Eye Movement Guidance in Reading Chinese

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Eye Movement and Reading Laboratory

眼動與閱讀實驗室

Eye Movement and Reading Laboratory

- Early character and word processing in the parafovea
  - Phonological, semantic coding of characters
  - Word segmentation
- Contextual influence in reading Chinese sentences
  - Word predictability
  - Semantic ambiguity resolution: Homographs
- Auditory and visual integration in language processing
  - Reading and listening: spoken character/word recognition
  - Scene viewing and listening
- Individual difference in reading Chinese
  - Learning Chinese as a second language
  - Traditional Chinese vs. Simplified Chinese

Why the eyes have to move?

Visual acuity
Attentional resource

Eye movements can reflect

- Visual preference/saliency

  - Color, contrast, brightness

- Cognitive preference/need
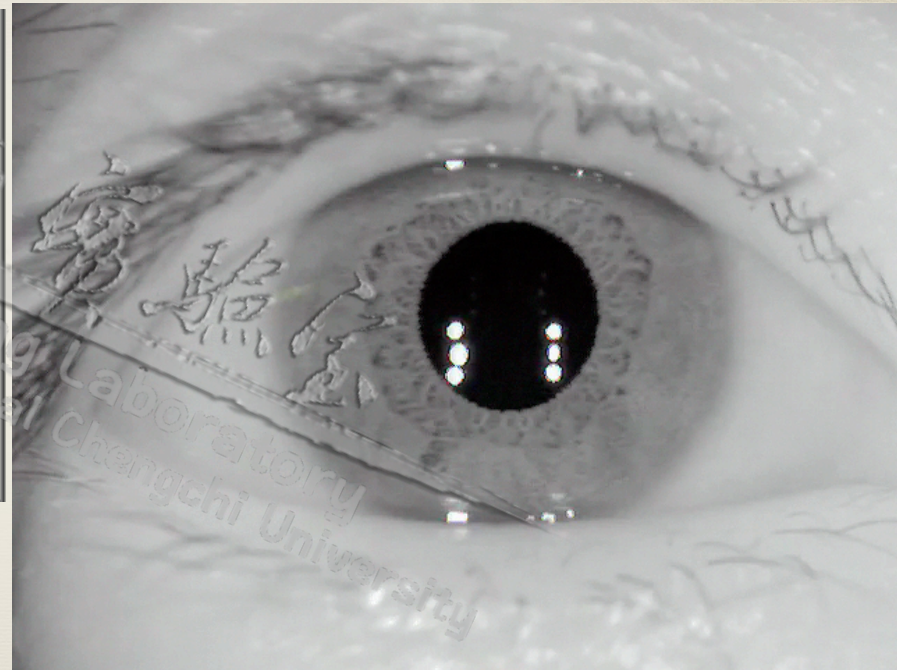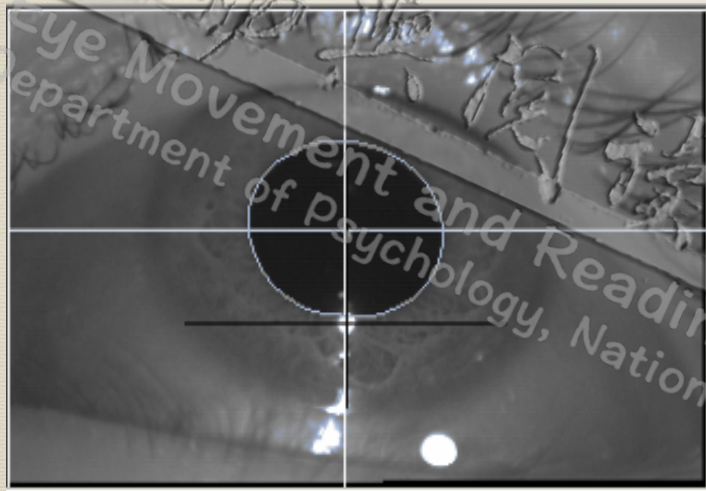
  - Intention, experience, knowledge, emotion

Eye tracking systems

Detection of pupil and corneal reflection

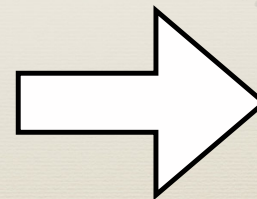# Calibration

Mapping eye movements to eye fixation locations

Eye movement experiments of reading

演一個很重要的角色；婦女出門會在手絹上噴一點，男士刮完鬍子也會抹一些，小孩被蚊蟲咬傷，大人會在他紅腫的地方擦幾滴明星花露水，保證立刻消腫。如今國外名牌化妝品大肆入境，綠色瓶裝的

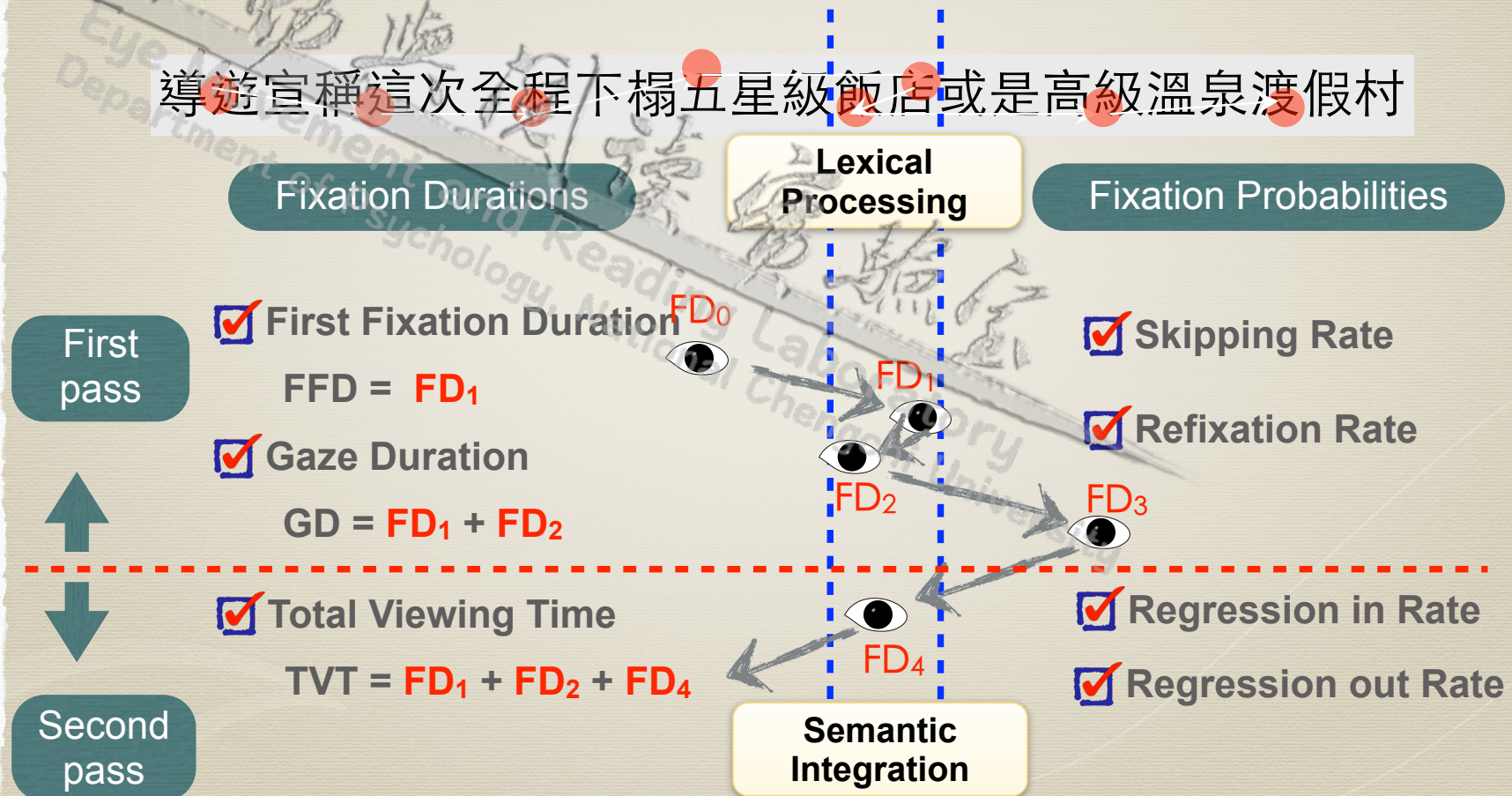**Fixation Durations**

Fixation Probabilities

Lexical Processing

Semantic Integration

Eye movement indices

導遊宣稱這次全程下榻五星級飯店或是高級溫泉渡假村

Fixation Durations

Lexical Processing

Fixation Probabilities

First pass

☑ **First Fixation Duration** FD_0

FFD = FD_1

☑ **Gaze Duration**

GD = $FD_1 + FD_2$

FD_1

FD_2

FD_3

☑ **Skipping Rate**

☑ **Refixation Rate**

☑ **Total Viewing Time**

TVT = $FD_1 + FD_2 + FD_4$

FD_4

☑ **Regression in Rate**

☑ **Regression out Rate**

Second pass

Semantic Integration

Two main stages of sentence reading

- **Word recognition**
  - access orthographic, phonological, semantic information
- **Comprehension**
  - integrate syntactic and semantic relations among words

- **Bidirectional Influence between two stages**
  - Bottom-up: recognized words are the elements for comprehension
  - Top-down: context can be used to predict or facilitate the recognition of the following word

Chinese Writing System

Chinese characters

- occupy a rectangular region of the same size, separated by space of an equal size in sentence
- map onto morphemes and syllables
- are composed of radicals
- are constituents of words

源

Character

氵原

Radical

能源

Word

Things become more complicated when characters are embedded in sentence.

Word ambiguities in Chinese sentence

- Four thousand characters (often-used) generate one hundred thousand words, most are compounds
  - lexical ambiguity
    - **Word length**: most words(type) are 2-charachers; in sentence corpus, the ratio is almost 1:1 for 1- and 2-character words(token).
    - **Orthographic:** The same characters can appear in many words
    - **Phonological:** homophones
    - **Semantic:** Morpheme carried by character is not always transparent to word meaning,
  - word boundary ambiguity
  - About 80% of characters can appear at more than one position within a word

地球 暖化 問題 日 趨 嚴重 ， 節 約 能 源 成 為 全 人 類 的 重 要 課 題

Contextual influence on word recognition

Context facilitates word recognition by decreasing dependency on visual and bottom up processing

- **Sites of the influence**
  - foveal /fixated word
  - parafoveal/ next to the fixated word
- **Type of the influence**
  - facilitate processing of the visually encoded information
  - guess what the next word is and ignore the encoded information

Contextual and lexical interaction in reading Chinese

- **Question**
  - Does contextual predictability influence lexical processing of words?
  - Does the contextual effect occurs early or late?
- **Methods**
  - Thirty-two participants
  - Frequency (low vs. high) x predictability (predictable vs. unpredictable) within-subjects design
  - One hundred two-character words; two hundred sentences.

Contextual and lexical interaction in reading Chinese

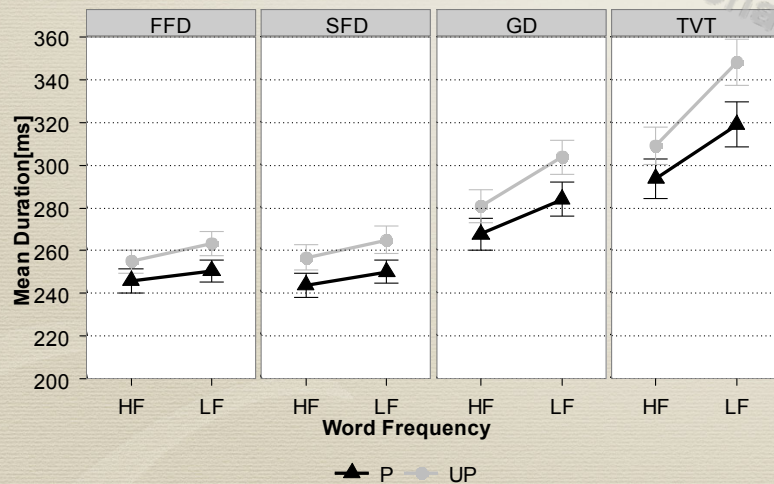Measuring contextual constraint: **word predictability**

- The Cloze task

商場如戰場，沒有明確的遊戲規則只能倚賴經驗累積與智慧

高挑美麗的主持人在台上將協會規則做清楚且詳盡的說明

Contextual and lexical interaction in reading Chinese

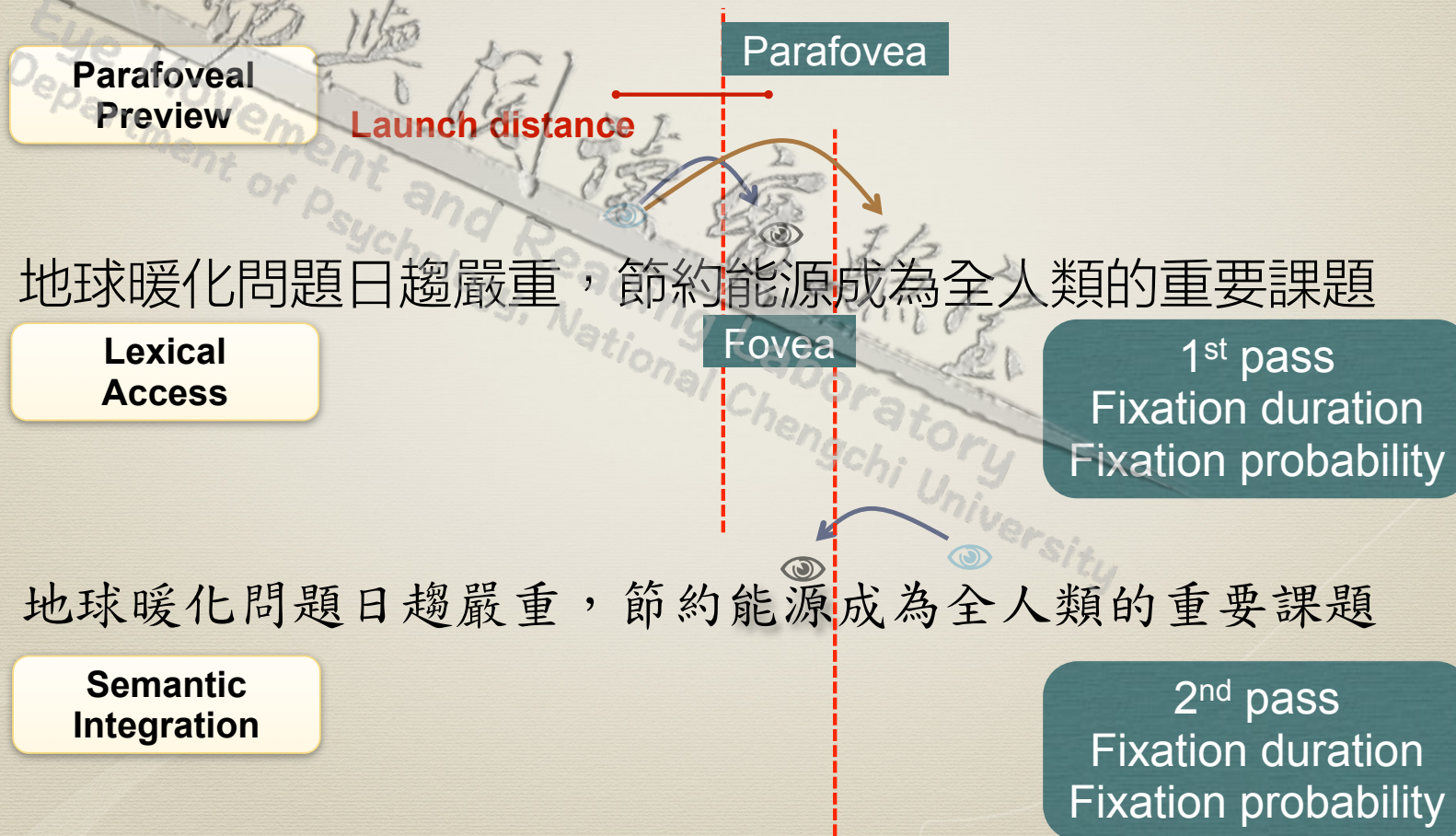|		WF	Strokes	Pred. values	Example
HF	P	91.08	21.10	0.78	尊遊宣稱這次全程下榻五星級飯店或是高級溫泉渡假村
	UP			0.01	經過規劃後，他們決定將飯店的一樓開放讓名牌廠商進駐
LF	P	1.58	22.08	0.73	為了正確讀出單字，先練習母音和子音的發音是有其必要的
	UP			0.01	他研究的題目主要是有關日語的子音及濁音錯讀的種種現象

- All fixation duration measures showed the word predictability effects.
- The word frequency was reliable on GD and TVT.
- An interaction was observed on TVT.

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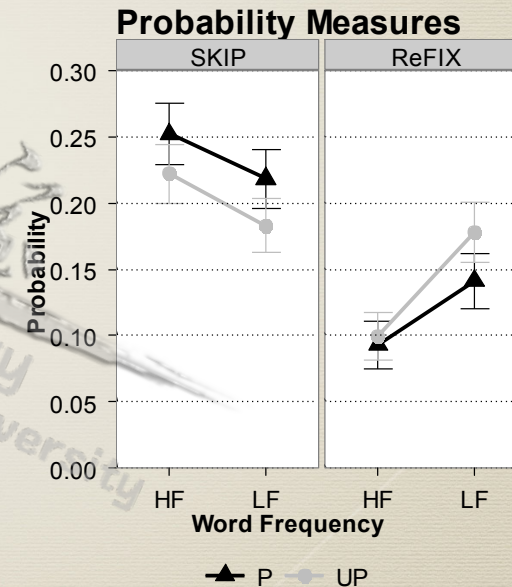# Contextual and lexical interaction in reading Chinese

- Word predictability facilitated both early lexical access and late semantic integration.

- The early effect of word predictability was independent of word familiarity.

- For semantic integration, context provides more support for unfamiliar words than familiar words

Different stages of involving contextual information

Parafoveal Preview

Parafovea

Launch distance

地球暖化問題日趨嚴重，節約能源成為全人類的重要課題

Lexical Access

Fovea

1st pass
Fixation duration
Fixation probability

地球暖化問題日趨嚴重，節約能源成為全人類的重要課題

Semantic Integration

2nd pass
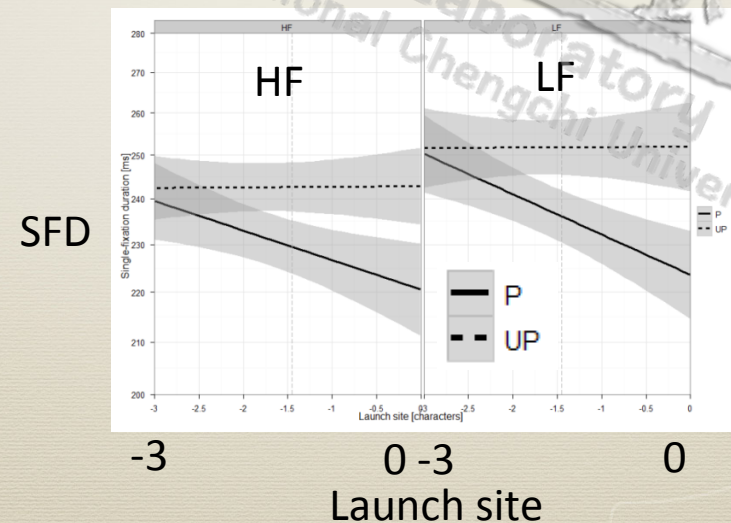Fixation duration
Fixation probability

Word predictability effect in parafoveal preview

- Word skipping: predictable words were skipped more than unpredictable words

- Two possible accounts

  - Context helps to retrieve word without using the visual information

  - Context facilitates the visual word processing in parafovea

Probability Measures

	SKIP	ReFIX

Probability

0.30
0.25
0.20
0.15
0.10
0.05
0.00

HF   LF   HF   LF
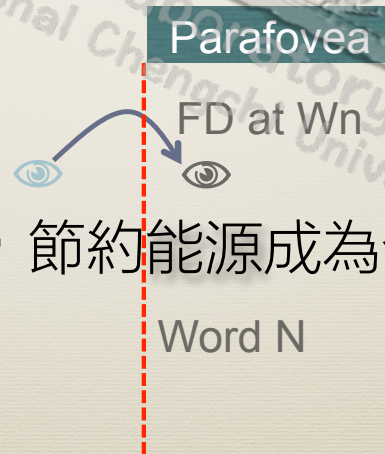
Word Frequency

P   UP

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Word predictability effect in parafoveal preview

- When adding the launch distance as a covariate, the interaction between predictability and launch distance was significant.

- Contextual information facilitates parafoveal target preview and subsequently reduces the fixation time on target word.

Parafoveal preview in reading

- Processing word N (Wn) can be initiated early when word N is in the parafovea of the prior fixation.

- Parafoveal preview benefit: Fixation time on Word N is shorten when word N is partially processed in parafovea.

Parafovea

FD at Wn

地球暖化問題日趨嚴重，節約能源成為全人類的重要課題

Word N

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The boundary paradigm

(Rayner, 1979)

- Set an invisible boundary at the location before the target.

- Change the preview character to the target when the eyes cross the boundary.

- Manipulate the shared features of the preview and target

- Preview benefit: fixation duration of target would be shorter for the similar preview than an unrelated preview, if the shared feature is processed parafoveally

Phonological preview

有關串聯兩部電腦的問題必須找驚通程式設計的人來解決

Unrelated preview

有關串聯兩部電腦的問題必須找巢通程式設計的人來解決

Target character

有關串聯兩部電腦的問題必須找精通程式設計的人來解決

Parafoveal preview in reading

- The parafoveal preview effect can indicate lexical processing in an early stage of parafoveal preview

- Early lexical processing can be examined in a reading situation with less task demanding (LDT, naming)

- For reading alphabetic scripts, both orthographic and phonological codes can be accessed in parafovea

Parafoveal preview effects of Chinese characters in reading

- Orthography / Phonology
  - Liu, Inhoff, Ye, & Wu (2002)
  - Tsai et al. (2004)
- Morphology
  - Yen, Tsai, Tzeng, & Hung (2008)
  - Yen, Radach, Tzeng, Hung, & Tsai (2009)
- Semantic
  - Yan, Richter, Shu, & Kliegl (2009)
  - Tsai, Kliegl, & Yan (2012)

Contextual influence on parafoveal preview effects

- Directly examine whether the preview benefit effect interacted with contextual predictability

- Use a boundary paradigm manipulating orthographic and phonological previews, and word predictability of targets

Contextual influence on parafoveal preview effects

Design: four preview types X two sentence frames

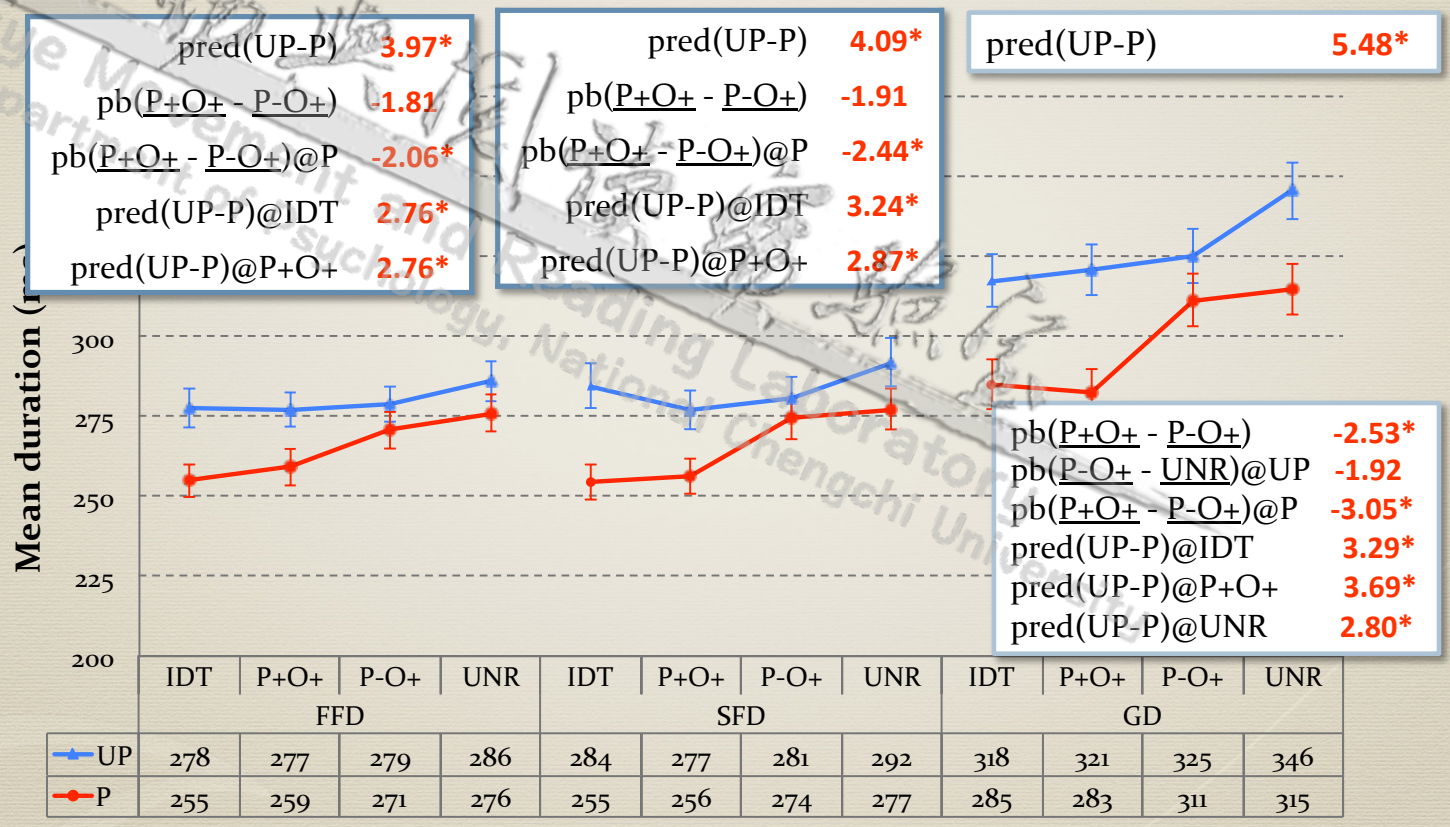|	Preview Types				Two-character target word	
	Identical/ target	P+O+	P-O+	Unrelated		
	M SD	M SD	M SD	M SD	M	SD
Example	煤	媒	謀	邪	煤炭	
Pronunciation	/ mej2/	/ mej2/	/ mow2/	/ ɕjɛ2/	/ mej2 tʰan4/	
Frequency	138.7 360.5	92.5 220.8	104.8 215.2	115.5 175.8	6.38	7.46
Strokes	11.6 3.7	11.9 3.3	11.6 3.3	11.9 2.8	22.5	5.3

Predictable(P)

工業革命時期的蒸汽火車透過燃燒煤炭加溫水以產生動力

Unpredictable(UP)

村民必須取植物的汁液並混合煤炭粉末才能做成黑墨

Contextual influence on parafoveal preview effects

pred(UP-P)	**3.97***
pb(P+O+ - P-O+)	**-1.81**
pb(P+O+ - P-O+)@P	**-2.06***
pred(UP-P)@IDT	**2.76***
pred(UP-P)@P+O+	**2.76***

pred(UP-P)	**4.09***
pb(P+O+ - P-O+)	**-1.91**
pb(P+O+ - P-O+)@P	**-2.44***
pred(UP-P)@IDT	**3.24***
pred(UP-P)@P+O+	**2.87***

pred(UP-P)	**5.48***

pb(P+O+ - P-O+)	**-2.53***
pb(P-O+ - UNR)@UP	**-1.92**
pb(P+O+ - P-O+)@P	**-3.05***
pred(UP-P)@IDT	**3.29***
pred(UP-P)@P+O+	**3.69***
pred(UP-P)@UNR	**2.80***

Mean duration (ms)

	IDT	P+O+	P-O+	UNR	IDT	P+O+	P-O+	UNR	IDT	P+O+	P-O+	UNR
		FFD				SFD				GD		
UP	278	277	279	286	284	277	281	292	318	321	325	346
P	255	259	271	276	255	256	274	277	285	283	311	315

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Contextual influence on parafoveal preview effects

- Phonological information of Chinese character is processed early in parafovea, though Chinese is a logographic orthography

- Context interacts with the availability of parafoveal preview, especially the phonological information

The subordinate bias effect in Chinese lexical ambiguity resolution

- Three types of target word
  - Low frequency ambiguous word (**A**, 6.62)
  - Low frequency unambiguous word (**LF**, 7.48)
  - High frequency unambiguous word (**HF**, 188.77)

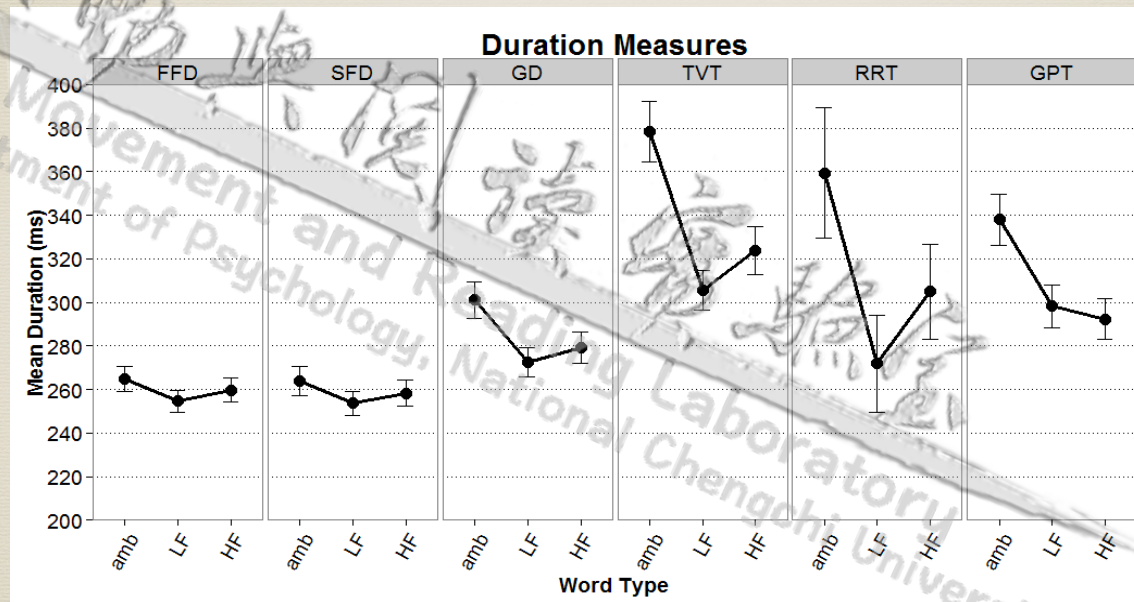| Design |
| --- |
| **Ambiguous target (A)** |
| 百年餅舖保留傳統原味並堅持絕無分號希望穩定產品的品質。 |
| **Low frequency unambiguous target (LF)** |
| 有些人習慣在飯後和睡前使用牙刷清潔齒垢以保持口腔健康。 |
| **High frequency unambiguous target (HF)** |
| 國際青年團體在世界各區域設立協會負責統籌舉辦各項活動。 |

(Tsai, Lu, & Lee, 2013)

The subordinate bias effect in Chinese lexical ambiguity resolution

- Context interacting with meaning activation of Chinese homographs can occur relatively early.
- The effect on GD supports the competition account, demonstrating the activation of dominate meaning competes with context-facilitated subordinate meaning

Conclusion

- In reading Chinese, contextual information supports

  - Later semantic integration and comprehension

  - Early lexical processing

  - Very early parafoveal processing (visual & lexical)

- The advantages of eye movement recordings for reading research

  - On-line processing In a natural reading situation

  - Time courses of lexical and sentence processing

  - Foveal and parafoveal processing

  - Integration of semantic and syntactic structures

Thank you !

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