

# The Cost of L2 Fluency: Eye-Movement Evidence for Reduced L1 Reading Automaticity



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## Introduction

Over 6.4 million students study abroad (UNESCO, 2023), including over 150,000 Chinese students in the UK (UKCISA, 2023). Reduced daily use of the first language (L1) can lead to L1 attrition, a gradual decline in native proficiency, due to immersion in a second language (L2) (Schmid, 2011). While spoken language has been widely studied, the processes supporting fluent reading remain less explored.

**Word frequency** and **length** are key predictors of reading fluency in both L1 and L2, influencing first fixation duration and total reading time. Their role in **bilingual reading**, particularly L1 Chinese under L2 English immersion, is still **underexplored**.

Eye-tracking studies identify **effects** such as:

- **Spill-over** : a difficult word affects fixations on the next word
- **Preview benefit**: upcoming words are partially processed during fixations on previous words
- **Parafoveal-on-foveal**: fixations are influenced by the properties of neighbouring words

These effects are well studied in monolingual readers. This study investigates whether **L2 English proficiency** and **exposure** shape these effects in L1 Chinese reading.

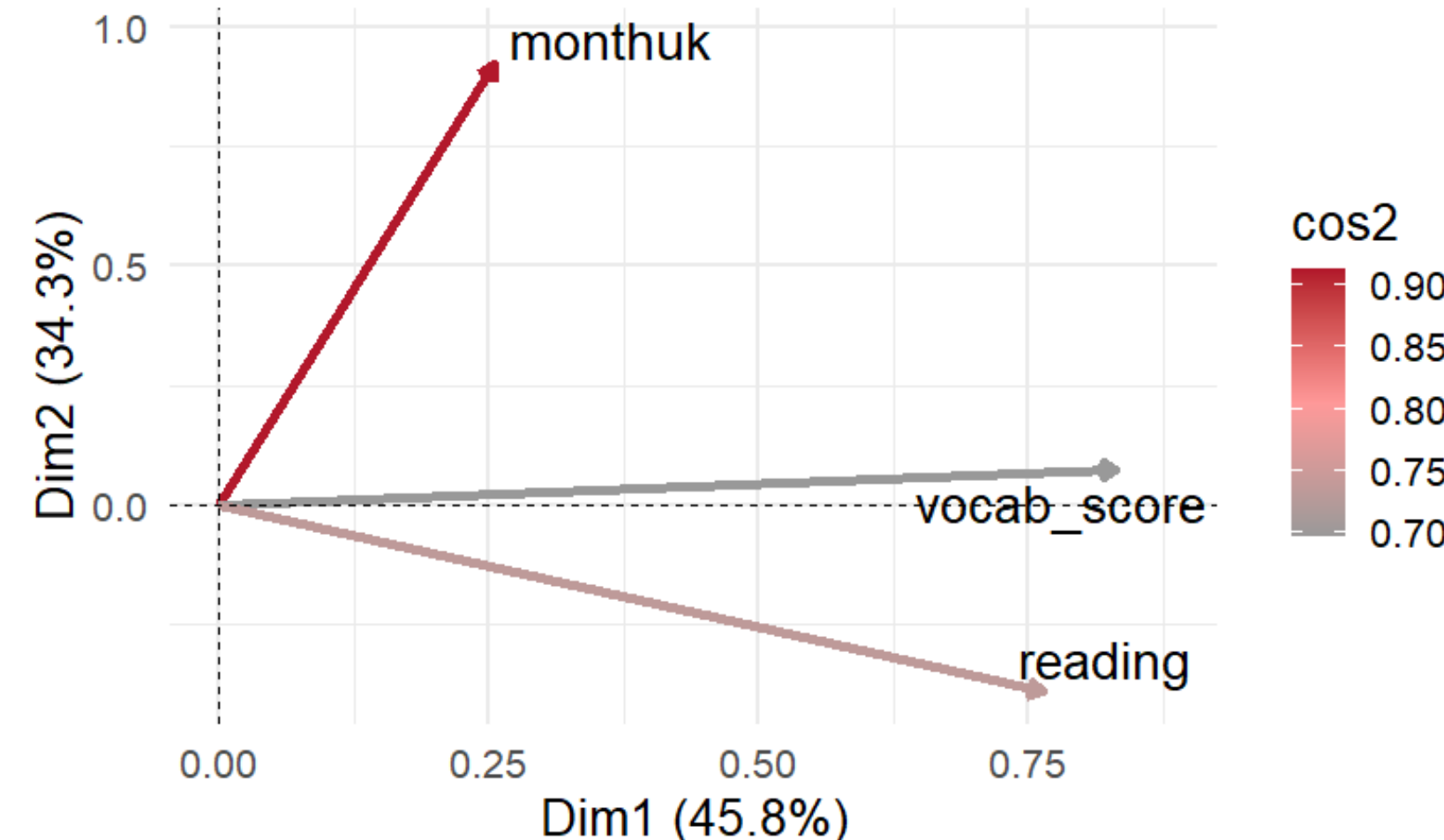
**Research Question: How prolonged L2 English immersion and L2 proficiency affect L1 Chinese reading fluency and eye-movement patterns during naturalistic reading?**

## Method

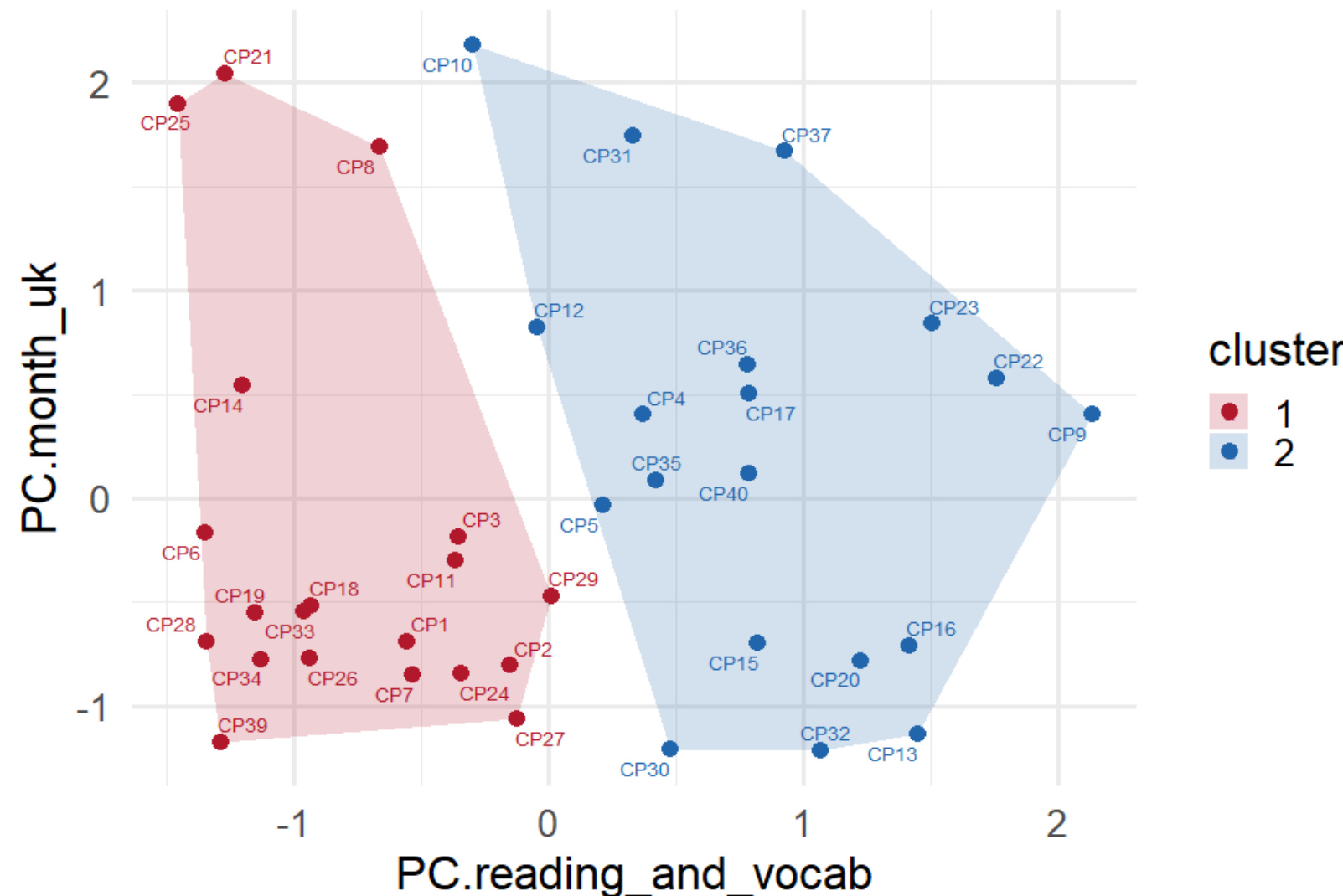
### Participants and Grouping Method

- Participants: 39 Chinese L2 learners of English
- Principle Component Analysis & Clustering Analysis
- Grouping based on:
  - IELTS reading scores and Vocab size test scores
  - durations of residence in the UK (in months)

#### Participant Grouping - PCA



#### K-means Clustering on PCA Scores



- > 20 in the upper intermediate group
- > 19 in the advanced group



Optimising participant grouping methods in bilingualism studies  
Insights from eye-tracking data  
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Group	Mean Vocabulary	Mean Reading	Mean Months
Upper-Int	9.9 (SD = 2.3)	6.6 (SD = 0.7)	11.1 (SD = 8.6)
Advanced	13.4** (SD = 2.2)	7.7** (SD = 0.8)	22.9 (SD = 12.4)

### Experimental items

- 24 short excerpts from online Chinese news
- Comprehension check: Yes/no question
- Word-based Interest Areas (IAs)
- Segmentation reviewed by two linguists → 95% agreement
- Example segmentation (hidden from participants):  
“他在图书馆借了一本有趣的小说”  
他 | 在 | 图书馆 | 借了 | 一本 | 有趣的 | 小说

### Measurements

- The eye-tracking experiment- multiline reading
- An English vocabulary size test
- Demographic info | IELTS scores | reading habits

### Apparatus

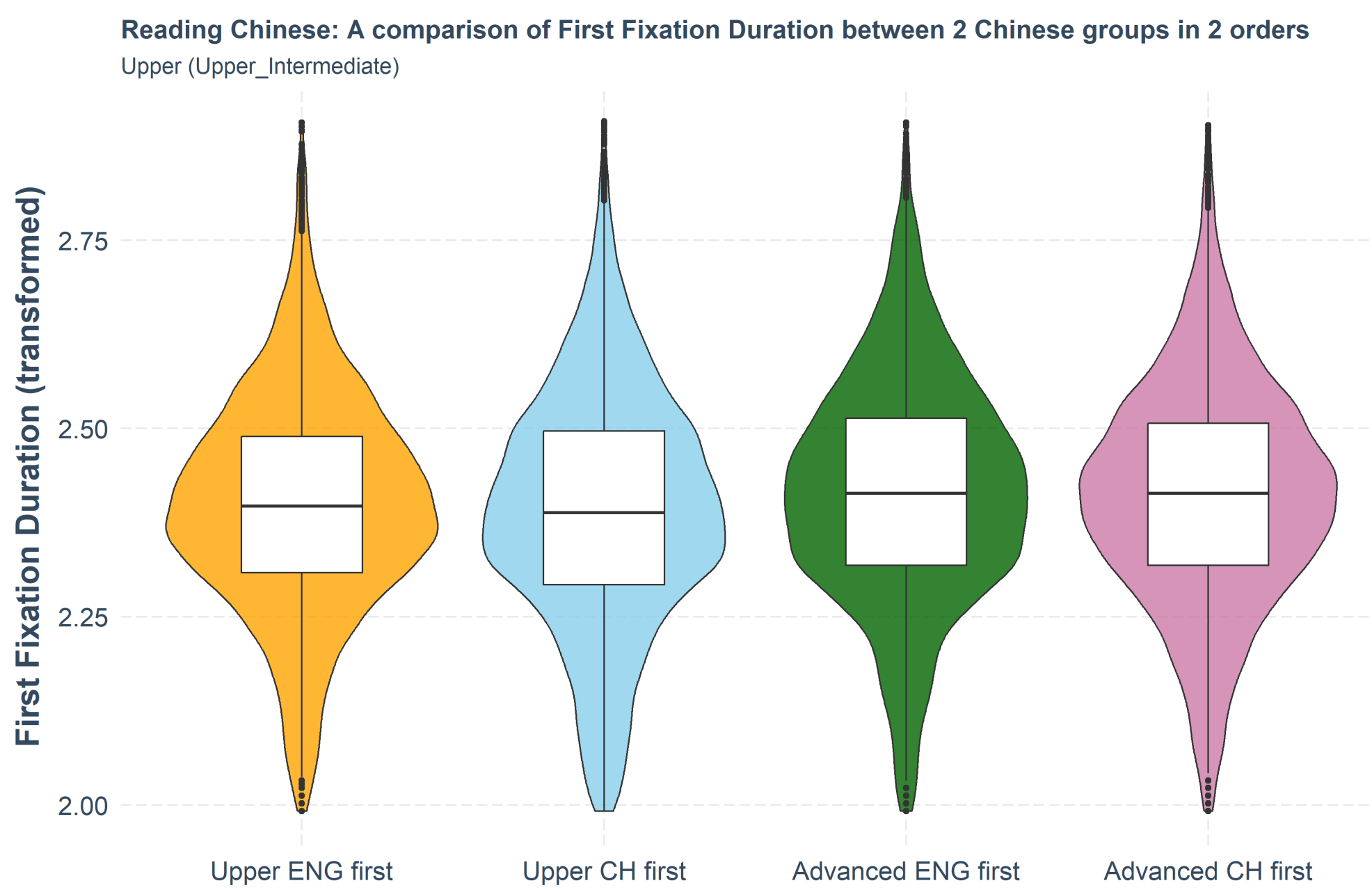
- EyeLink Portable Duo
- head-stabilised monocular recording
- 24-inch screen with a refresh rate of 500 Hz
- Courier New /size 18 /double vertical spacing



## Eye-movement Measures

- **First Fixation Duration** (FFD, the length of the first fixation made on a word)
- **Total Reading Time** (TRT, the sum of all fixations made on a word including re-reading)

## Descriptive Analysis - FFD



Group	Mean	Median	SD	MAD
Upper ENG first	2.399	2.397	0.148	0.132
Upper CH first	2.391	2.388	0.162	0.150
Advanced ENG first	2.416	2.414	0.154	0.143
Advanced CH first	2.411	2.414	0.151	0.141

Advanced group (high L2 proficiency & immersion):  
Longer mean FFD than Upper Intermediate

## Descriptive Analysis - Total Reading Time

Group	Mean	Median	SD	MAD
Upper ENG first	5.399	5.347	0.486	0.441
Upper CH first	5.363	5.328	0.501	0.466
Advanced ENG first	5.430	5.384	0.489	0.459
Advanced CH first	5.449	5.403	0.492	0.467

Despite high L2 English proficiency Advanced group displayed:  
Longer fixation times as evidence of prolonged lexical access

## Modelling Results -FFD

A complete list of variables included in the most parsimonious model to predict the first fixation durations on word N in reading Chinese

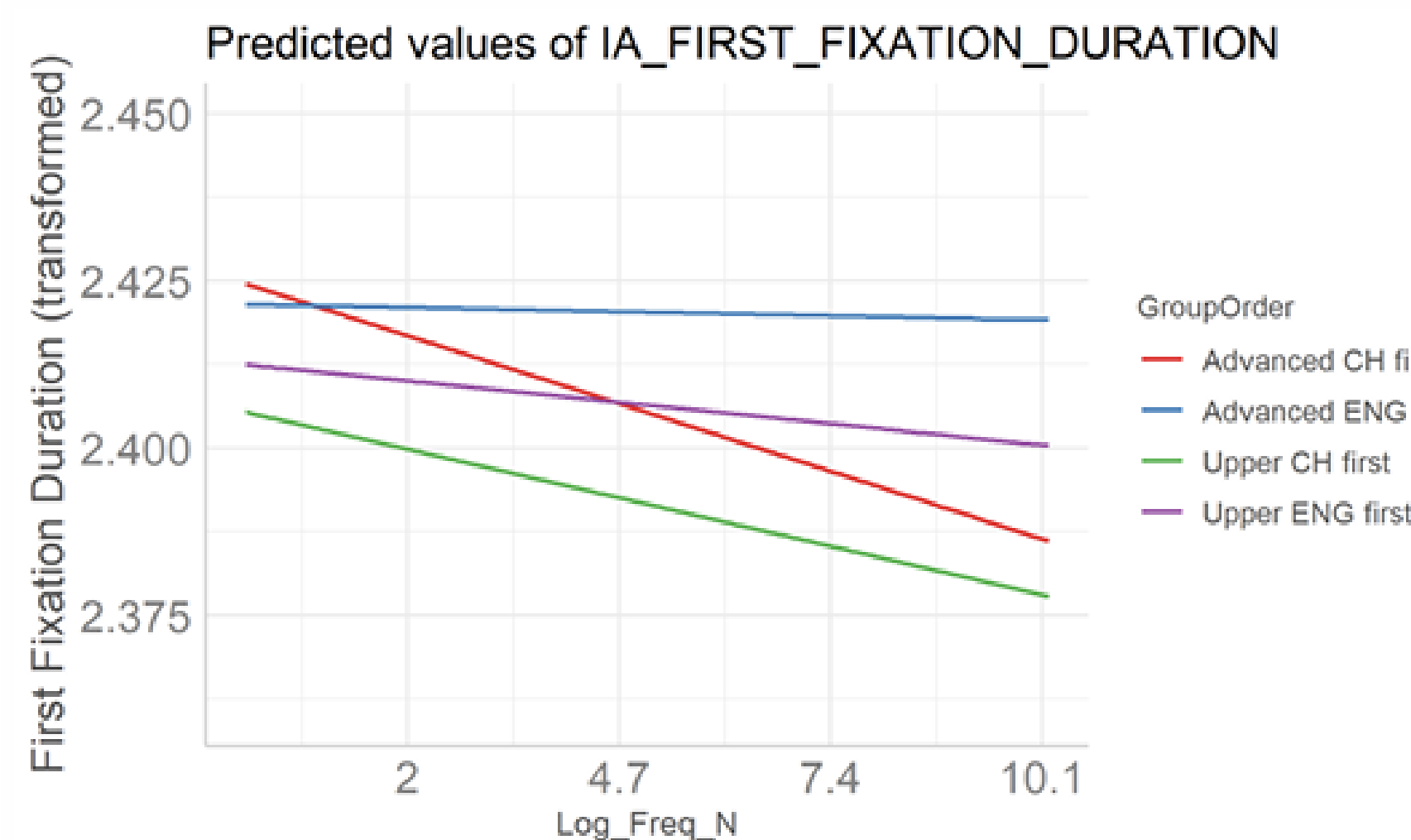
Property Types	Variable Names	Explanation
Word-level Properties	Log_Freq_N	the frequency after logarithm of the current fixated word N
	Wordlength_Next	the length of the upcoming word, N+1
	Log_Freq_Prev	the frequency of the word left to the current fixated word, i.e., word N-1
Text-level Property	Scaled_Word_Story_Order	the combined order of a word in a story and the order of a story in the reading study

The specification of the final best model is:

```
IA_FIRST_FIXATION_DURATION_PowerT ~  
GroupOrder / (  
  poly(Scaled_Word_Story_Order, 2) +  
  Log_Freq_N +  
  Wordlength_Next +  
  poly(Log_Freq_Prev, 3)) +  
(1 | Participant_ID) +  
(1 | Story_ID) +  
(1 | Word_ID)
```

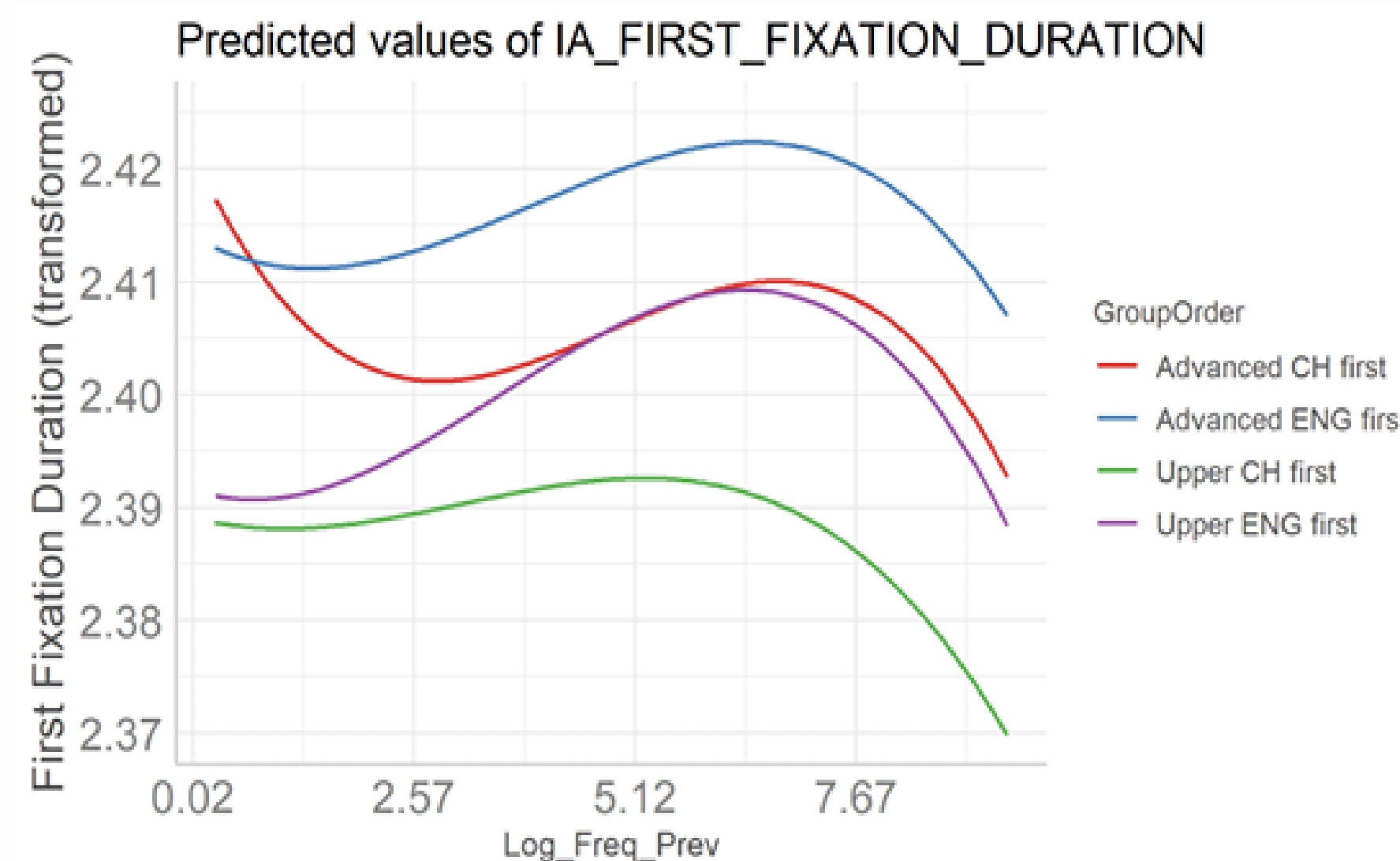
## Plots - FFD

The effect of the frequency of the currently fixated word N on the first fixation durations on word N for two Chinese groups in reading Chinese with different reading orders



## Plots - FFD

The effect of the frequency of the previous word N-1 on the first fixation durations on word N for two Chinese groups in reading Chinese with different reading orders



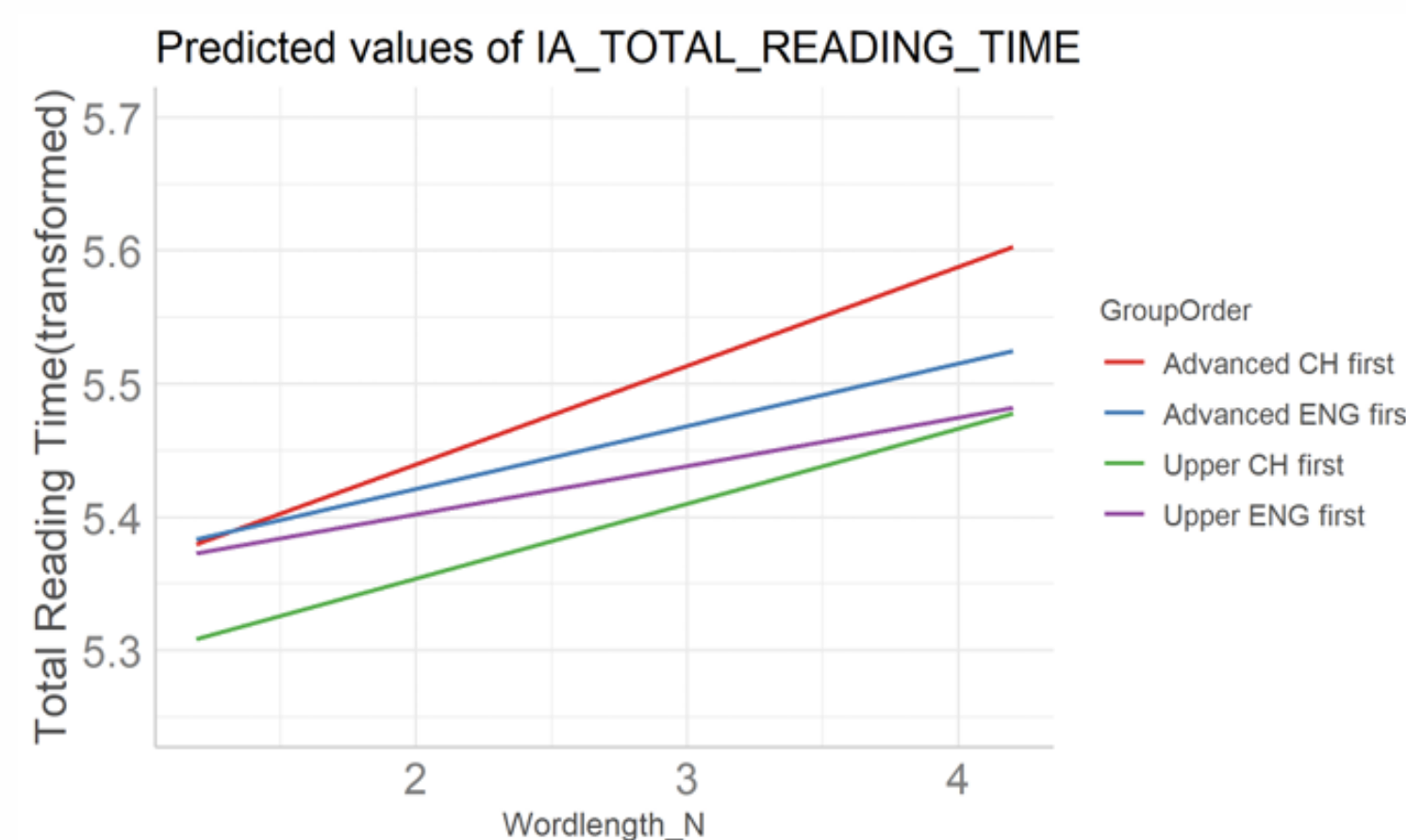
## Modelling Results -TRT

A complete list of variables included in the most parsimonious model to predict the total reading time on word N in reading Chinese

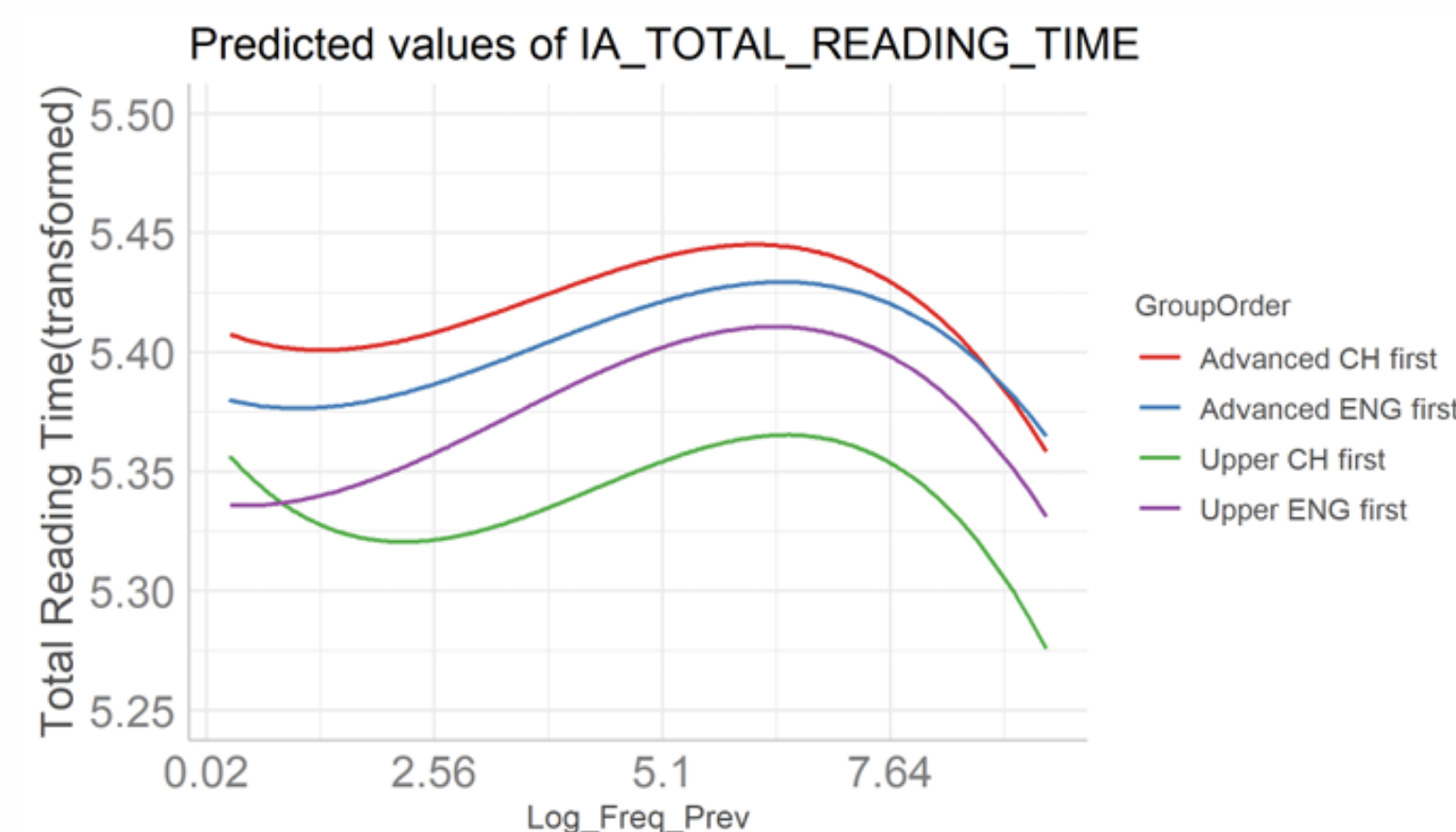
Property Types	Variable Names	Explanation
Word-level Properties	Wordlength_N	the length of the current fixated word N
	Log_Freq_N	the frequency after logarithm of the current fixated word N
	Wordlength_Next	the length of the upcoming word, N+1
	Log_Freq_Prev	the frequency of the word to the left of the current fixated word, i.e., word N-1
Text-level Property	Log_Freq_Next	the frequency of the upcoming word, N+1
	Scaled_Word_Story_Order	the combined order of a word in a story and the order of a story in the reading study

## Plots - FFD

The effect of the length of the currently fixated word N on the total reading time on word N for two Chinese groups in reading Chinese with different reading orders



The effect of the frequency of the previous word N-1 on the total reading time on word N for two Chinese groups in reading Chinese with different reading orders



## Summary Points

Attrition is Modulated by Word Characteristics:

- Longer and low-frequency L1 words caused greater disruption in Advanced bilinguals, aligning with the attrition-by-disuse hypothesis.
- High-frequency words showed partial resilience, supporting compensatory facilitation, though not always sufficient.

L1 Attrition Effects Are Detected at the Word Level:

- The fine-grained, word-level analysis (FFD & TRT) reveals subtle signs of attrition missed by sentence- or discourse-level studies.
- This micro-level focus sets this study apart from prior research on L1 attrition and highlights eye-tracking as a powerful tool in uncovering lexical shifts.

## Conclusions

Word-level eye-tracking reveals early signs of change.

Rather than sentence-level comprehension, micro-level fixation patterns are where attrition first becomes visible.

Advanced L2 users show restructured L1 processing.

They display slower lexical access, weaker frequency effects, and greater reliance on L2-like reading strategies - a signal of orthographic and cognitive adaptation.

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