跨文化認知神經科學研究

Cross-cultural Cognitive Neuroscience Research

-- Specificity & Universality --

以認知神經科學取向

探討中文字處理之神經生物基礎

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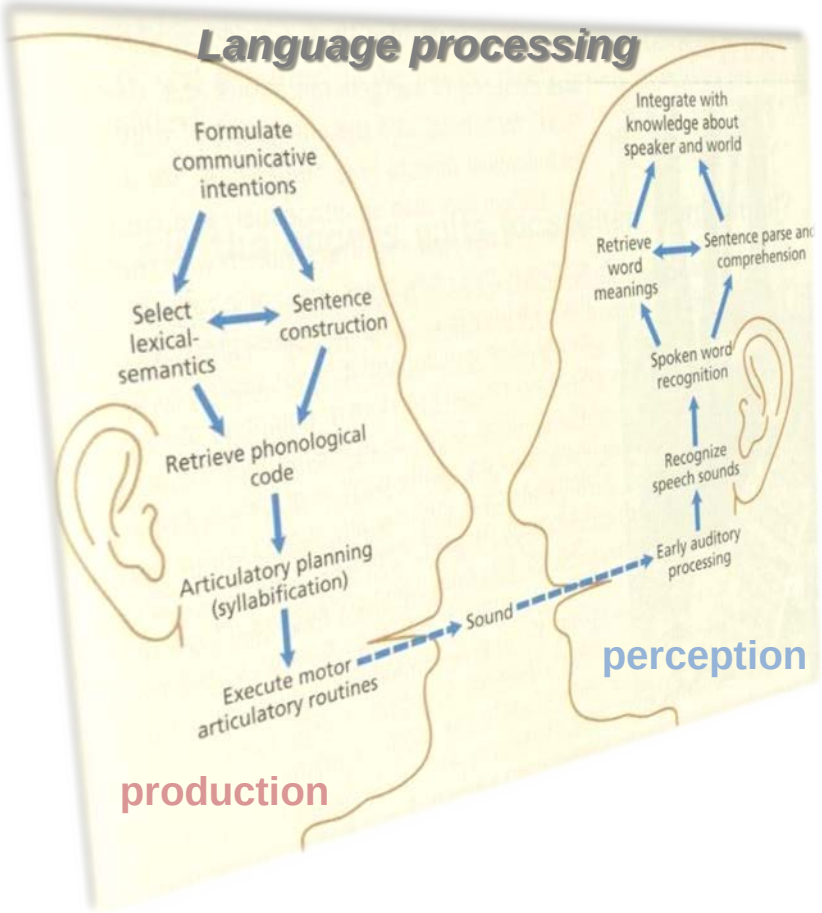
跨文化認知神經科學研究

Cross-cultural Cognitive Neuroscience Research

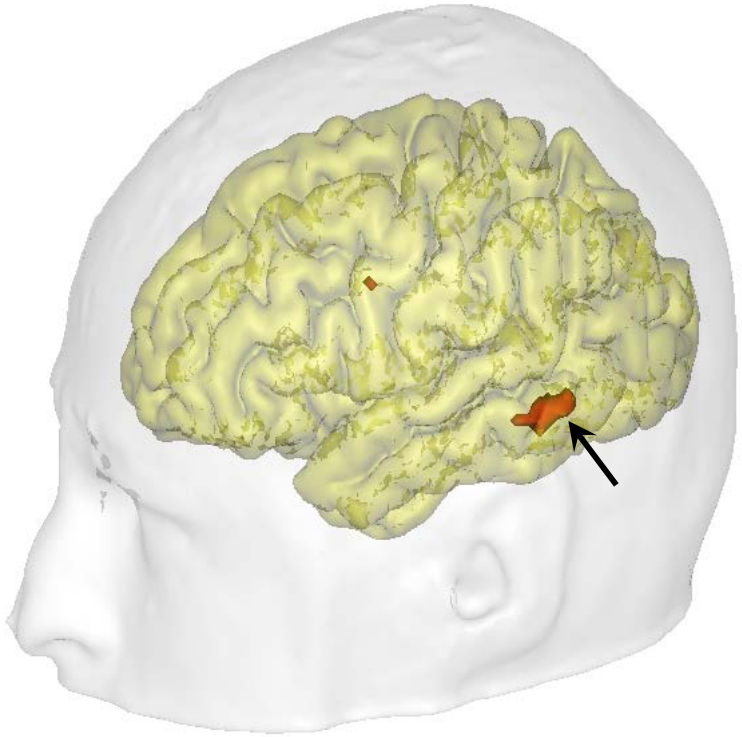
-- Specificity & Universality --

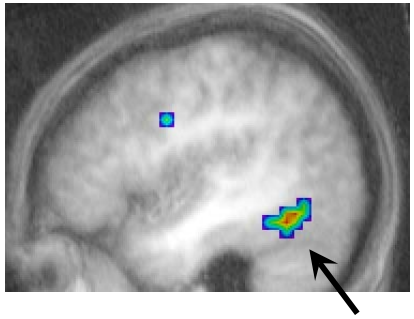


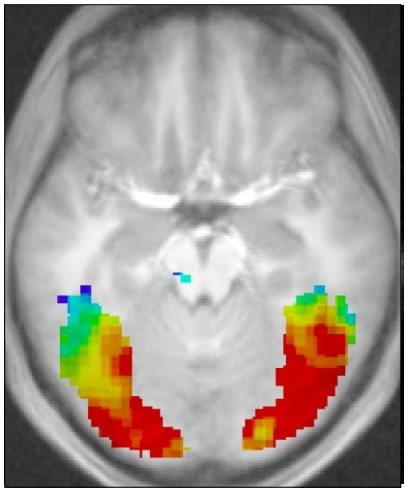
Language, Reading , and the Brain

- Spoken language is a biological specialization but written language is largely a cultural invention. Moreover, spoken language is mastered naturally in almost all people, without direct instruction. But reading is difficult and reading failure occurs in large numbers of children across all written languages.
- In every writing system, graphemes visually represent information about phonological or morphological features of spoken words, and discovering those correspondences between print and speech is a fundamental task of learning to read.
- Cross-linguistically speaking, changes along cognitive and neurobiological developmental trajectory would be expected to be common across different writing systems.

The visual word form area (VWFA)







- A **reproducible** site of activation during **reading in all cultures** (e.g. Bolger, Perfetti & Schneider, 2005)
- Always located at the **same coordinates** in the left lateral occipito-temporal sulcus
- Whose lesion can cause **pure alexia**, an acquired selective disability in reading (e.g. Déjerine, 1892; Gaillard et al., 2006)
- Which activates more to **known scripts** than to other categories of visual stimulis (e.g. Baker et al., 2007)
- A high-level **visual** area, **invariant for location and case** in word identification (e.g. Dehaene et al., 2001; Cohen et al., 2002)
- An automated system, capable of activating even to **subliminal stimuli** (e.g. Dehaene et al., 2001, 2004)
- Organized as a **posterior-to-anterior hierarchy** sensitive to increasingly frequent and larger fragments of words: letters, bigrams, etc (e.g. Binder et al., 2006; Vinckier et al., 2007)

Reading involves a set of cognitive processes. The very basic, important one is the mapping of a word form (orthography) onto its sound pattern (phonology).

For Chinese, a word can be comprised of
one character,
two characters,
or more,

Therefore, ***character*** and ***word*** in Chinese reading are two basic, functional units for processing. It is important to know how they are processed, not only in our mind but also in our brain.

SCIENTIFIC AMERICAN

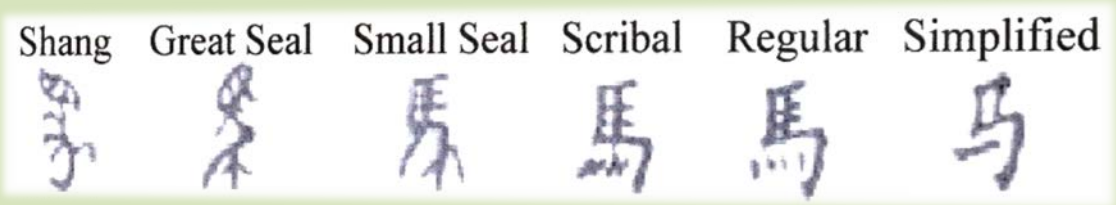
HUMAN COMMUNICATION

Language and Its Psychobiological Bases

With introductions by William S-Y. Wang

養 忘

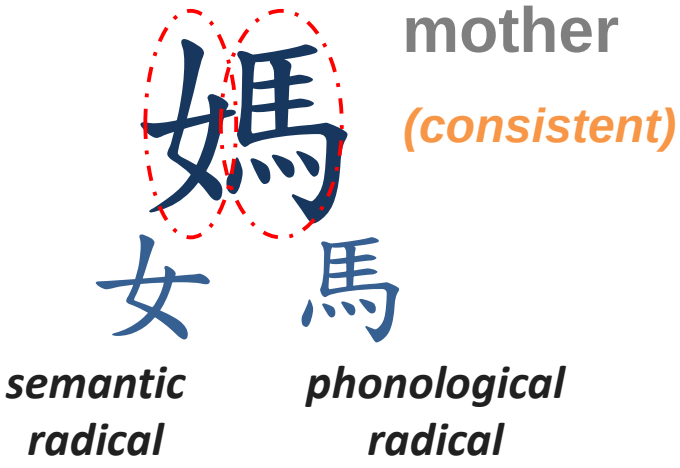
It has also been often considered Chinese characters are pictographic.



No, not really.

In English, there are grapheme-to-phoneme conversion (GPC) rules, which can be applied to help reading English words (even for those you don't know their meaning). For example, *CAT, DOG. TABLE, BRANE, …*

How about Chinese?



Do *properties* of the components (radicals) of a character have a systematic influence to its processing ***?***

Structural classification of Chinese characters

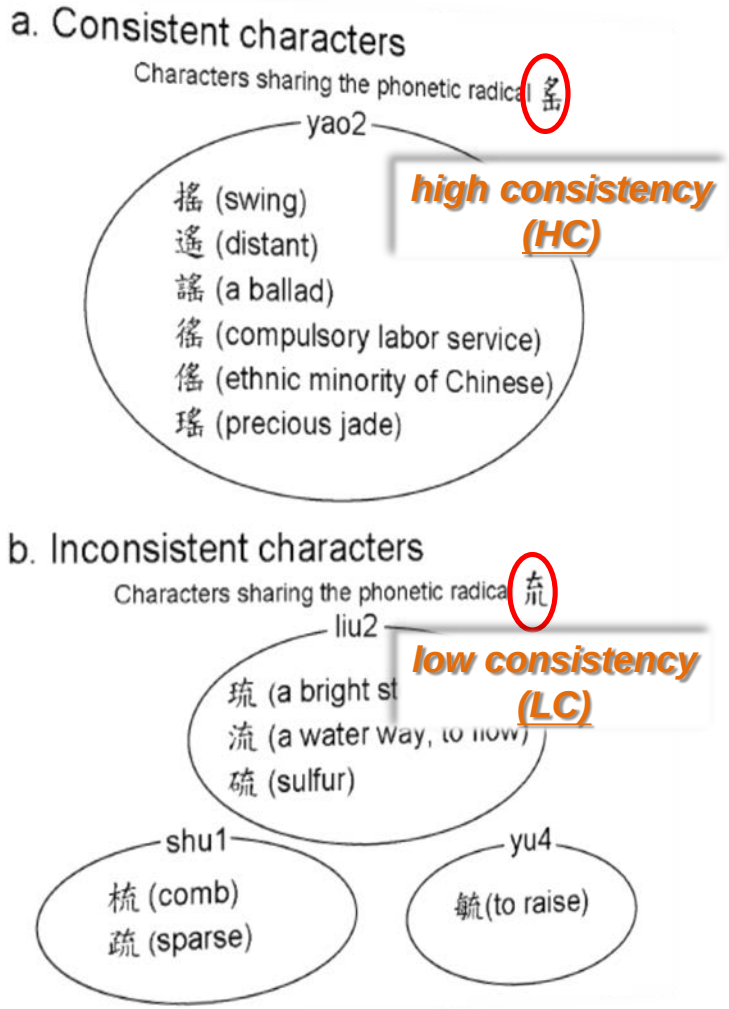
Principles	*Oracle Bones* (Shang dynasty, 1100-1400 BC)	*Xu Shen* (Han dynasty, 2nd century)	*Zheng Qiao* (Song dynasty, 12th century)	*Kang Xi* (Qing Dynasty, 18th century)
Pictographic	227 (23%)	364 (4%)	608 (3%)	~ 1500 (3%)
Simple indicative	20 (2%)	125 (1%)	107 (1%)	
Compound indicative	396 (41%)	1167 (13%)	740 (3%)	
Semantic-phonetic	334 (34%)	7697 (82%)	21810 (93%)	47141 (97%)
Total number	977	9353	23265	48641

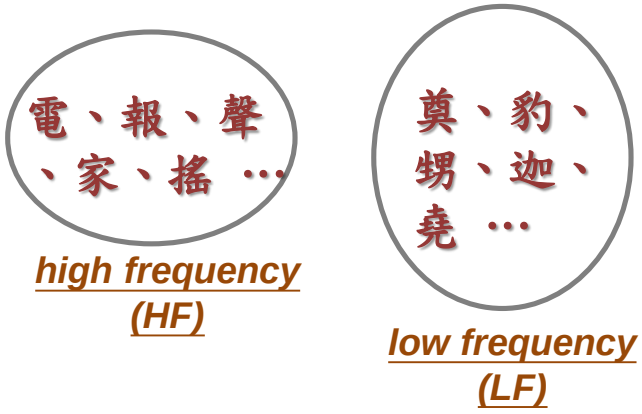
(John DeFrancis, 1991)

醋 錯 措 借 惜 …

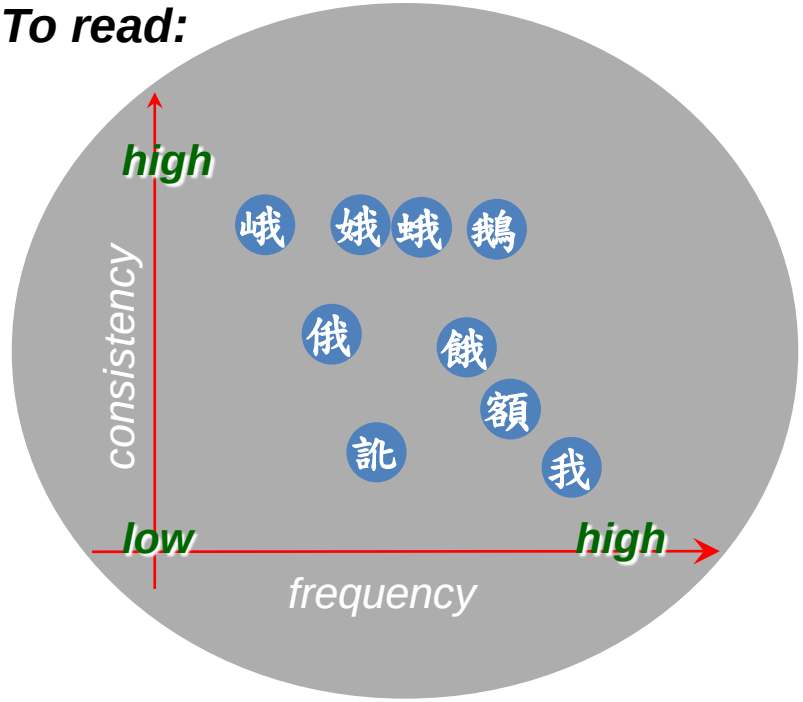
What regularities do we derive from reading experience for processing Chinese characters?

The processes



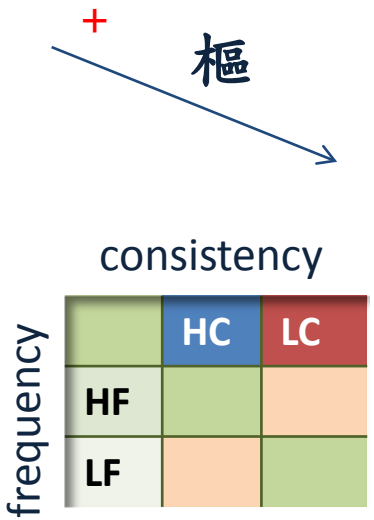


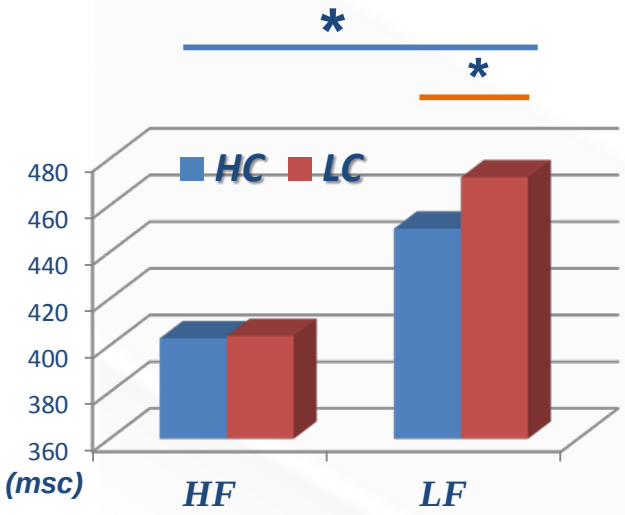
To read:



The task and findings

In a naming task, …

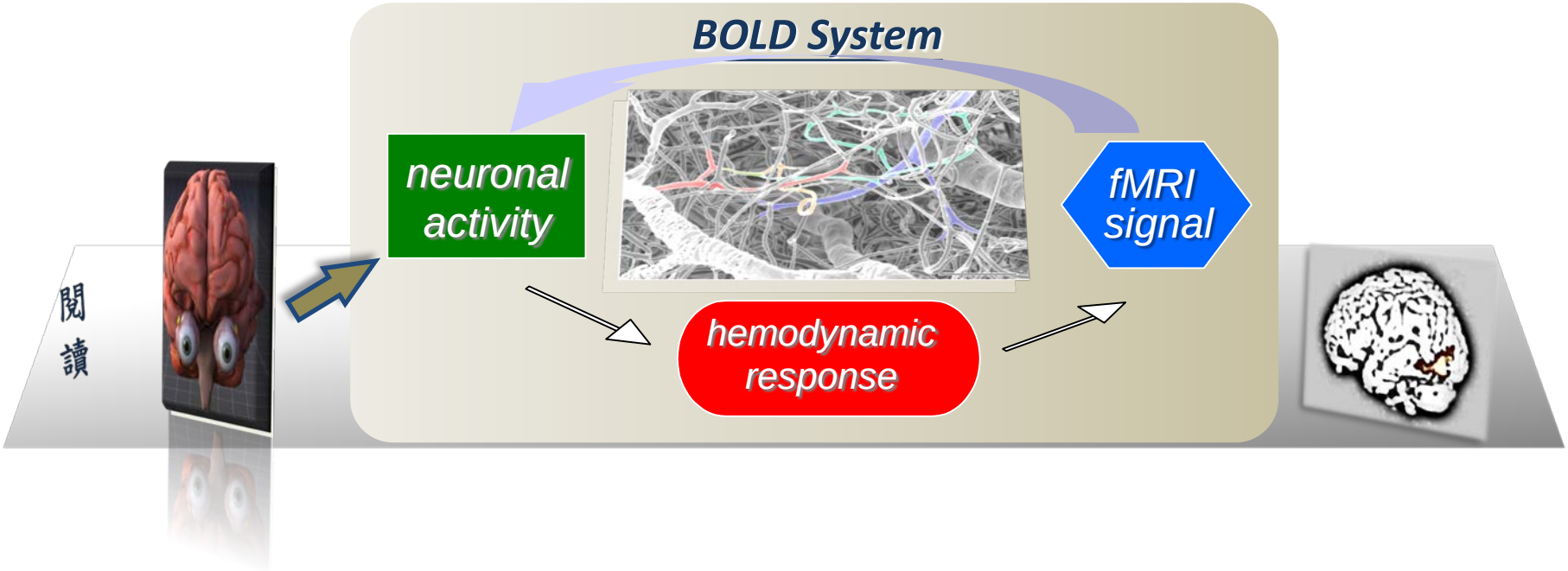




Yes, *the findings indicated that component properties* of a character can influence its psychological processing in a systematic way.
Phonological recording in Chinese reading was, therefore, suggested.

Is there a way to help us visualize how reading processes proceed in the brain?

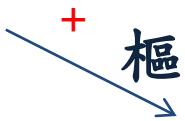
Functional MRI is a neuroimaging technique/procedure to depict neural correlates of psychological processes of interest by detecting the changes of blood oxygenation level in the brain. By using fMRI, we are able to look for neural underpinnings of reading.

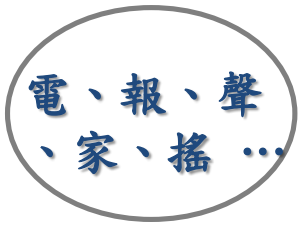


Study I: Neuronal effects of Chinese reading related to character frequency, consistency, and their Interaction

- *3T event-related fMRI paradigm*
- ***18** college students volunteered for subjects*
- ***a naming task***
- ***frequency** and **consistency** are 2 independent variables for manipulation (2x2 within-subject design)*

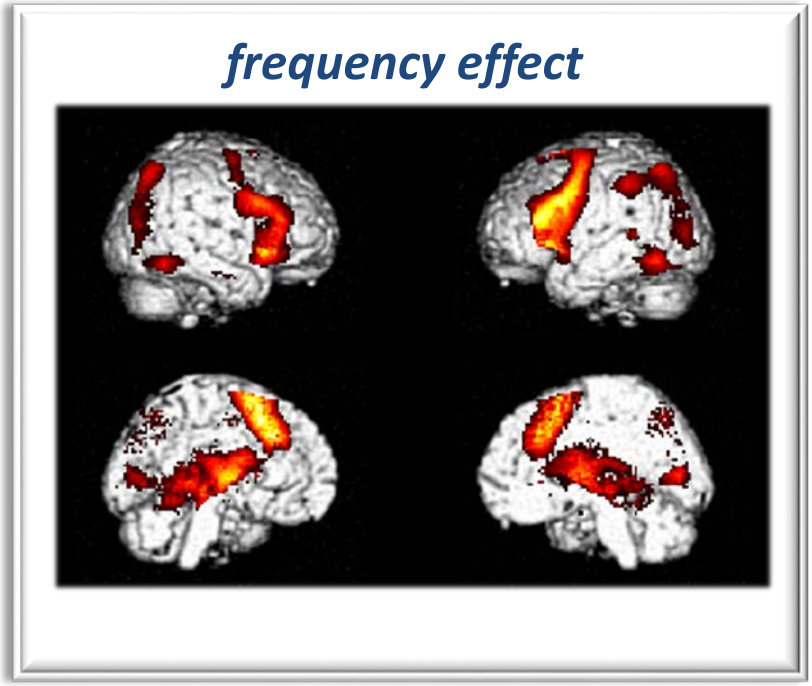
In a <u>naming</u> task, …





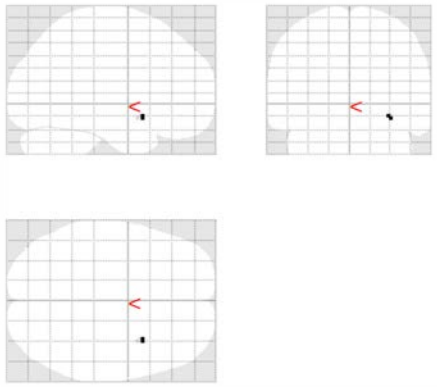
high frequency (HF)

low frequency (LF)

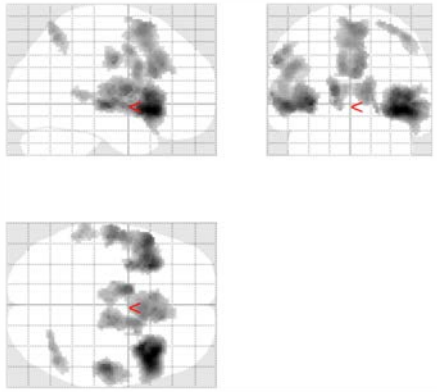


- The brain areas noted underpinned those processes adherent to character frequency variation.
- Both dorsal and ventral visual pathways are involved in the frequency effect.
  - ✓ The dorsal activation suggests …
  - ✓ The ventral activation suggests …
- The inferior frontal, inferior parietal, and superior temporal activation …
- The sub-cortical activation also gave clues to …

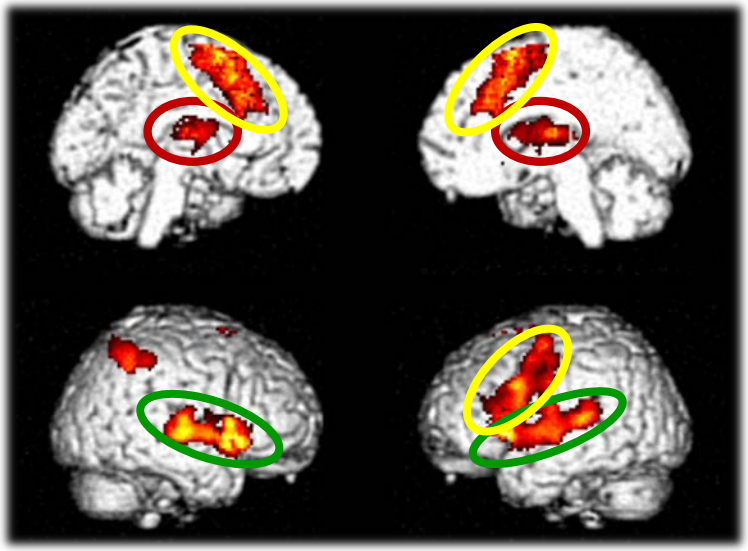
frequency-by-consistency interaction



(LC-HC) @ HF



(LC-HC) @ LF



*T*hose are brain areas constitute a network to work for *transformation from orthography to phonology*. It is highly connected with the language network.

*Study 2: C*hinese character-word processing difference

More than three decades ago, it has been behaviorally demonstrated by using tachistoscopic (very brief) presentation to the two VHF and showed hemispheric processing asymmetry for Chinese characters and words (Tzeng, Hung, Cotton, and Wang, 1979).

- ✓ LVF/RH advantage for processing of single characters
- ✓ RVF/LH advantage for processing of 2-character words

Can fMRI help to delineate Chinese character-word processing difference in the two cerebral hemispheres ?

Hemispheric specialization/lateralization

It is well known that the left hemisphere and the right hemisphere may feature different ways of information processing.

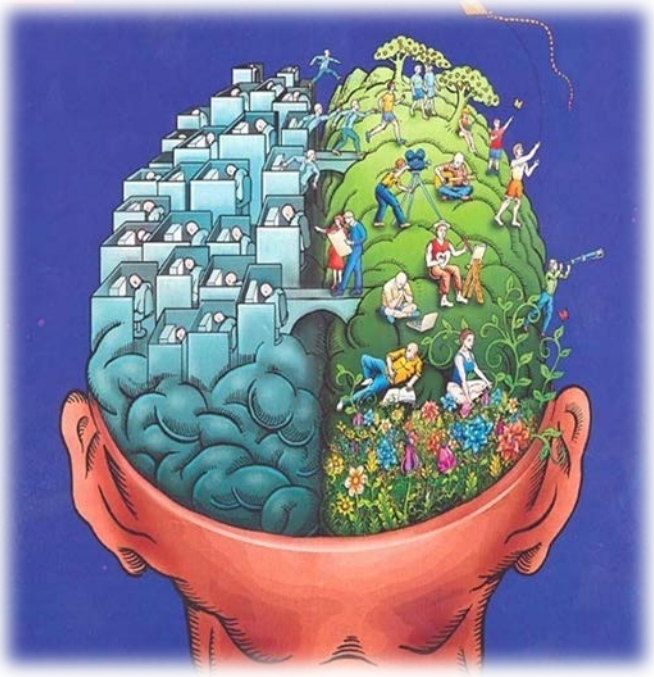
Rational

Analytic

Sequential

Logical

Linguistic



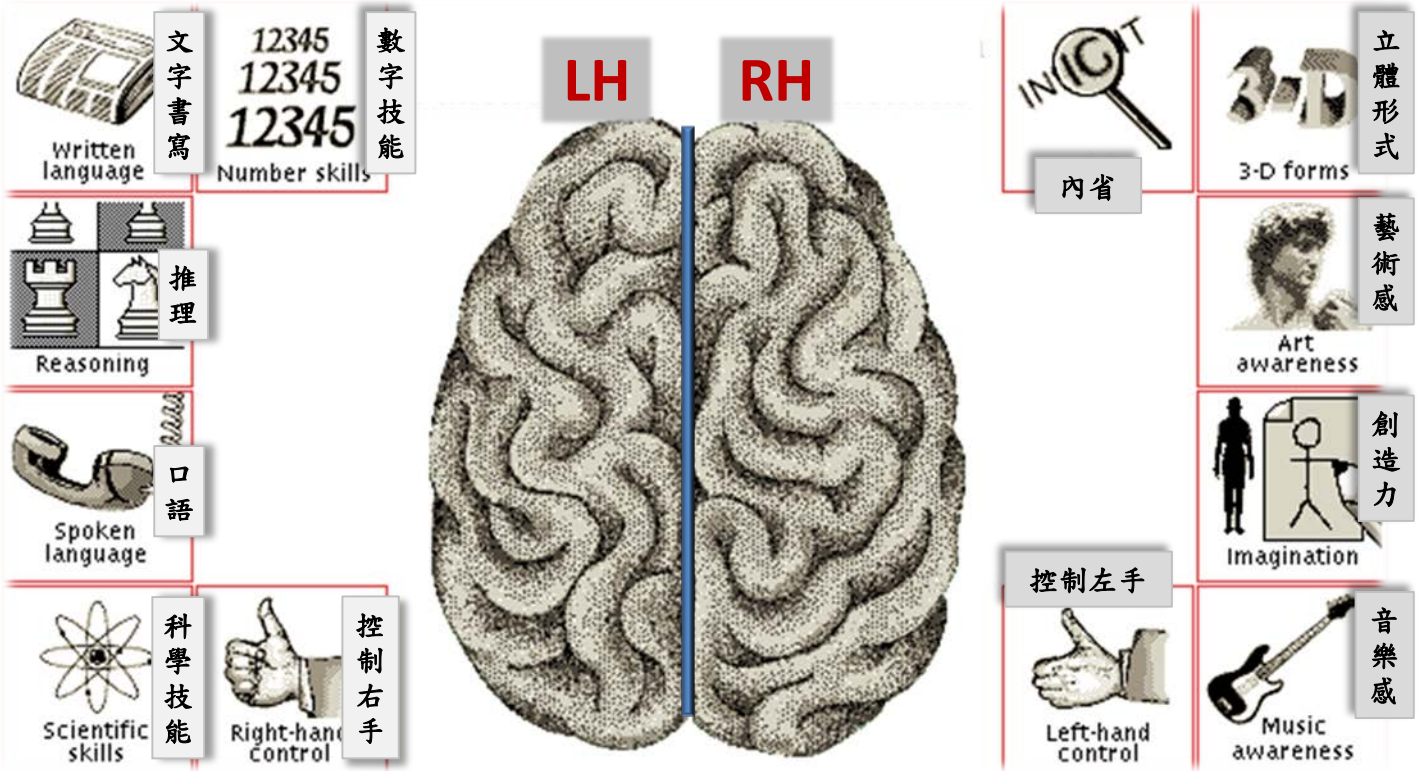
Emotional

Holistic

Parallel

Humorous

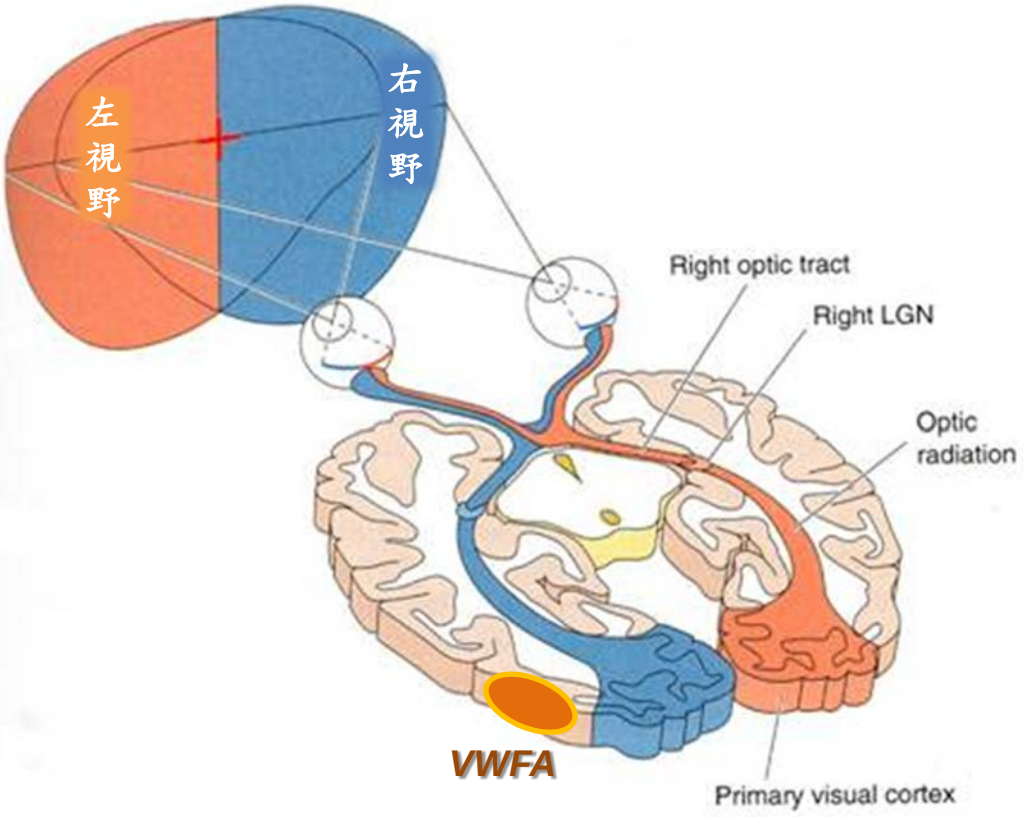
Silent


LH
RH
文字書寫
Written language
12345
12345
12345
數字技能
Number skills
推理
Reasoning
口語
Spoken language
科學技能
Scientific skills
控制右手
Right-hand control
內省
立體形式
3-D forms
藝術感
Art awareness
創造力
Imagination
控制左手
Left-hand control
音樂感
Music awareness

To look for processing difference of character and word in the two cerebral hemispheres, …

"Visual lateralization effect in reading *Chinese characters*"

Tzeng et al., 1979, Nature.



- **Visual half-field (*VHF*) with tachistoscopic presentation**
- **Character/word identification (i.e. a naming task)**
- **Single character word processing: ***LVF/RH*** advantage**
- **Two-character word processing: ***RVF/LH*** advantage**
- **Hemispheric asymmetry in processing Chinese character and word**
- **However, …**

Can fMRI help to delineate Chinese character-word processing difference in the two cerebral hemispheres ?

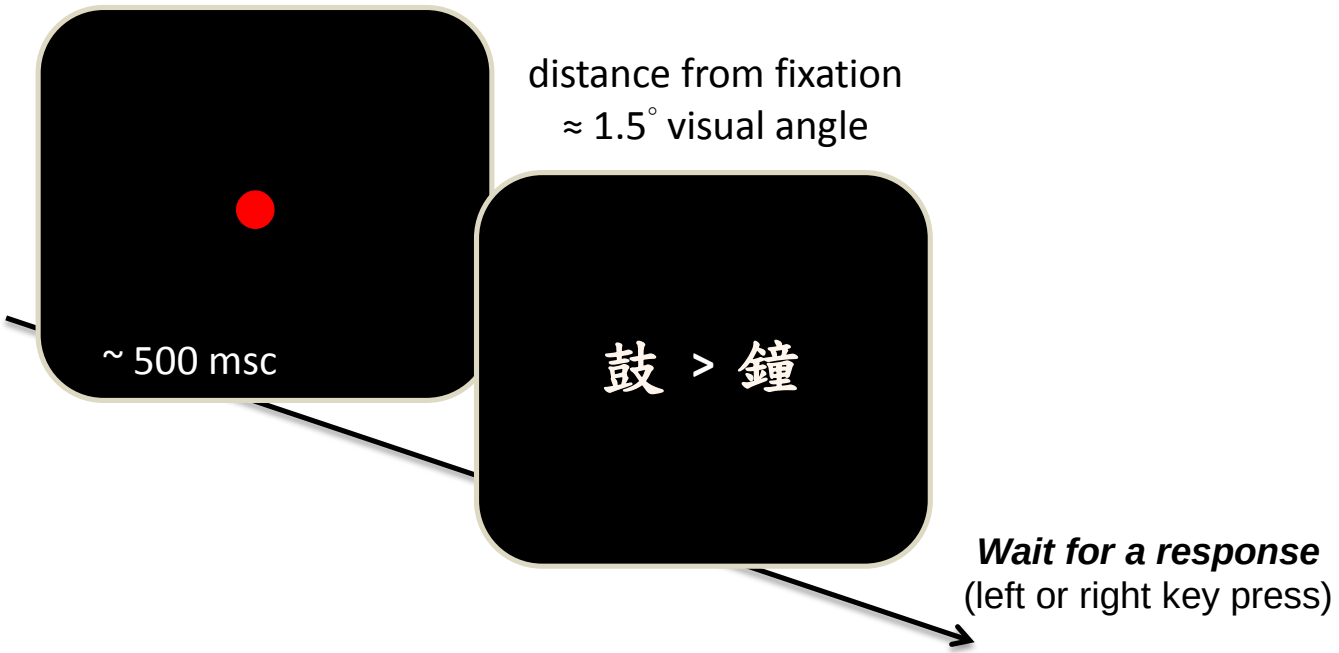
EXP 1:

Processing Chinese single characters in the *LVF* and *RVF*

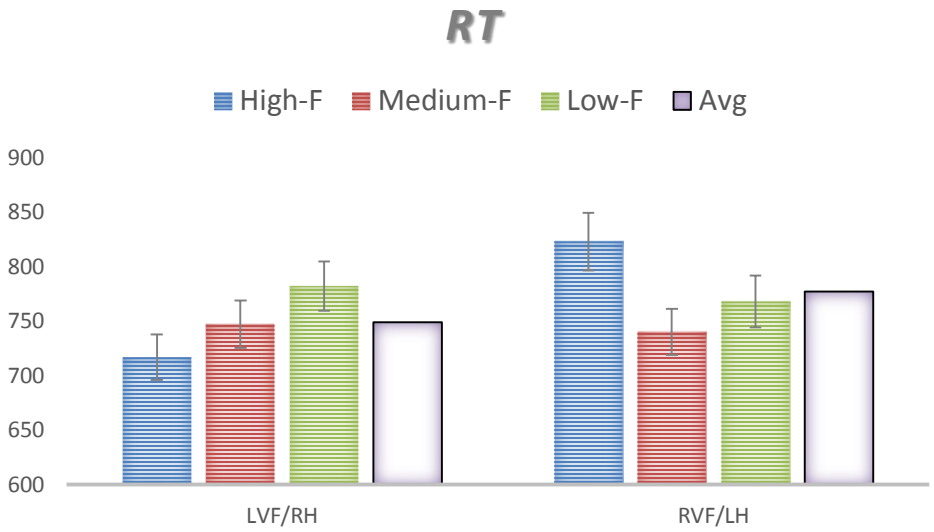
Lexical decision task (*LDT*)

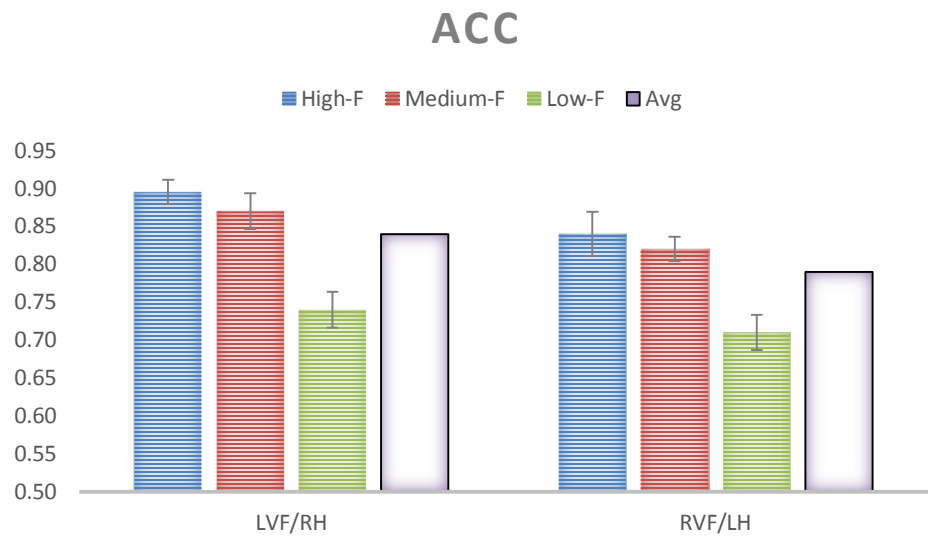
- ✓ 1st IV: visual field (LVF, RVF)
- ✓ 2nd IV: character frequency (low/51, medium/527, high/1123)

In a trial, two characters were simultaneously bilaterally presented for 150 msc in the ***LVF*** and ***RVF***. The target character was indicated by a central cue embedded in the same presentation frame.



Results





Subject number= 32

ACC

- *VF: F(1, 31)= 5.51, p< 0.05*
- *Freq: F(2, 31)= 87.2 , p< 0.01*
- *VF x Freq: F(2, 62)= 0.895, p> 0.1 n.s.*

RT

- *VF: F(1, 31)= 11.81, p< 0.01*
- *Freq: F(2, 62)= 76.45, p< 0.01*
- *VF x Freq: F(2, 62)= 0.806, p> 0.1 n.s.*

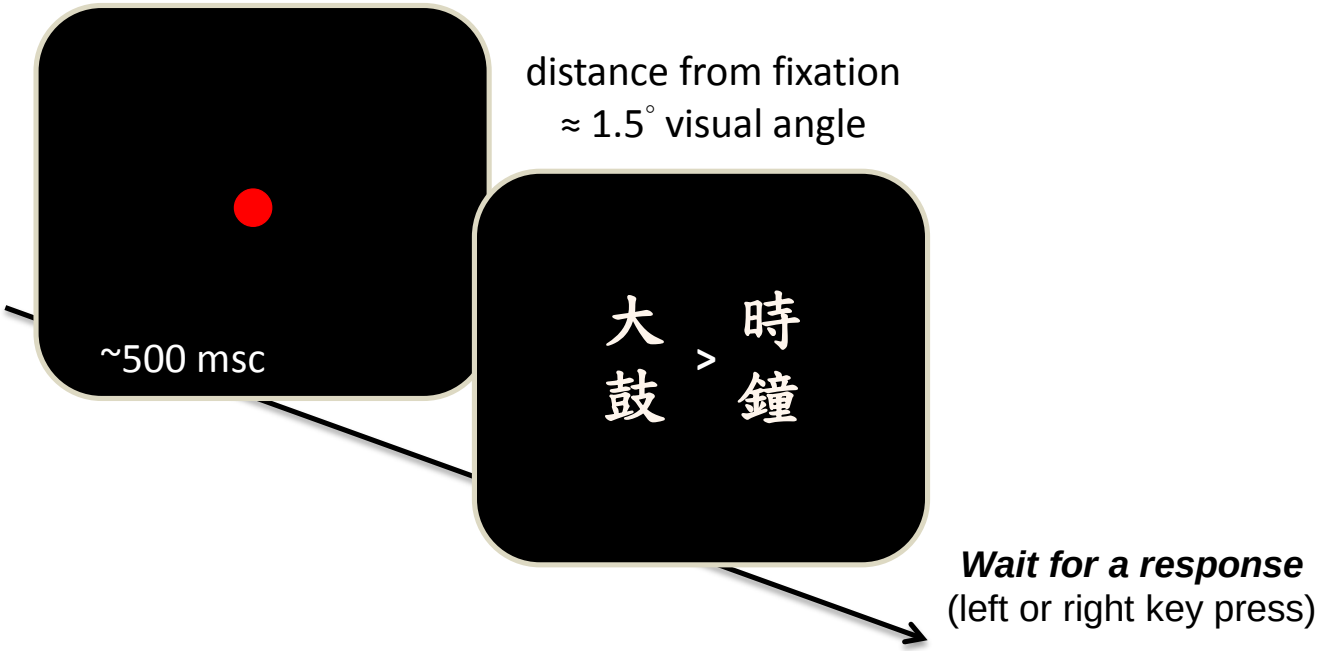
EXP 2:

Processing Chinese 2-character words in the LVF and RVF

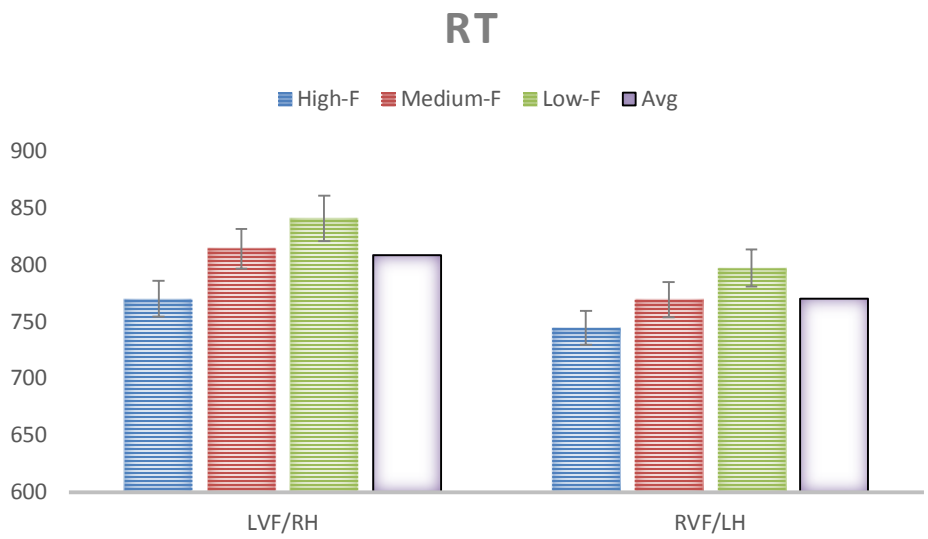
Lexical Decision Task (*LDT*)

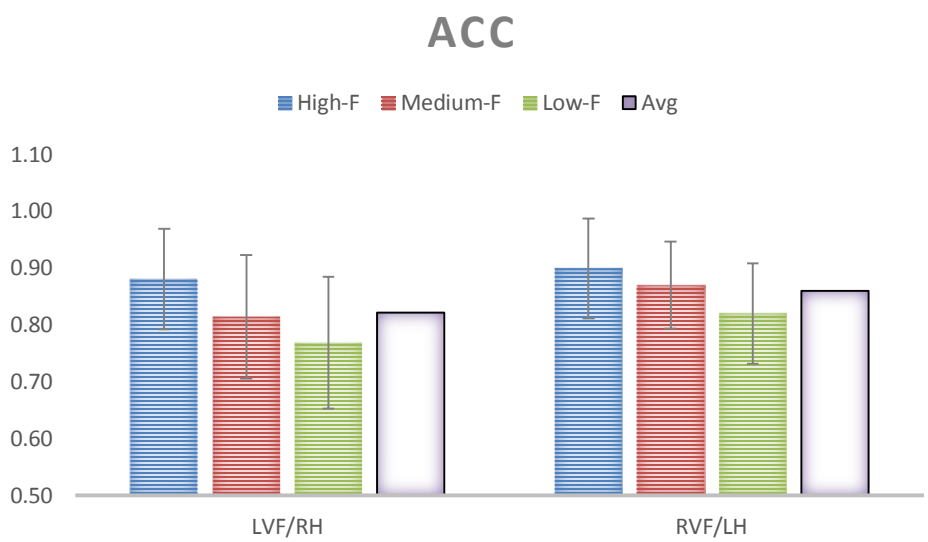
- ✓ 1st IV: visual field (LVF, RVF)
- ✓ 2nd IV: character frequency (low/25, medium/70, high/370)

In a trial, two 2-character words were simultaneously bilaterally presented for 150 msc in the ***LVF*** and ***RVF***. The target word was indicated by a central cue embedded in the same presentation frame.



Results





Subject number= 36

ACC

- *VF: F(1, 35)= 12.33, p< 0.01*
- *Freq: F(2,70)= 50.73, p< 0.01*
- *VF x Freq: F(2, 70)= 2.84, p> 0.05 n.s.*

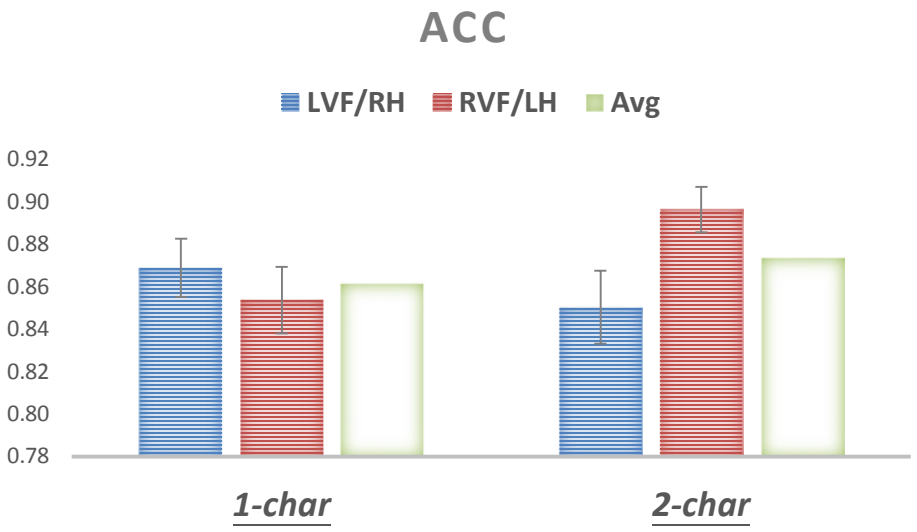
RT

- *VF: F(1, 35)= 11.63, p< 0.01*
- *Freq: F(2, 70)= 72.98 ,p< 0.01*
- *VF x Freq: F(2, 70)= 2.84, p> 0.05 n.s.*

EXP 3:

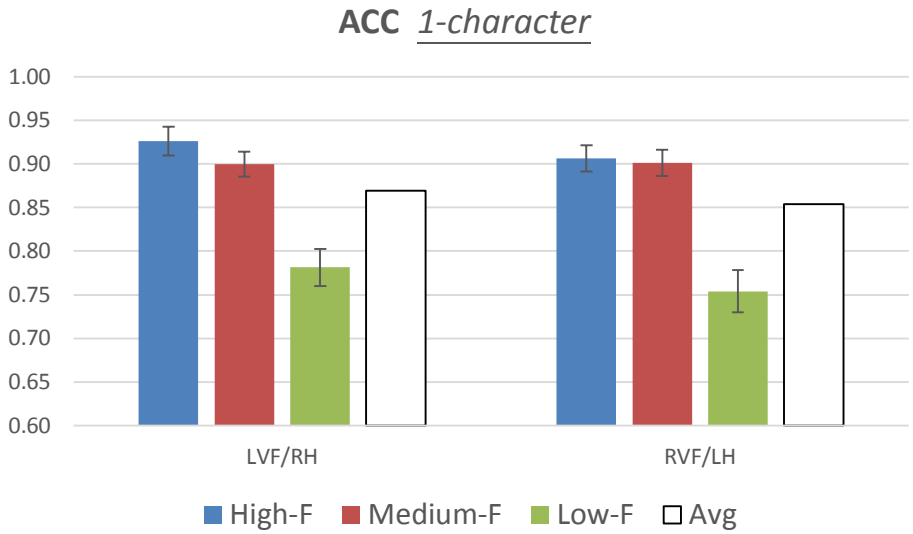
Processing Chinese 1-character and 2-character words in the LVF and RVF: a within subject design

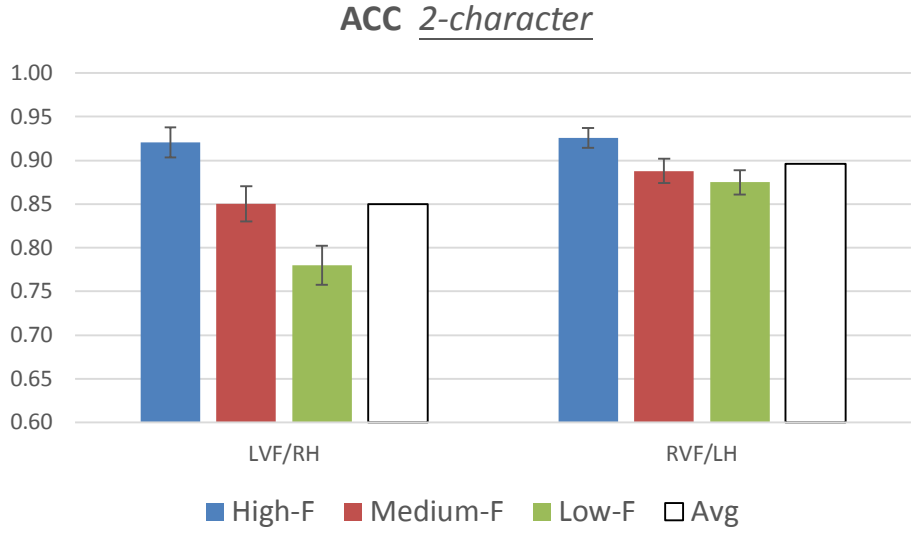
Results (1/2)



- ***Subject number= 36***
- LVF/RH advantage for 1-char processing
- RVF/LH advantage for 2-char word processing

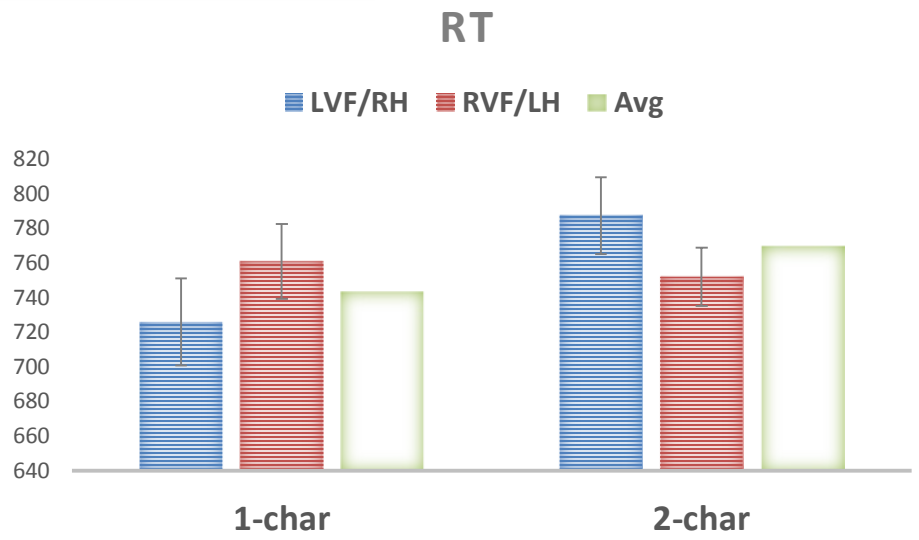
- Frequency effect is the same in the LVF and RVF for single character processing
- Frequency effect is larger in the LVF/RH than in the RVF/LH for 2-character word processing.





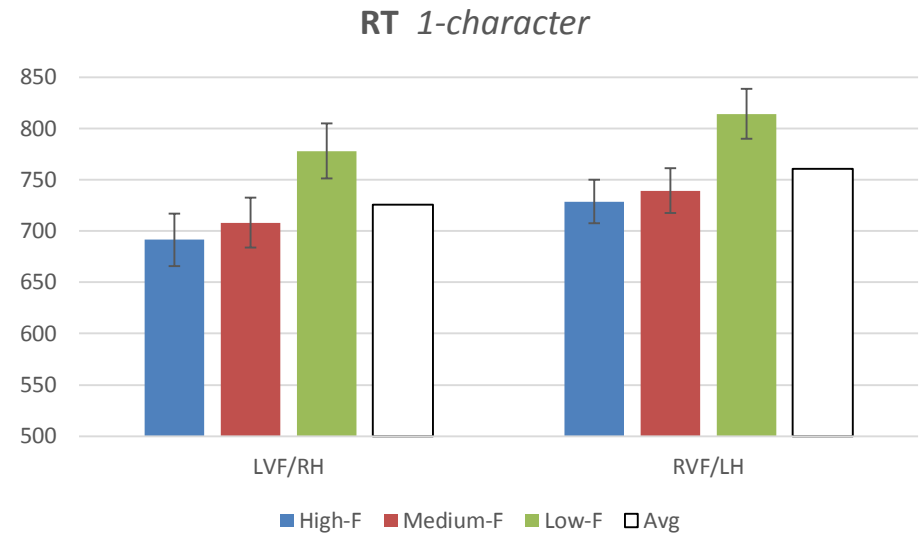
Effect size of frequency for 2-char: 0.489 (LVF) 0.202 (RVF)

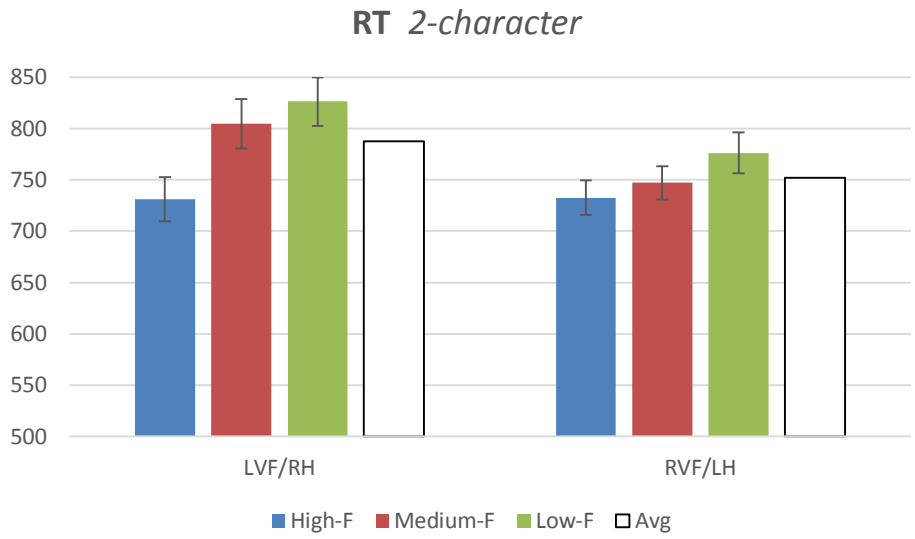
Results (2/2)



- LVF/RH advantage for 1-char processing
- RVF/LH advantage for 2-char word processing

- Frequency effect is the same in the LVF and RVF for single character processing
- Frequency effect is larger in the LVF/RH than in the RVF/LH for 2-character word processing.





Effect size of frequency for 2-char: 0.540 (LVF) 0.247 (RVF)

- *Results of the third experiment replicated results of Exp1 and Exp2. Especially, the within-subject design allowed us to interpret the results as follows.*
  - *For the LVF/RH advantage of 1-character condition, it indicates that at single character Chinese characters do need more visuo-spatial analysis/decomposition.*
  - *Frequency effect of 1-character condition may include both lexical and perceptual level. Therefore, there is no difference in both the LVF and RVF presentation.*
  - *For the RVF/LH advantage of 2-character condition, it indicates that it relies more on the LH's contribution.*
  - *Frequency effect of 2-character condition is larger in the LVF/RH than in the RVF/LH.*

"Visual lateralization effect in reading Chinese characters"

Tzeng, Hung, Cotton, and Wang, 1979, Nature.

Thank you for your listening.