Group Project

The Effect of Phonological Similarity on Bilingual Word Superiority Effect: Evidence from EEG

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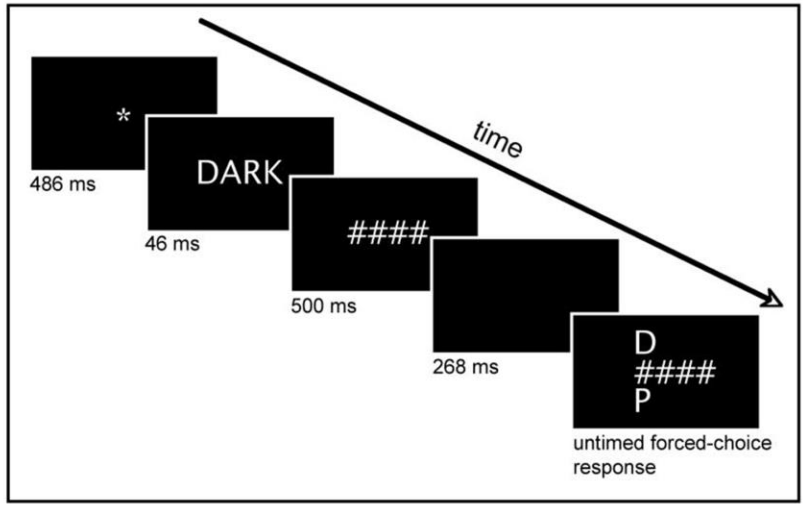
Introduction of WSE

Reicher-Wheeler paradigm
(Reicher, 1969; Wheeler, 1970)



(Ripamonti et al., 2017)

People can recognize letters more accurately and quickly when they are presented within the context of a word, compared to when the same letters are presented in isolation or within a non-word string.

A whole word recognition > Individual letters identification

From Word-letter Phenomenon (WLP) to Word Superiority Effect (WSE)

"Pronounciable words are owning more superiority effect than non-words."
Baron & Thurston, 1973

Phonological factor

"Processing words is faster than single letter; all four letters in a four-letter word are perceived significantly better."
Johnston & McClelland, 1973

Orthographic/Semantic factor

"Vocal cues before masks enhance the accuracy and reaction speed of single-letter recognition."
Merzich, 1973

Phonological Cueing factor

Associated:
Pseudoword Superiority Effect (PSE)

Letter Recognition in Pseudoword > Letter Recognition in Non-word (Unpronounceable)

e.g
“WORC”

e.g
“WRSC”

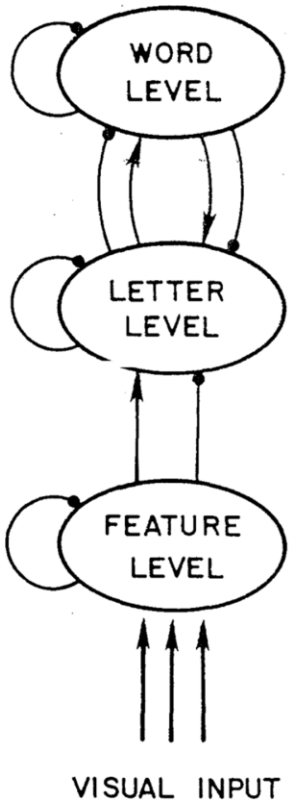
Word Superiority Effect
(Phonogram表音文字)

Genuine lexical effect

Interactive Activation Model
(IAM)

Top-down processing

Bottom-up processing



(Rumelhart & McCllende, 1981)

WSE in Chinese lexicon processing

Word semantic transparency plays a role in Chinese compound word recognition visually.Compounds with at least one opaque constituent (fully and partially opaque) patterned together and
displayed a larger WSE (more word-like) than fully transparent compounds. （Mok, 2016)

e.g. “徒”： “徒弟”vs“徒交”

Native Chinese readers develop strong representations at both the character and the word level, while low-**proficiency** Chinese learners are more dependent on the word level... （Chen et al., 2018)

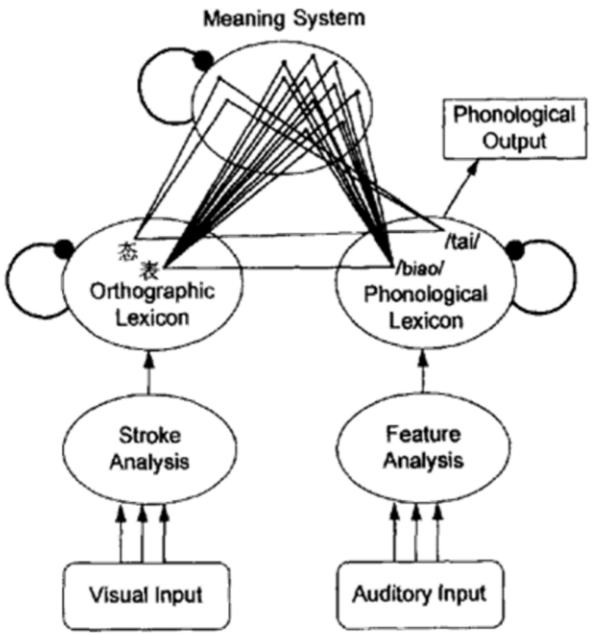
Word Superiority Effect
(Logogram表意文字)

Genuine lexical effect

Interactive Activation Model
(IAM)

Top-down processing

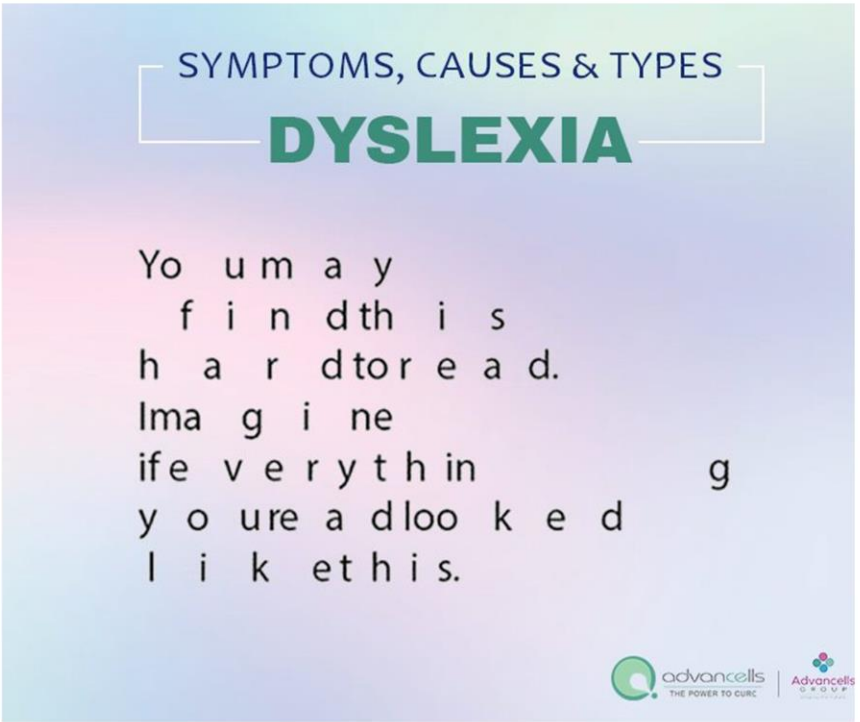
Bottom-up processing



(Perfetti & Tan, 1981)

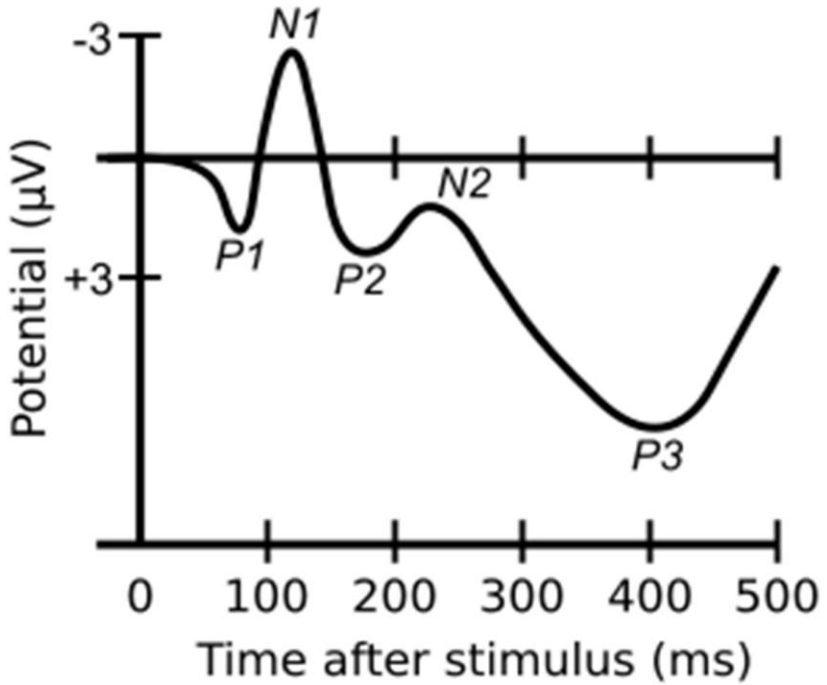
WSE in Visual Processing and Reading (e.g. dyslexia/reading disorder)

Letters were better identified in the dyslexic group when belonging to orthographically familiar strings. Letter-position encoding was very impaired in dyslexic children who did not show any word context effect in contrast to CA-controls. (Jucla et al., 1990)

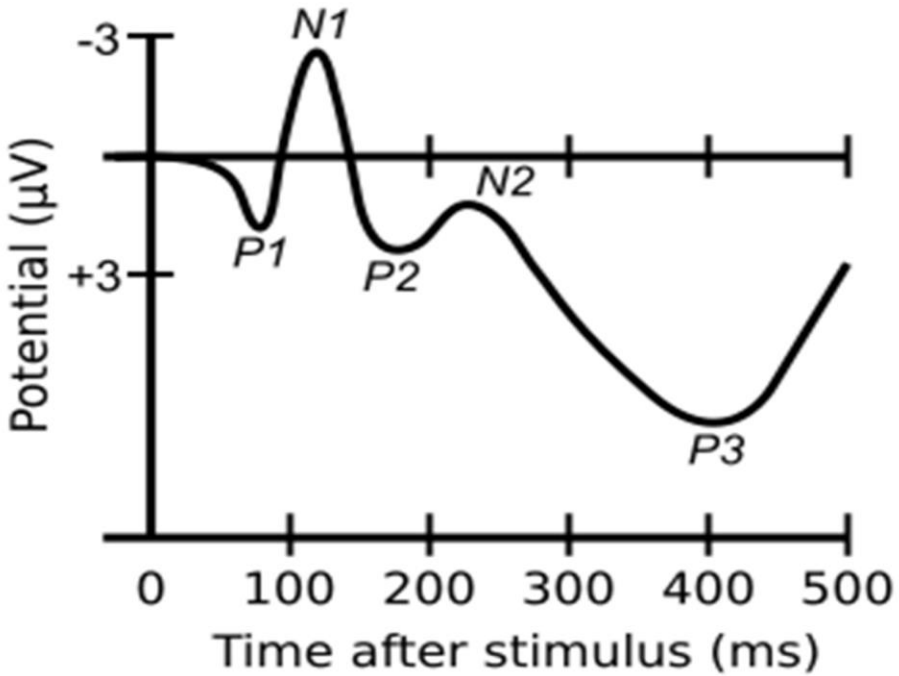


EEG Components in WSE

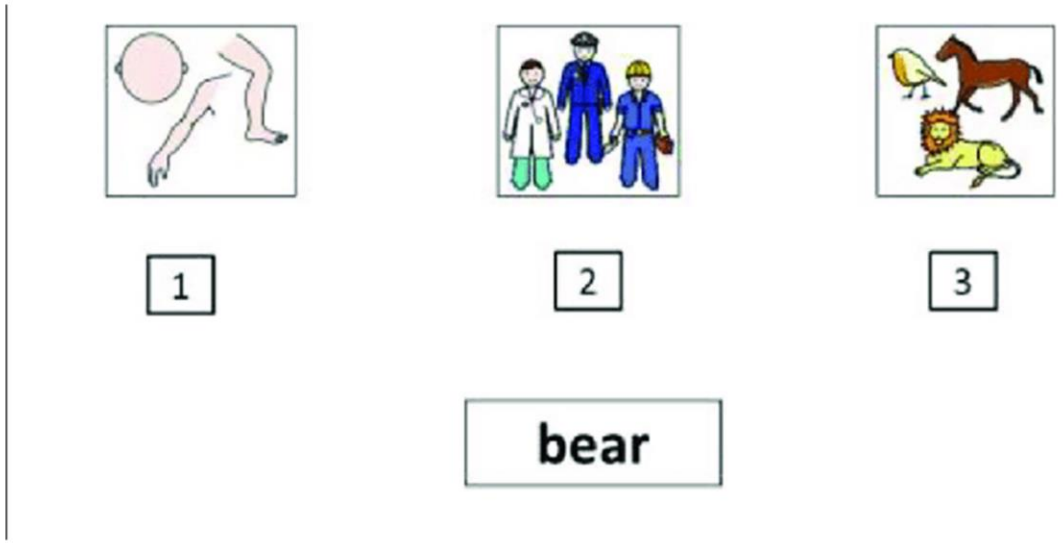
- **Timing:** Occurs approximately 50-100 milliseconds after visual stimulus.
- **Primary Location:** Occipital visual cortex.
- **Functional Relevance:** Associated with processing of physical attributes of a stimulus such as brightness and color.

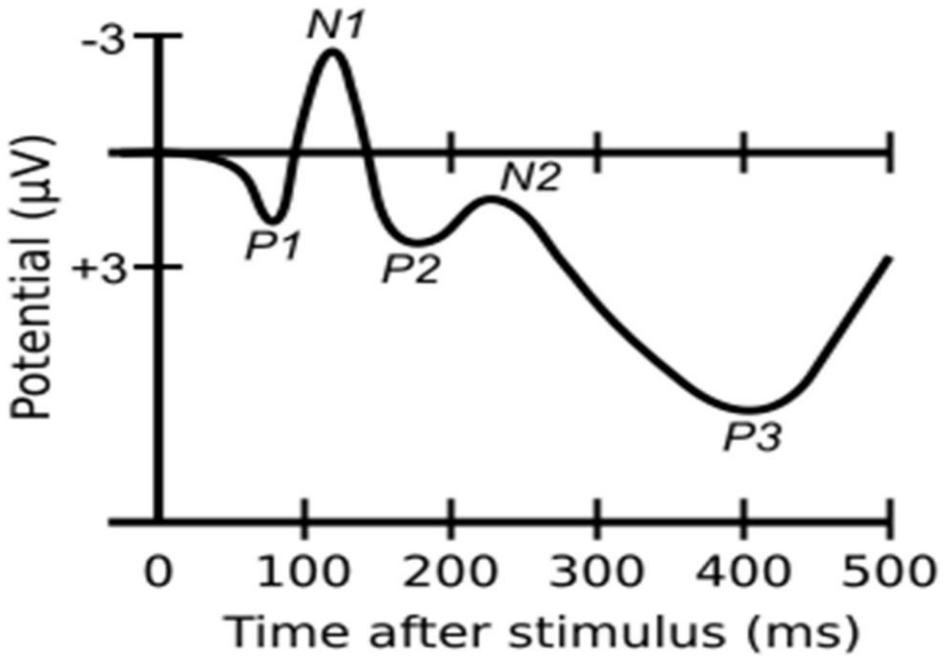


- **Timing**: Occurs approximately 100-200 milliseconds after visual stimulus.
- **Primary Location**: Visual and auditory cortices.
- **Functional Relevance**: Related to selective attention to stimuli.



- **Timing**: Occurs approximately 150-250 milliseconds after visual stimulus.
- **Primary Location**: Includes temporal and frontal lobe regions.
- **Functional Relevance**: Associated with the categorization and preliminary semantic processing of stimuli.

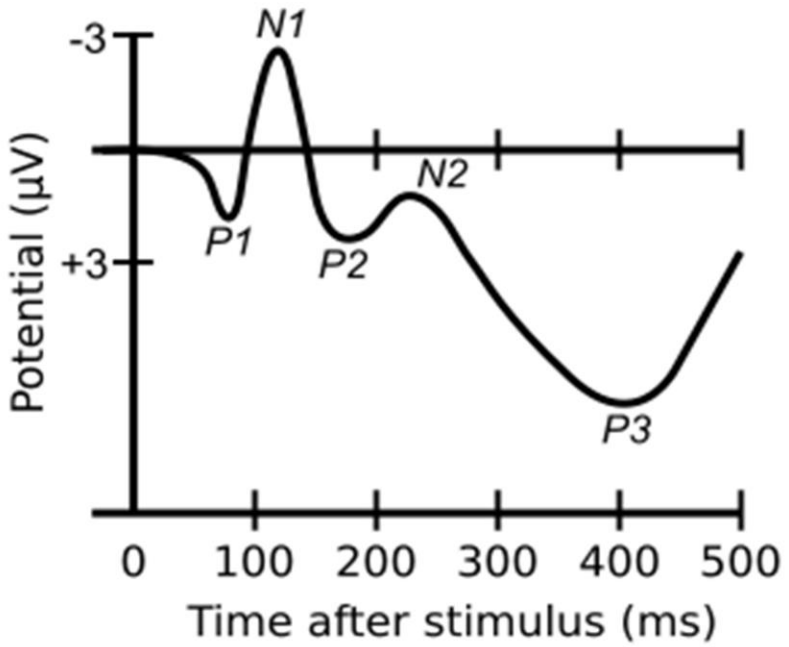




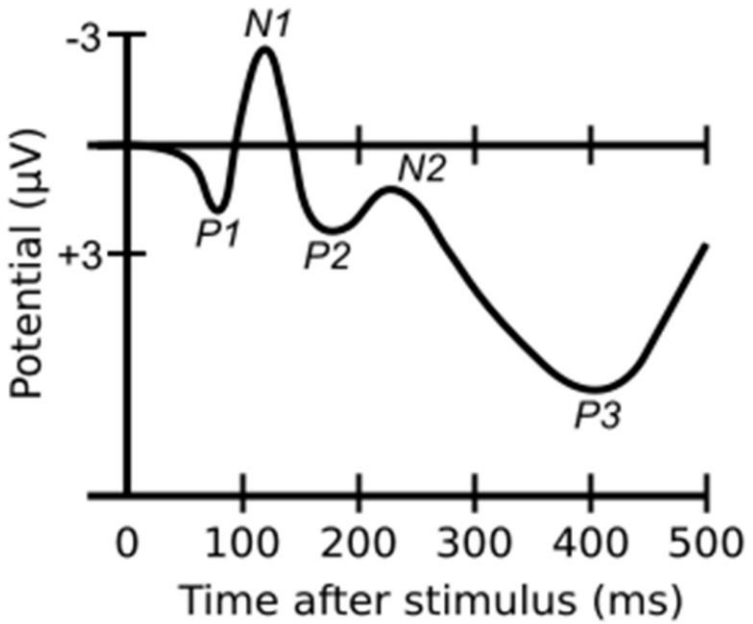
- **Timing**: Occurs approximately 200-350 milliseconds after visual stimulus.
- **Primary Location**: Typically associated with frontal cortex activity.
- **Functional Relevance**: Related to cognitive control and conflict monitoring.

Red Green Purple
Brown Blue Red

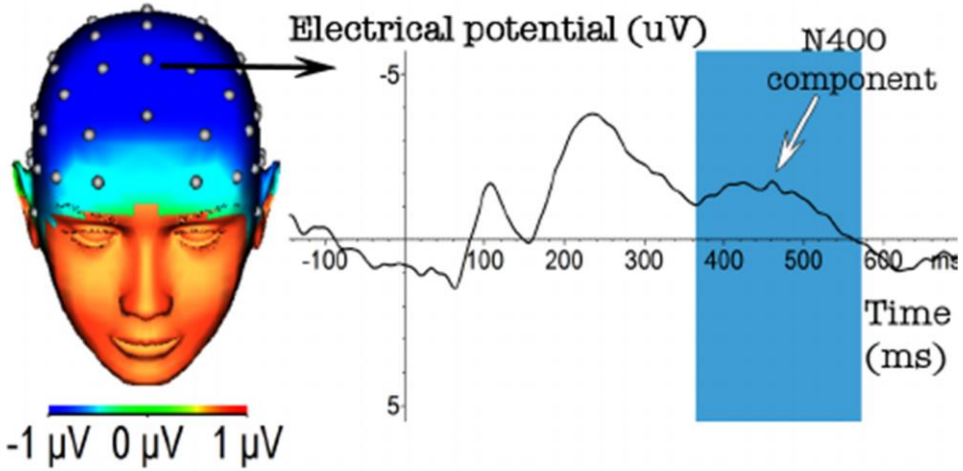
Purple Red Brown
Red Green Blue



- **Timing**: Occurs approximately 250-500 milliseconds after visual stimulus.
- **Primary Location**: Broadly distributed, including frontal and parietal lobes.
- **Functional Relevance**: Associated with the categorization of stimuli, allocation of attentional resources, word and sentence comprehension, as well as verbal fluency.



- **Timing**: Occurs approximately 400 milliseconds after semantic stimulus.
- **Primary Location**: Middle temporal cortex.
- **Functional Relevance**: Linked to semantic processing and expectation violations of word meaning.



EEG Component Related to WSE

- **P100 Component**
  - First in a series responding to visual stimuli.
  - Positive-going peak observed around 100 ms.
  - Linguistic Relevance: Marks the stage of letter string identification.
- **N170 Component**
  - Reflects neural processing of words within ERP.
  - Linguistic Relevance: Corresponds to the identification of lexical entries.
- **N400 Component**
  - Negative deflection peaking around 400 ms, range 250-500 ms.
  - Maximal over centro-parietal sites.
  - Linguistic Relevance: Engaged in lexico-semantic processing, crucial for word recognition.
- **Orthographic and Familiarity Effects**
  - Detected at the P150 time window.
- **Lexicality Effects**
  - Observed at the N200 time window, indicating early lexical processing.

Experiment and Result

Logic Chains of the Study
Hypothesis

N170
Visual Component

N400
Semantic Component

P3
Auditory Component

The existence of **Mental Lexicon** (top-down)

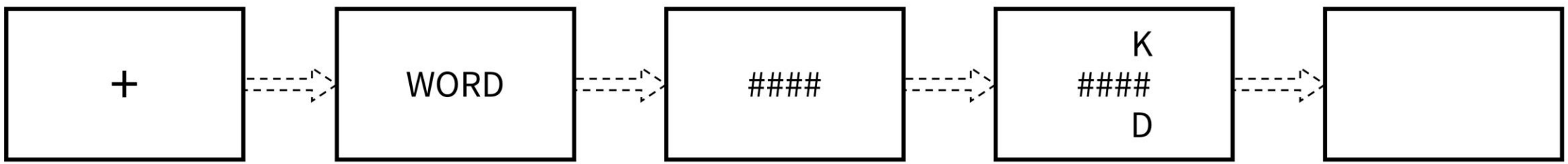
If people read in their heads.
Orthographic Mapping

Or, put it in another way,

If people with high-proficiency, are more into utilizing phonological cues.
Hypothesis

Reicher-Wheeler paradigm
Modified version

A total of **6n trials** (depends on how many qualified words we can find).



Fixation
1000 ms

Priming
50 ms

Masking
500 ms

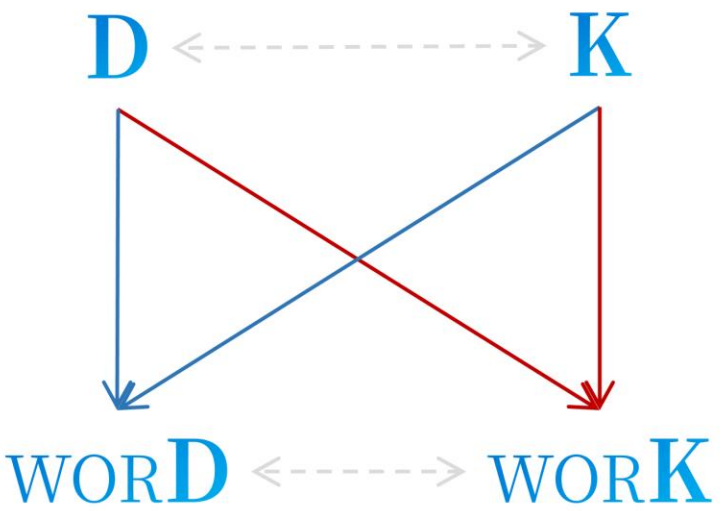
Response
3000 ms

SOA
Random 45-55 ms

Experimental Design
Principal for Selecting Materials

/d/ /di:/
WOR**D** → **D**

/θ/ /eɪtʃ/
BOT**H** → **H**



R/B O/Q F/E

E/M Y/C K/S

Ground Rule (基本规则)

- Both LETTERS should be OK to complete a four-letter (maybe) word.

Phonological Distance/Similarity (音韵距离/相似度)

- Phonological similarity between letter pair pronunciation (**D-K**), should be statistically controlled.
- High Similarity - Their pronunciations should share same consonant (**WORD-D/K**).

Orthographic Distance/Similarity (正字法距离/相似度)

- Orthographic similarity between letter pair (**D/K**), should be statistically controlled.

Experimental Design
Variables and Materials

Reaction Time (反应时)
Accuracy (正确率)

Dependent Variables
Behavioral Measurement

Within-Subject Design
Linear Mixed Model

N170, P2, P3, N400, LPC, etc.

Dependent Variables
EEG Components

3 (**Target Word**: Word, Pseudo word, Nonword)

WOR**D/K**　　PRU**D/K**　　XXX**D/K**

2 (**Phonological Similarity**: High, Low)

WOR**D** /d/ → /di:/ **D**

MAT**H** /θ/ → /eɪtʃ/ **H**

WOR**K** /k/ → /k/ **K**

MAT**E** /t/ → /i:/ **E**

2 (**Proficiency**: High, Low)

Student Participants
University of Macau

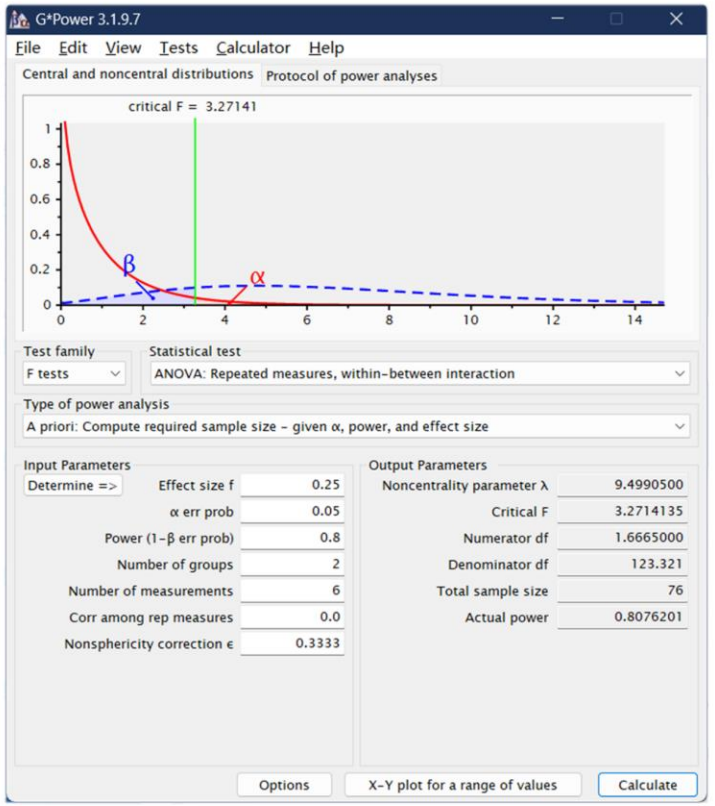
澳門大學
UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

Chinese-English Bilinguals

*whose **proficiency** may be treated as a potential variable

Number of Participants = 76/(3*2*2)≈7

(from G*Power 3.1.9.7)



Expected Results

Statistical Analysis Method

Linear Mixed Model
RT and ERP averaged amplitudes

Generalized Linear Mixed Model
ACC

RT
ACC
N400
new_comp

~ Tar_Word * Phon_Sim * Proficiency +

(1|subject)
(1|item)
(1|letter_phon_sim)
(1|ortho_sim)

Only **correctly responded** trials will be retained in RT, N400, and new components.

Expected Results

Statistical Analysis Method

Linear Mixed Model
RT and ERP averaged amplitudes

Generalized Linear Mixed Model
ACC

RT
ACC
N400
new_comp

~ Tar_Word * Phon_Sim * Proficiency +

(1|subject)
(1|item)
(1|letter_phon_sim)
(1|ortho_sim)

Either **N400 amplitude** changes, or **new component** emerges.

Expected Results
Statistical Analysis Method

Linear Mixed Model
RT and ERP averaged amplitudes

Generalized Linear Mixed Model
ACC

RT
ACC
N400
new_comp
~ Tar_Word * **Phon_Sim** * **Proficiency** +
(1|subject)
(1|item)
(1|letter_phon_sim)
(1|ortho_sim)

We expect **phonological similarity** could work, regardless in main effect or any interactions.

Expected Results
Statistical Analysis Method

Linear Mixed Model
RT and ERP averaged amplitudes

Generalized Linear Mixed Model
ACC

RT
ACC
N400
new_comp
~ Tar_Word * Phon_Sim * Proficiency +
(1|subject)
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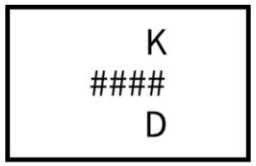

Both **orthographic** and **phonological similarity between letters** should be controlled.

Expected Results
Main Effect

1. Target Word

RT (**Word**) < RT (**Pseudo Word**) < RT (**Nonword**)
ACC (**Word**) > ACC (**Pseudo Word**) > ACC (**Nonword**)
Amp (**Word**) > Amp (**Pseudo Word**) > Amp (**Nonword**)

Typical WSE

2. Phonological Similarity

RT (**High**) < RT (**Low**)
ACC (**High**) > ACC (**Low**)
Amp (**High**) > Amp (**Low**)

Phonological WSE

3. Proficiency

RT (**High**) < RT (**Low**)
ACC (**High**) > ACC (**Low**)
Amp (**High**) > Amp (**Low**)

Phonological Similarity * Proficiency

RT (**Word**) < RT (**Pseudo Word**) < RT (**Nonword**)
ACC (**Word**) > ACC (**Pseudo Word**) > ACC (**Nonword**)
Amp (**Word**) > Amp (**Pseudo Word**) > Amp (**Nonword**)

Only in HIGH-proficiency

Bilinguals with high proficiency utilize more phonological cues.
Hypothesis

Thanks for listening!