Form and meaning in the reading of Chinese compounds

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Fifth International Conference on the Mental Lexicon
Oct. 11, 2006

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Thanks to...

- Chiang Ching-Kuo Foundation grant RG001-D-02
- Assistants (and Chinese-speaking linguists) Wang Wenling, Chiu Zhenhao, Peng Yuru, Ko Yuguang

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Factors affecting compound recognition

- Formal factors
  - Position
  - Cross-morphemic predictability
- Morpho-semantic factors
  - Semantic transparency
  - Headedness
- Reading direction…?

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Position

- First morpheme frequency
  - English and Chinese (Taft & Forster, 1976; Zhang & Peng, 1992)
- First morpheme priming
  - Bulgarian, Greek, Polish, Chinese, and Dutch (Jarema et al., 1999; Kehayia et al., 1999; Myers et al., 2004; Sandra, 1990)
- First morpheme transparency
  - English and Chinese (Libben et al., 2003; Myers et al., 2004)

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Cross-morphemic predictability

- Mutual information (Church & Hanks, 1990)
  - Applicable to compounds (Myers & Gong, 2002)
  Log of **ratio of** proportional **word frequency (WF)** to product of proportional **morpheme frequencies (MF)**
  [cf. morphological family size (Schreuder & Baayen, 1997), information residual (Moscoso del Prado Martín et al., 2004)]
- But mutual information is collinear with $\log(WF) - [\log(MF_1) + \log(MF_2)]$
- Solution: $\mathbf{\log(MF_1) \times \log(MF_2)}$
  - Lower value = more predictable = faster access

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Semantic transparency

- Opaque components compete with word-level semantics (slower access)
- Yet opaque compounds are less productive, so generally more predictable (faster access)
- So transparency effects are confusing unless predictability is factored out
  - **Helps:** French, Chinese (Jarema et al., 1999; Tsai, 1994)
  - **Hurts:** Bulgarian, Chinese (Jarema et al., 1999; Su, 1998)

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Headedness

- Headedness ≠ transparency: Hogwash!
- The modifier-noun relation can be primed
  - English and Chinese (Gagné & Spalding, 2004; Ji & Gagné, 2004)
- First-position effects have been claimed to be restricted to right-headed compounds
  - Chinese (Zhang & Peng, 1992; Zhang, 1997)

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The time course of form and meaning processes

- What causes first morpheme effects?
  - Lexical representations treat it as special…
  - … or it's just the first thing you "see"?
- When do transparency and headedness come into play?
  - Partly late, after whole-word access…
  - … but could they start much earlier?
    (e.g. if morpheme access occurs early)

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Enter an orthographic quirk…

- In Taiwan, Chinese is written three ways:
  - Top down: traditional
  - Left to right: becoming the default (e.g. computers)
  - Right to left: restricted use (e.g. headlines, old signs)

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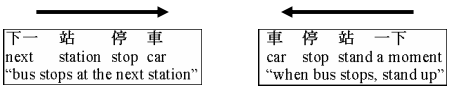

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Exploiting the quirk

- The two horizontal directions allow us to test the "first thing you see" hypothesis
  - Orthographically first ≠ morphologically first
- They also help us test when transparency and headedness effects kick in
  - Direction effects must be early effects
  - So if direction modulates transparency or headedness effects, these must also start early

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Materials: Positional transparency

- Following Libben et al. (2003), eighty compounds were divided into four types by pretested opacity (**O**) and transparency (**T**):

OO: 神經 (god-scripture) "nerve"
OT: 火車 (fire-vehicle) "train"
TO: 時光 (time-bright) "time"
TT: 白色 (white-color) "white"

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Materials: Headedness type

- Compounds were later classified by native-speaking linguists as right-headed compounds vs. not:

	Right-headed	Not right-headed
OO	海報 (sea-report) "poster" (4)	神經 (god-scripture) "nerve" (16)
OT	火車 (fire-vehicle) "train" (16)	風景 (wind-scenery) "scenery" (4)
TO	女士 (female-scholar) "lady" (9)	時光 (time-bright) "time" (11)
TT	白色 (white-color) "white" (10)	海洋 (sea-ocean) "ocean" (10)

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Materials: Frequency etc

- Log word frequency was matched across transparency types
- Log character frequency also matched
  - Characters ≈ morphemes
- Only nonreversible compounds
  - E.g. not used:
    蜂蜜: (bee) honey
    蜜蜂: honeybee

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Design

- Task: Visual lexical decision
- Four groups of participants:
  - Left to right only (20)
  - Right to left only (20)
  - Both directions mixed (40)
  - Top down (20) - not discussed here

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Analysis

- Multi-level modeling (Pinheiro & Bates, 2000)
  - Subjects and items both treated as random
- Independent variables (predicting **log(RT)**):
  - **Dir**: left to right vs. right to left
  - **Mix**: one consistent direction vs. mixed
  - **CS_1, CS_2**: character transparency types (T vs. O)
  - **Head**: right-headed compound vs. not
  - **CF_1, CF_2**: log character frequencies
  - **WF**: log word frequency

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Interactions we care about

- **$CF_1 \times CF_2$**: Cross-morphemic predictability
- **$CS_1 \times CS_2$**: TT/OO vs. OT/TO
- **Dir × CS, Dir × Head**: Influence of direction
  - Do transparency & headedness effects occur early?
- Model tested:

$$\underbrace{\text{Dir} \times \text{Mix} \times CS_1 \times CS_2 \times \text{Head}}_{\text{“early” \& “late” factors}} + \underbrace{CF_1 \times CF_2 + \text{WF}}_{\text{predictability \& other nuisance}}$$

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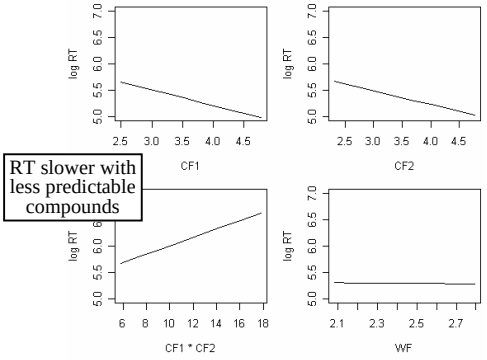
Frequency and predictability



RT slower with less predictable compounds

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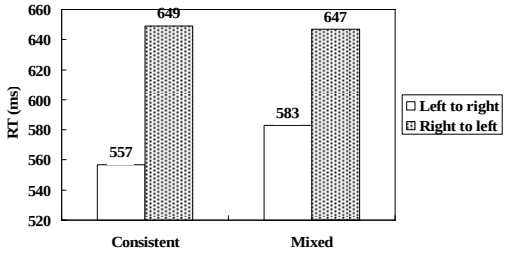
Direction and mixing



Right to left is significantly slower

(Consistency and interaction not significant)

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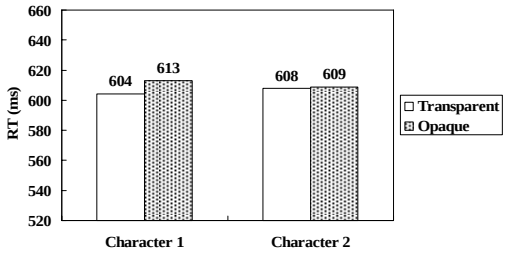
Semantic effects not robust overall



(CS_1 and interaction significant only by subject)

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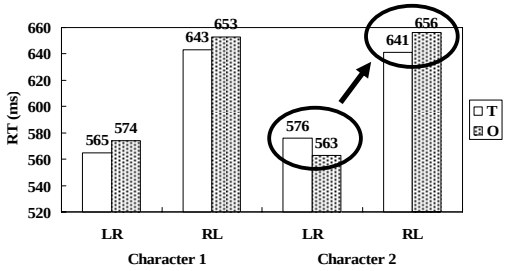
Right-to-left reading reverses C_2 transparency effect



Only when C_2 is on left does its opacity hurt access

(C_1 unaffected by direction: late process?)

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Transparency and reading direction

- The processor first accesses leftmost character, even if it's the "second" morpheme
- If opaque, word access is slowed
- Character-based access makes sense:

  Chinese reading requires composition, not decomposition (Myers et al. 2006)

  - Characters ≈ morphemes
  - No word boundaries

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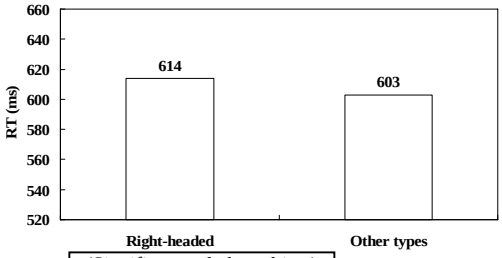
Headedness effects not robust overall



(Significant only by subject)

(Also, no interaction with transparency)

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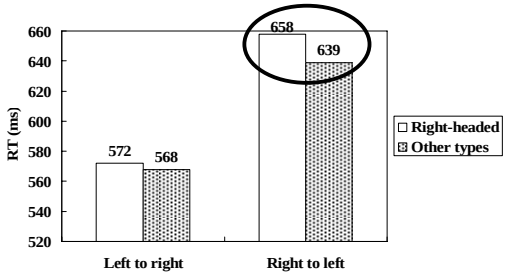
Right-to-left reading enhances headedness effect



Only when head is on left does headedness hurt access

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Headedness and reading direction

- The processor expects to the head to be "second" in a left-to-right direction
- In the less familiar right-to-left direction, the head (on left) is misclassified as modifier
- Recovering from this mistake takes time

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Summary

- Reading direction influences both positional transparency and headedness effects
  - Hence both start early
  - Their effects are distinct from each other and from predictability
- Semantic transparency effects start early because of character-by-character access
- Yet head assignment must also start early
  - Characters are accessed with their expected morphological roles in mind

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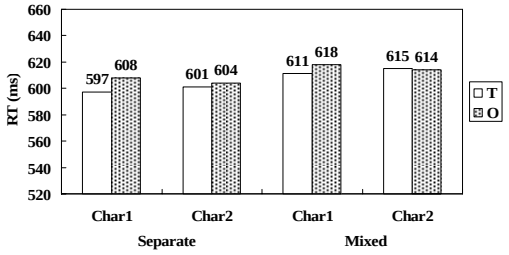
Appendix I: Direction consistency affects semantic consistency effects...?



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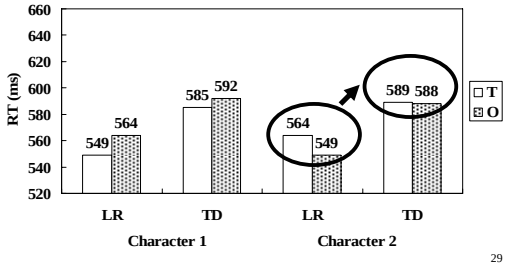
Appendix II: Top-down direction flattens C_2 semantic transparency effects



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