Prosody-like asymmetries in handwritten Chinese characters

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Prosody, including syllable structure and lexical stress, plays a crucial processing role in both speech (Levelt et al., 1999) and signing (Van der Kooij & Crasborn, 2008). Among many other things, predictable locations for prominence allow nonprominent gestures to be underarticulated. Writing systems are expected to benefit from such asymmetric structures as well, given that they share deep formal similarities with speech and signing (Meletis, 2020) and also involve articulatory planning in real time. Consistent with this expectation, our experiment demonstrates that there is systematic asymmetrical structure in the handwriting of Chinese characters.

Chinese character strokes and components are generally larger on the right (林; 馬 in 媽 vs. 騎) and bottom (二; 大 in 尖 vs. 奇). Myers (2019) argues that enlargement in Chinese characters is analogous to lexical stress, as further suggested by analogs to primary vs. secondary stress (圭), stress clash (adjacent strokes cannot both be enlarged: 土 and 士 vs. 聿), and most relevantly here, weight: components with fewer strokes favor the prosodically weak positions at the left (冰) and top (安) (see Wang, 1983, for other character patterns, Myers, 2021, for analogs of syllables in characters, and Evertz, 2018, for prosodic analyses of alphabetic systems). Quantitative analyses (Myers, 2024, February) of the Wenlin Character Description Language database (Bishop & Cook, 2007) confirm an asymmetry in physical component size in the standard serif typeface for Chinese (like that used in this abstract), even with stroke count factored out. The patterns are particularly robust along the horizontal axis, the most common character configuration.

To look for asymmetries in handwriting, we asked 34 Taiwanese university students (six more with accuracy rates below 80% were dropped) to handwrite 199 traditional characters varying widely in frequency (from 1 to 50,048 tokens per ten million; Tsai, 2006), each composed of two horizontally arranged components. To avoid biasing productions, components were matched in stroke counts and characters were prompted with decomposed forms (e.g., 靜 was prompted with 青+爭). Pen positions were tracked using a Wacom One tablet controlled by PsychoPy (Peirce et al., 2022; Myers, 2023). The handwritten component stroke counts and widths were computed automatically, while the visual forms of the characters were judged for acceptability by two readers.

6,146 acceptably written character tokens were analyzed in separate linear mixed-effects models predicting handwritten component stroke count asymmetry and width asymmetry from log character frequency and the corresponding asymmetries in the standard typeface. All asymmetries divided the right component by the left, and were rescaled so that zero represented full symmetry. Handwritten stroke count and width asymmetries both went in the expected direction, as shown by significantly positive coefficients for the intercept, even with the typeface asymmetries factored out. That is, not only were left-side components written as narrower than right-side components, but they were also written with fewer strokes. The asymmetry in stroke count, but not in width, was also significantly greater for less frequent characters, as in the analogical regularization of rarer words (e.g., *flow~flowed* vs. *blow~blew*; Bybee, 2002). This suggests that forms that are harder to recall may have lexical patterns like stroke count asymmetries regularized by default, whereas patterns in physical width, analogous to phonetics, may apply regardless of frequency.

Like the lexical prosody of spoken and signed languages, then, writers place prominence in a consistent location in Chinese characters while underarticulating in the nonprominent position. This study thus adds to the growing body of research suggesting that prosodic structure is fundamental to the processing of complex linguistic structures regardless of modality.

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