% Korean, 4% Thai, 4% Arabic, 2% Nepali, 2% Hindi

  European/South American/African-L1:

  12% Spanish, 4% Italian, 4% Portuguese, 2% Dutch, 2% German, 2% Slovene, 2% Greek, 2% Hungarian, 2% Russian
- 20% male, 80% female
- 17-49 years old (M=26.4, SD=7.57)
- 2-25 years studied English (M=11.4, SD=4.95)
- .5-13 years lived in English-speaking country (M=1.72, SD=2.28)
- 21% foundation year students, 4% UG students, 65% PG students, 12% employed

Looking into reading proficiency

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Methodology

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L2 reading test

DIALANG reading test (http://dialangweb.lancaster.ac.uk/)

- 44 items
- Item types:
  - Multiple choice (39)
    - 37 four-option, 1 three-option, 1 five-option
    - traditional MC-question, MC text completion, MC gap-fill
  - Matching headings (4)
  - Fill-in-the-blank (1)

Methodology

Lancaster University

L2 reading test

DIALANG reading test (http://dialangweb.lancaster.ac.uk/)

- Types of reading:
  - Reading for main idea (14)
  - Reading for detail (8)
  - Inferencing (22)
- CEFR A1-C2

Looking into reading proficiency

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Methodology

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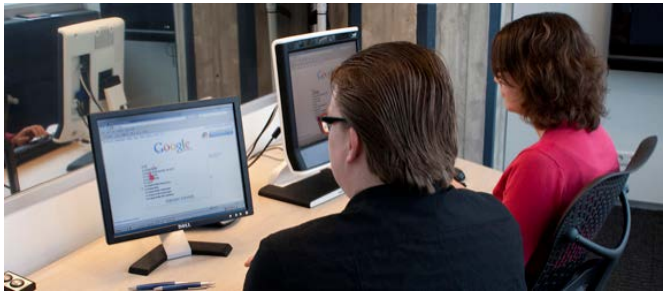
Tool

Tobii TX300 eyetracker



Methodology

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Eye-tracking data collected on L2 texts

Nine L2 texts:

- 3 Cambridge ESOL computer-based suite
  - One text from each of these:
    - Cambridge English: Preliminary (PET) – B1

      Text: 261 words
    - Cambridge English: First (FCE) – B2

      Text: 655 words
    - Cambridge English: Advanced (CAE) – C1

      Text: 816 words
  - + 1 four-option MC item per text
  - Types of reading:
    - inferencing - main idea (3)

Methodology

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Eye-tracking data collected on L2 texts

- 6 DIALANG reading items
  - Two from each of these:
    - Basic level

      Text: 34 & 48 words
    - Intermediate level

      Text: 79 & 54 words
    - Advanced level

      Text: 70 & 41 words
  - + 1 three- or four-option MC item per text
  - Types of reading:
    - Identifying main idea (3)
    - Inferencing (3)

Methodology

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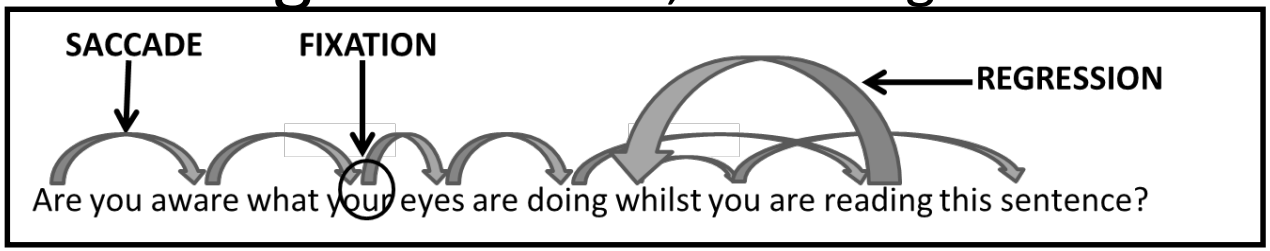
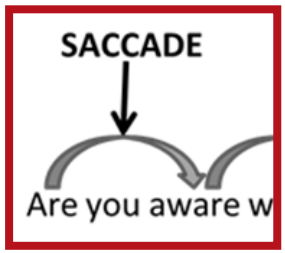
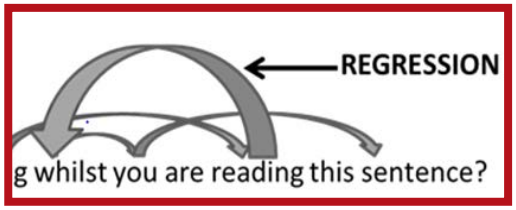
Eye-tracking measures, following the L1 literature:



a) Fixation number & duration

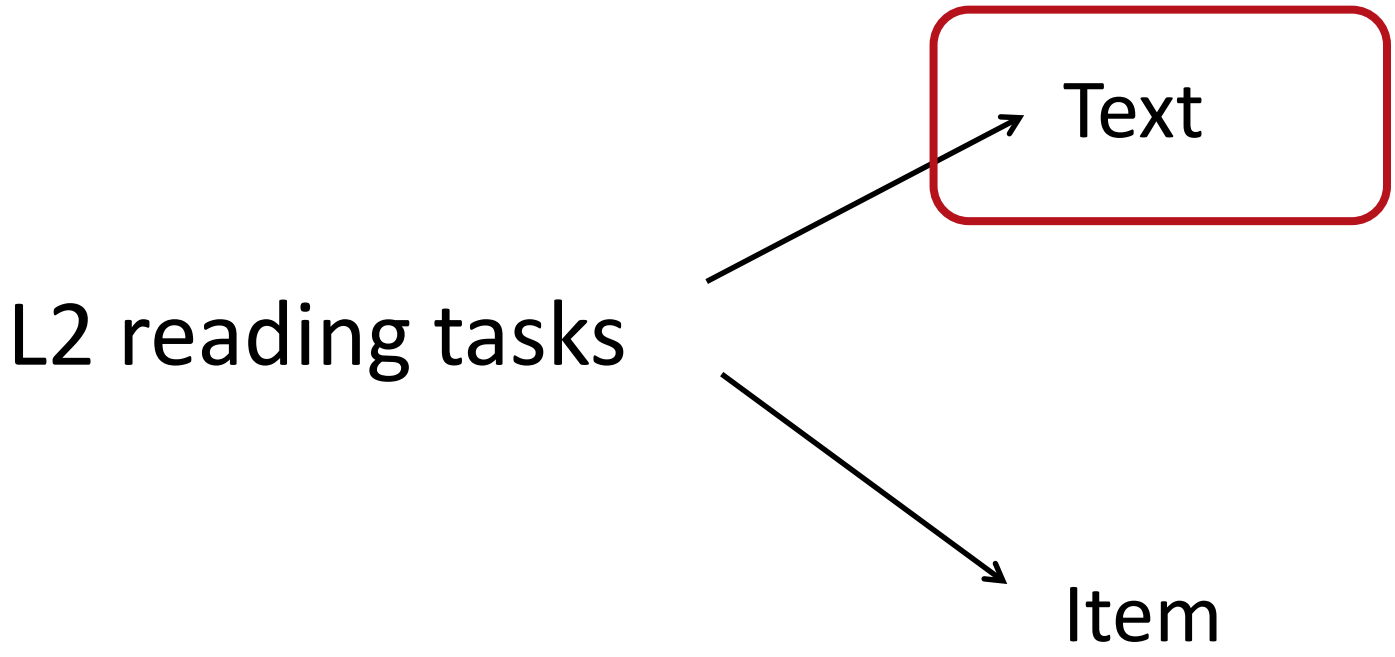


b) Saccade number & length



c) Regression number & length

Methodology

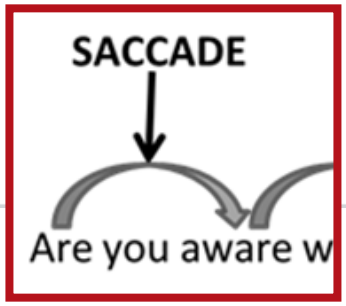


Methodology

Fixation-related measures

Measure name	Description	Expectation
N.fix	The total number of fixations	More proficient readers will have fewer fixations, reflecting the fact that they need fewer fixations to process the text.
Sum.fix.dur	The sum of fixation times on a text	More proficient readers will have a shorter sum fixation duration, reflecting their increased overall processing speed.
Med.fix.dur	Median log fixation duration	More proficient readers will have shorter median fixation duration, reflecting the speed with which they can process the textual information from a fixation.

Methodology



Saccade-related measures

Measure name	Description	Expectation
N.sac	Number of saccades	More proficient readers will have a lower number of saccades due to their longer saccade length and decreased need for re-reading.
Med.sac.length	Median log length of a saccade	More proficient readers will have a longer median saccade length due to their ability to take in more text in a single fixation.
SD.sac.length	SD of log length of saccade	More proficient readers will have a more regular reading pattern and thus a lower SD of log saccade length.

Methodology

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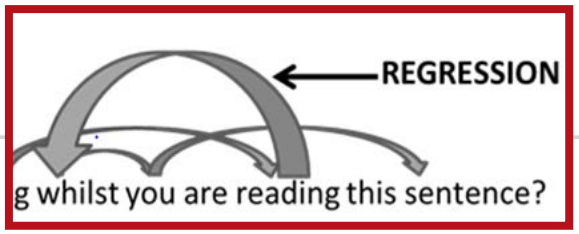
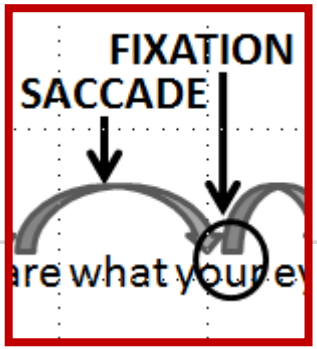
Regressions-related measures



Measure name	Description	Expectation
N.reg	Number of regressions	More proficient readers will have a lower number of regressions, because they don't (or less often) need to re-read parts of the text.
Med.reg.length	Median log length of a regression	Potentially, more proficient readers make regressions for different reasons (e.g. slight overshooting rather than re-reading entire bits of text).
SD.reg.length	SD log length of a regression	More proficient readers will have a more regular reading pattern and thus a lower SD of log regression length.

Methodology



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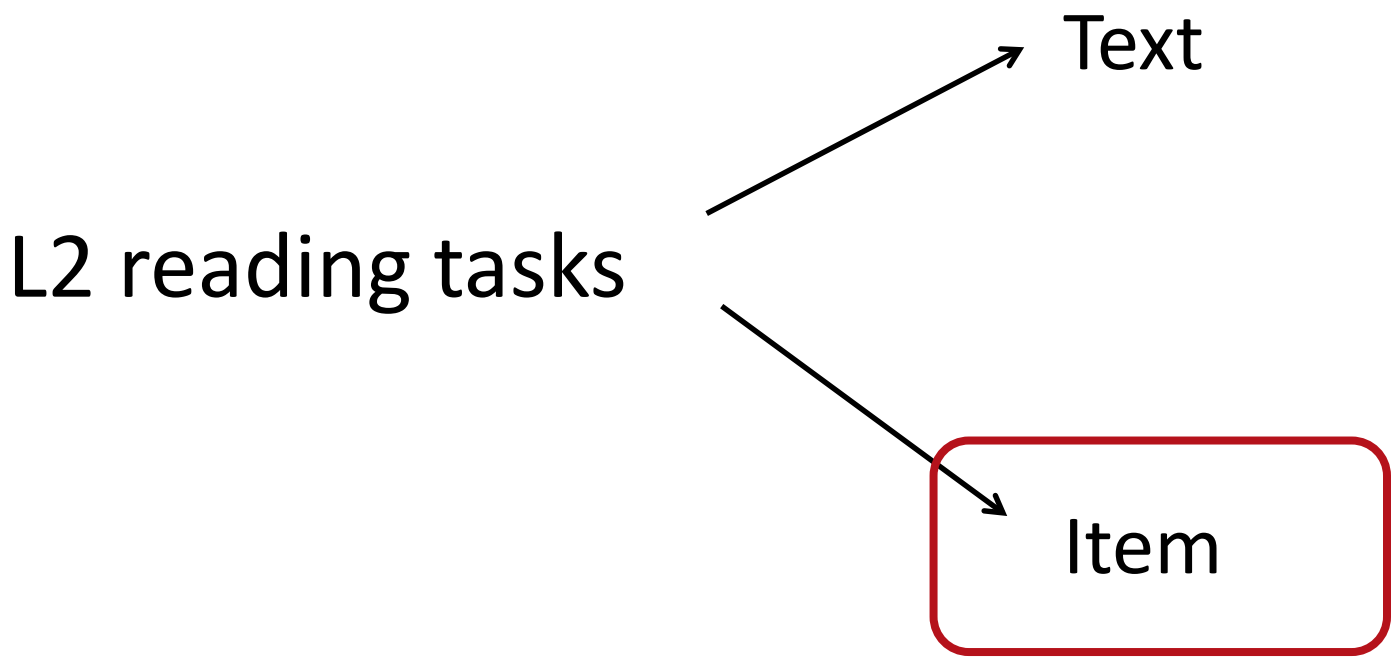
Combined measures

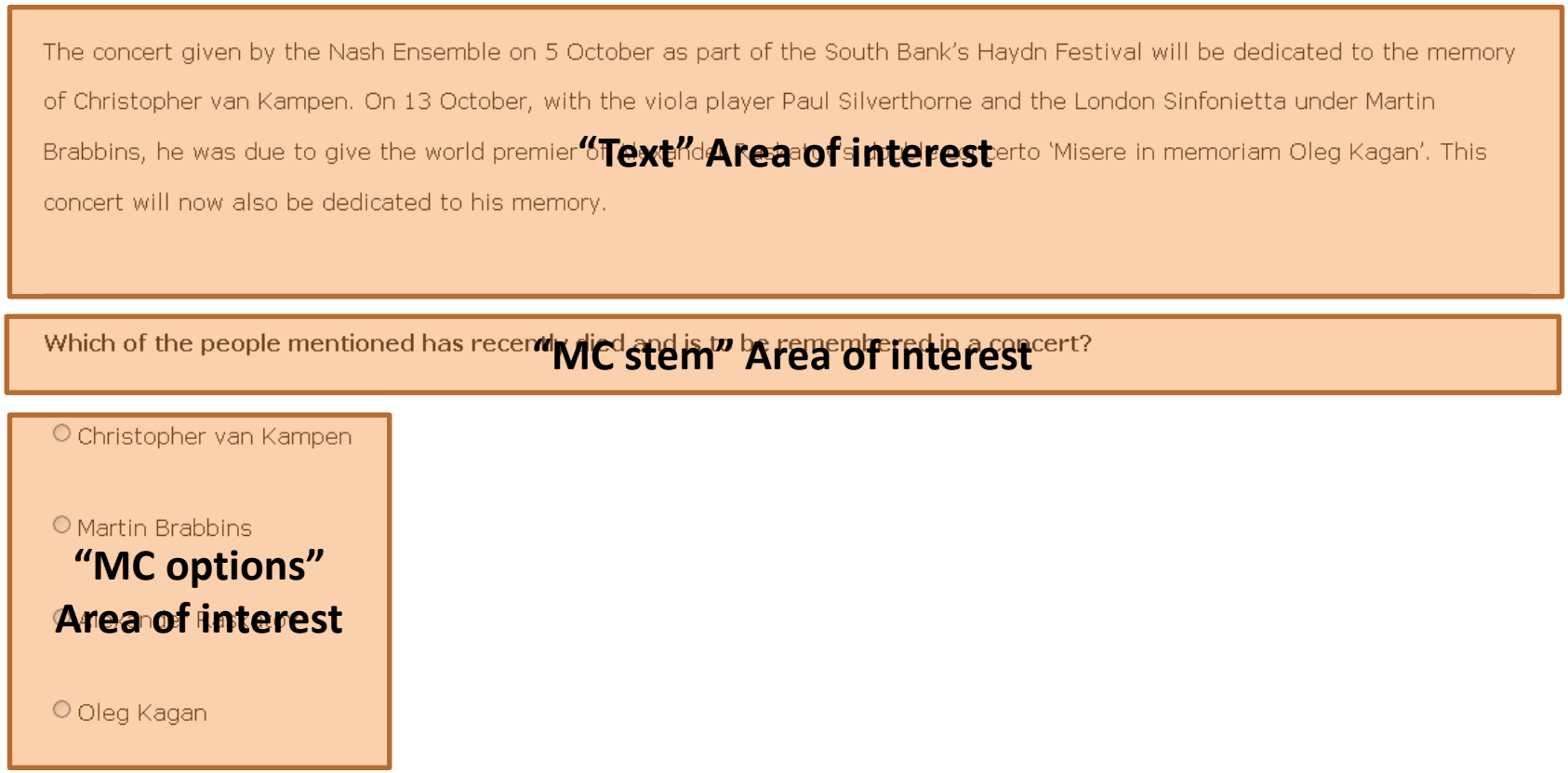
Measure name	Description	Expectation
Info.measure	Median log forward saccade length divided by log of following fixation duration	More proficient readers will have a higher info measure as they can take in more characters in a lower time period (i.e. faster processing).

Methodology



Methodology

Areas of Interest (AoI)



Methodology

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AoI-related measures

Measure name	Description	Expectation
Text.to.stem	Number of switches between the 'Text' AoI and the 'MC stem' AoI	More proficient readers will have a lower number of switches between the 'Text' and the 'Stem' as their more accurate initial processing of the text does not require them to switch (as much) in order to correctly respond.
Text.to.option	Number of switches between the 'Text' AoI and the 'MC options' AoI	More proficient readers will have a lower number of switches between the 'Text' and the 'Options' as their more accurate initial processing of the text does not require them to switch (as much) in order to correctly respond.

Analyses

1. Pearson's correlations between L2 reading ability and each individual eye-tracking measure.

2. Backwards stepwise multiple linear regression to investigate the joint predictive power of the variables.

Initial Findings

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Eye-tracking measures related to the **text**

Variable	Mean (SD or -1sd , +1sd)	Correlation with L2 reading
Raw.scores	31.86 (6.74)	NA
N.fix	2005 (408)	-0.00 (p=0.98)
Sum.fix.dur	482 (125) Seconds	0.09 (p=0.52)
Med.fix.dur	219 (119, 242) Milliseconds	-0.17 (p=0.23)
N.Sac	1281 (303)	0.01 (p=0.94)
Med.sac.length	**72.10 (61, 85) Pixels**	**0.30 (p=0.04)**
SD.sac.length	**0.46 (0.07) log (Pixels)**	**-0.32 (p=0.02)**
N.reg	380.42 (160)	0.17 (p=0.23)
Med.reg.length	-52 (42, 64) Pixels	0.06 (p=0.70)
SD.reg.length	**0.75 (0.10) log (Pixels)**	**-0.41 (p=0.00)**
Info.measure	**0.79 (0.04)**	**0.35 (p=0.01)**

*p<.05

Initial Findings

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Eye-tracking measures related to the **items**

Variable	Mean (SD or -1sd , +1sd)	Correlation with L2 reading
N.fix	985 (280)	-0.04 (p=0.80)
Sum.fix.dur	209 (67) Seconds	-0.06 (p=0.68)
Med.fix.dur	192 (174, 213) Milliseconds	-0.04 (p=0.76)
N.Sac	496 (148)	-0.06 (p=0.69)
Med.sac.length	111 (93, 132) Pixels	0.28 (p=0.06)
SD.sac.length	**0.58 (0.09) log (Pixels)**	**-0.29 (p=0.04)**
N.Reg	239(87)	0.01 (p=0.97)
Med.reg.length	82 (68 -102) Pixels	0.12 (p=0.42)
SD.reg.length	**0.76 (0.08) log (Pixels)**	**-0.34 (p=0.02)**
Info.measure	**0.88 (0.04)**	**0.29 (p=0.04)**
Text.to.stem	**11 (5.5)**	**0.36 (p=0.01)**
Text.to.option	37 (17)	-0.06 (p=0.67)

*p<.05

Analyses

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1. Pearson's correlations between L2 reading ability and each individual eye-tracking measure.

2. Backwards stepwise multiple linear regression to investigate the joint predictive power of the variables.

Findings

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Eye-tracking measures related to the **text**

Variable	Estimate (Standardised)	P-value
Sum.fix.dur	0.43	0.007**
SD.sac.length	-0.55	0.000***
info.measure	0.72	0.000***
Adjusted R-Squared = 0.35 *P-value = 0.00****		

Findings

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Eye-tracking measures related to the **items**

Variable	Estimate (Standardised)	P-value
SD.sac.length	-0.44	0.01*
info.measure	0.32	0.00***
Text.to.stem	0.40	0.00**
Adjusted R-Squared = 0.34 *P-value = 0.00****		

Conclusions

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L2 reading

- When modelled separately a number of eye-tracking variables correlate with L2 reading
- Three-variable model explaining 35% of the L2 reading variance:
  - Fixation-related measure:
    - sum of fixation duration
  - Saccade-related measure:
    - SD length saccades
  - Combined measure (saccade & fixation):
    - Info measure

Conclusion

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- The **consistency of the length of saccades** seems to be a good predictor of L2 reading ability
- The **combination of sequential saccade lengths and fixation durations** seems to be a good predictor of L2 reading ability
- The fact that the results were similar across two different stimuli (text vs items) is promising and further research to confirm the findings is desirable
- The finding that, when other variables are accounted for, the switching between text and item stem is a significant explanatory factor is also new

Conclusions

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Methodological innovations

1. Inclusion of interactions between measures in the modelling process
2. The extraction and analysis of more complex eye-tracking metrics than are commonly seen in the investigation of reading

But note that this is an exploratory study, not a confirmatory one --> further research needed!

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Thank you for listening, and watching!

Tineke Brunfaut

Lancaster linguistics eyetracking lab:

http://wp.lancs.ac.uk/ltrg/eye-tracking-lab/