Thin & curvy

Unconscious knowledge of a subtle Chinese character stroke pattern

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Thanks!

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- Software
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  - PsychoPy (https://www.psychopy.org)
  - R (https://www.r-project.org)

- Colleagues
  - Jane Tsay
  - You!

Overview

- Stroke curving shows partly predictable regularities in Chinese characters

- These regularities interact with character width

- A new experiment shows that Chinese readers automatically activate their knowledge of this curving/width interaction

- The experiment sheds light on the role of linguistic regularities in perception, even outside speech

Curved strokes in Chinese characters

- Vertical stroke with a leftward curve (彎), AKA 豎撇 or 直撇

丿

- (Almost) never appears anywhere except the left edge
 ① 川 介 弗 月 舟 用 爪 飛 片 爿
  ② 明 所 淵
  ③ 辣 羚 邦 朔 辡 艸 班

Do readers know the left-edge restriction?

- Myers (2019) *The grammar of Chinese characters* (Routledge)
  - Acceptability judgments for 320 fake stroke combinations

Yes, it seems that they do!

The role of width

- Dominant axis (e.g. via stroke intersections; Myers 2019)

  (cf. Wang 1983, *Toward a generative grammar of Chinese character structure and stroke order*, University of Wisconsin-Madison Ph.D. thesis; Peust 2006, Script complexity revisited, *Glottometrics* 12)

Vertical: 月 2 / 3

Horizonal: 雨 7 / 4
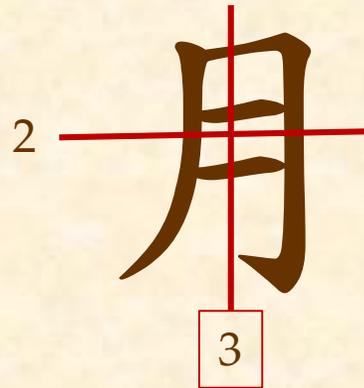
Wider = less likely to be curved

- Myers (2019)

	Dominant axis		
	<u>Horizontal</u>	<u>Vertical</u>	<u>None</u>
Curved		月甩周有舟角	丹用
Straight	冊同岡巾內向兩肉市	再甬高商喬	同冏冉柬

- An old observation
  - Wang (1983): 周 is taller than 同 and that's why it's curved
  - Unicode uses different widths for the "arches" 周字框 vs. 同字框

$$ 冂 \text{ vs. } 冂 $$

So width affects the predictability of curving

- Very narrow components usually show left-edge curving

<p style="text-align:center; color:red">介　卄　升　月　丹　舟　片　爿</p>

- Very wide components usually do not show left-edge curving

<p style="text-align:center; color:red">冊　兩</p>

- Curving is less predictable in medium-width components

<p style="text-align:center; color:red">角　vs.　甬　　　　周　vs.　同</p>

Is this correlation productive?

- Curving has historically generalized in narrow components

$$肉+半 → 月+半（胖）$$

$$有 \text{ vs. } 有 \quad 非 \text{ vs. } 非 \quad 册 \text{ vs. } 册（冊）$$

- Curved components avoid "squat" positions at top or bottom

甬：俑 埇 蛹 誦 踊 恫 捅 桶 涌 vs. 勇 恿 筩 ｝ "squat"

角：哨 埆 捔 桷 确 斛　　　　　vs. ⋯

(This pattern is statistically significant beyond these examples: Myers 2019)

A new experiment

- Speeded categorical identification task
  (cf. Yang & Wang 2018, Categorical perception of Chinese characters by simplified and traditional Chinese readers, *Reading and Writing* 31).

- Flash narrow and wide "arches" with gradiently varied curving
  (Created with the help of Wenlin)
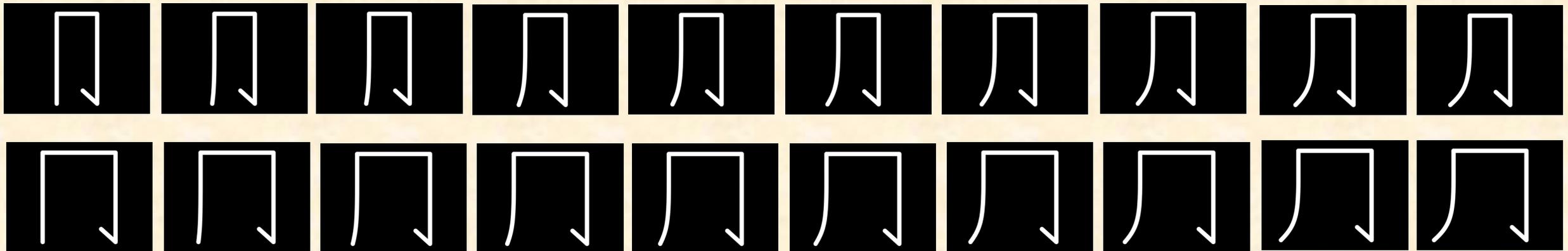
- Will width affect the detection of curving?

Display

- Very small (2° visual angle) to fit into fovea (hi-res point of eye)
  (O'Shea 1991, Thumb's rule tested, *Perception* 20)

- Very brief (50 ms) followed by visual mask (2000 ms)
  (This makes it hard to be consciously aware of shape: Yang & Wang 2018)

1 second
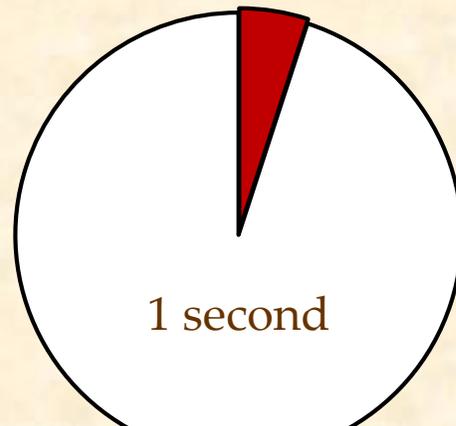
Procedure

- 44 traditional Chinese character readers
- Quickly decide if leftmost stroke is straight or curved
  - Response key locations counterbalanced across participant groups
  - Ordering of wide & narrow blocks were also counterbalanced
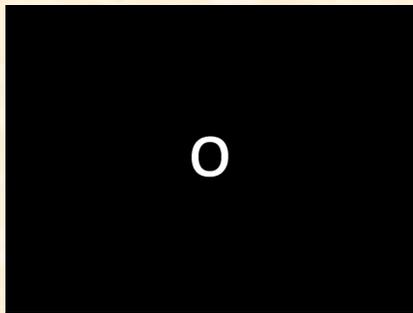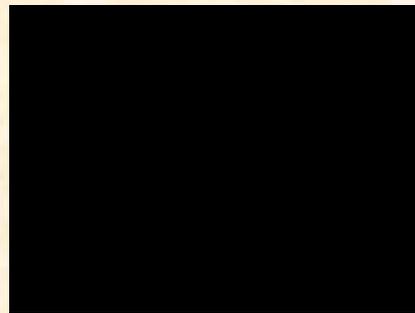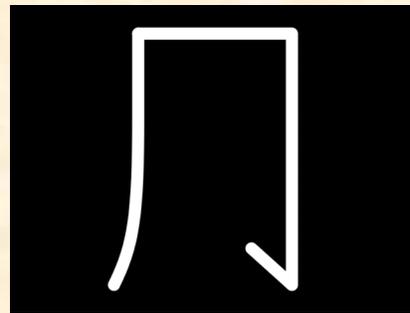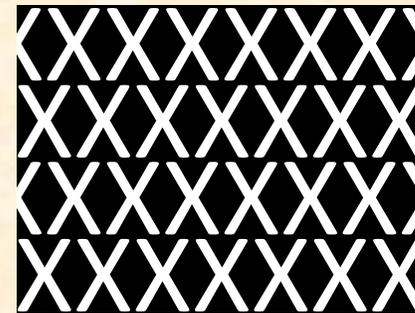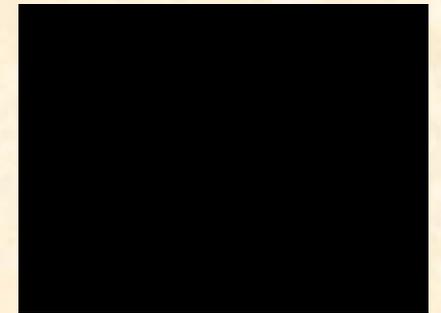
fixation	blank	stimulus	mask	blank
1000 ms	500 ms	50 ms	2000 ms	200 ms

- In each block, items were presented in random order 10 times
- PsychoPy recorded responses and reaction times (RT)

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Analyses

- Generalized additive mixed modeling (GAMM)
  - Permits a certain degree of wiggliness in the trend lines
    (Wood & Scheipl 2020, *gamm4*, R package)

- Participants as random variable
  - Random slopes (in case participants show different effects)

- Choices ("curved" vs. "straight") predicted via logistic model

- RT analyzed separately for "curved" and "straight" responses

- Key "interaction" was handled via ordered factor approach
  - First capture effect of curving degree in narrow stimuli
  - Then compare this with effect of curving degree in wide stimuli

Response choices
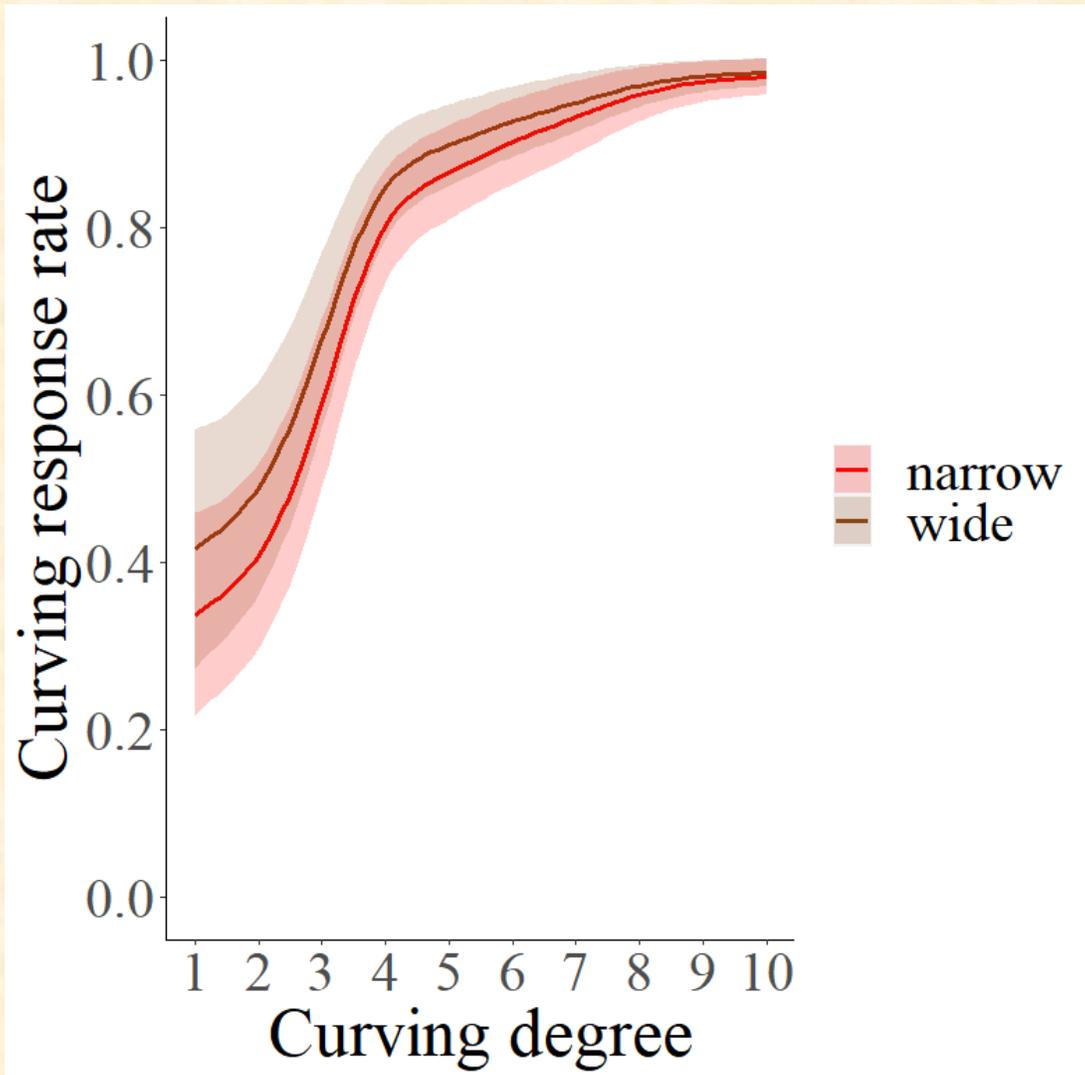
- Categorical perception
- Most items looked curved
  - Many degrees of curving, but only way to be truly straight
  - Curved strokes also stand out because most strokes in real characters are straight

- But width didn't matter

Curving × width: $p > .8$

Reaction times for "curved" & "straight"

"Curved" RT

Curving × width:
p < .01

narrow
wide

"Straight" RT

Curving × width:
p < .005
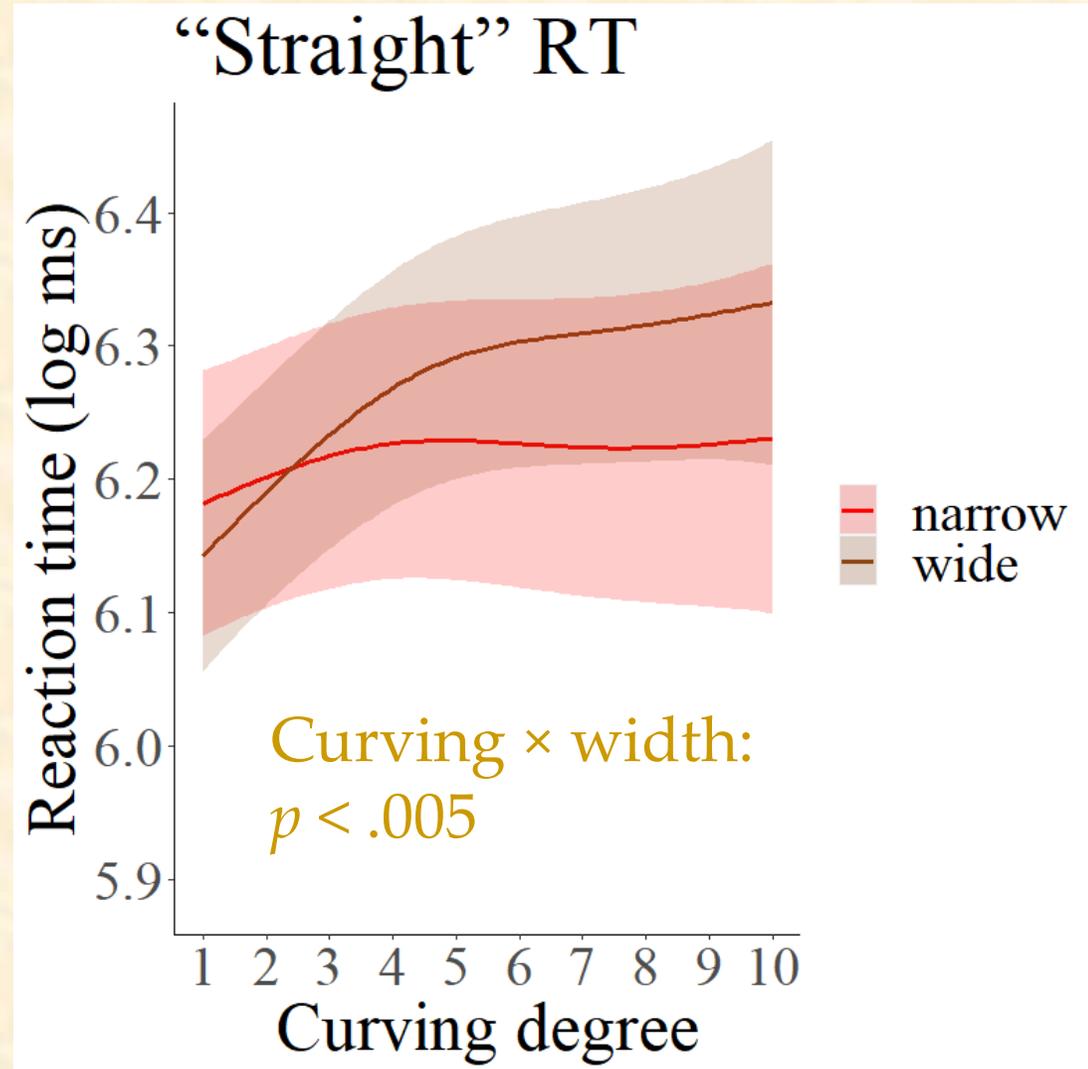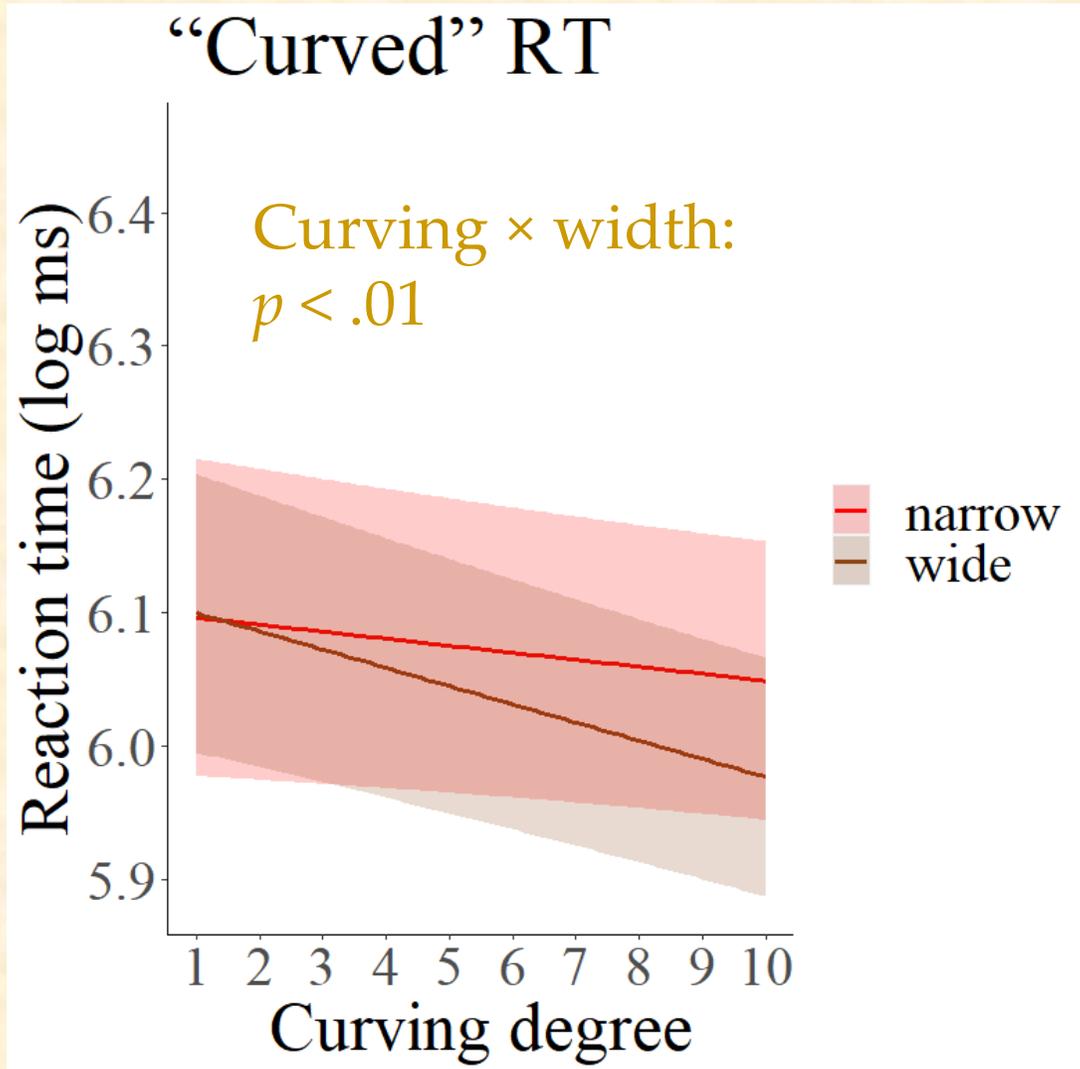
narrow
wide

In other words...

- In narrow characters, curving degree had little effect on RT
- In wide characters, curving degree had large effect on RT
  - The more curved the stroke, the faster the "curved" responses
  - The less curved the stroke, the faster the "straight" responses
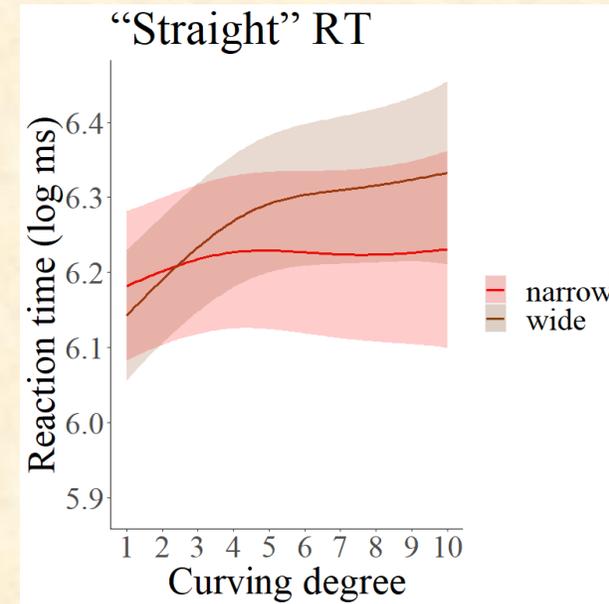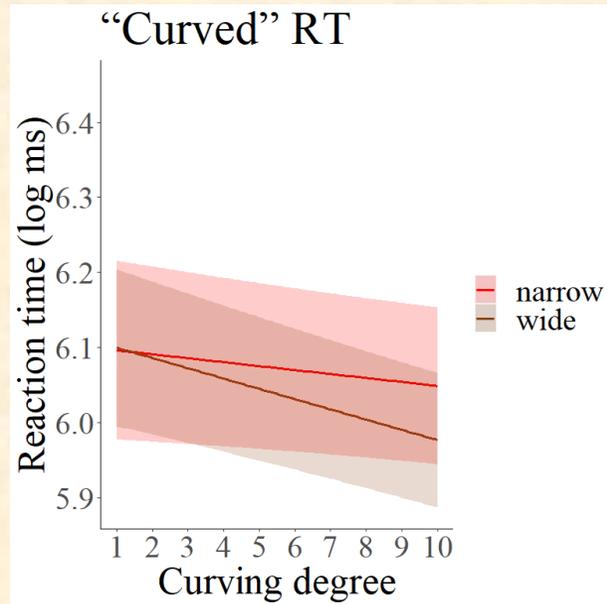
Why?

- In narrow characters, only curved strokes are expected
  - So readers have easy judgment: "acceptably curved: yes or no?"
- In wide characters, curved and straight strokes are both expected
  - So readers have harder judgment: "like 周 or like 同?"
- Stimuli flashed quickly & effect only in RT, not in overt choices
  - So this orthographic knowledge is activated unconsciously

So what?

- Reading depends on unconscious statistical learning

  (Treiman & Kessler 2022, Statistical learning in word reading and spelling across languages and writing systems. *Scientific Studies of Reading* 26(2))

- Contrastive and noncontrastive info interact in perception

  (Lu & Lee-Kim 2021, The effect of linguistic experience on perceived vowel duration: Evidence from Taiwan Mandarin speakers. *Journal of Phonetics* 86)

  - Width affects curving perception even though width itself is rarely contrastive

    日 vs. 曰   土 vs. 士   未 vs. 末

- More evidence for "orthographic prosody"?

  (cf. Myers 2019; Evertz 2018, *Visual prosody: The graphematic foot in English and German*, Walter de Gruyter)

Curving & width: A prosodic analysis

- Right side is generally larger in Chinese characters

<p style="color:red; text-align:center">川　　林　比　　瑪　駐　　鴻（江+鳥）</p>

  - Right-headed "foot" (weak-strong: strong=head, weak=the rest): [WS]

- Curving is "lenition", restricted to weak prosodic position: 班

- Meanwhile, separate stroke groups = no curving (generally)

<p style="color:red; text-align:center">門　鬥　段　行　竹　段　（非　拜）</p>

  - So each stroke group forms its own "foot" (each just a head): [S][S]

- Thus the curving/width pattern reflects the number of "feet"

<p style="color:red; text-align:center">川　[WS]　　　　冊　[S][S]</p>

The End