# Efficiency, Cognitive Processes, and Fluency in Mandarin Sentence Production: Effects of Syntactic Structure and Classifier Information on Grammatical Encoding

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Grammatical encoding coordinates lexical retrieval and syntactic structure building [1, 2], but whether sentence planning is driven primarily by lemma-level information, syntactic structure, or both remains debated. Linear and Hierarchical Incrementality accounts differ in the relative roles of lexical retrieval and syntactic structure building [1, 3–6]. We examined whether syntactic structure and classifier-related lemma information jointly constrain the scope and timing of grammatical encoding in Mandarin.

**Methods.** Thirty-six native Mandarin speakers described three-object pictures during 32-channel EEG in a 2 × 2 within-subjects design (Figure 1) crossing subject structure (single vs conjoined NP) with classifier congruency (same vs different classifiers). Praat annotations yielded onset latencies, articulation durations, and silent pauses. Fluency [7] was indexed by mean length of syllables (MLS) and silent-pause occurrence; other disfluencies were described due to low base rates. LMMs analysed MLS and ERP amplitudes, and GLMMs onset latencies and silent-pause occurrence. ERP analyses combined collapsed-localiser-defined windows/ROIs [8] with permutation-corrected mass-univariate TFCE [9].

**Results.** Onset latencies showed a Structure × Congruency interaction (Figure 2): incongruency delayed Conjoined-NP onsets by ~53 ms ($p < .0001$) but had no effect in the Single-NP condition. Conjoined-NP utterances were articulated faster and were less likely to contain silent pauses than Single-NP utterances (both $p < .001$), with no robust congruency effect on fluency. Both ERP analyses showed a late Structure × Congruency interaction in central-parietal activity (Figure 3; collapsed localiser: 500–700 ms, $p = .046$; TFCE: 510–718 ms, $p = .015$). TFCE also identified an earlier posterior Structure effect (Figure 4; 358–494 ms, $p < .001$), and the primary analysis showed a marginal effect in the same direction (300–400 ms, $p = .072$), with Single more positive than Conjoined.

**Discussion.** These findings show that classifier-related lemma information modulates grammatical encoding under specific structural conditions: congruency affected speech onset in conjoined but not single NPs. ERPs further reveal the time course of this pattern: structure differentiates planning early at posterior sites, whereas the interaction between classifier congruency and syntactic structure emerges later in central-parietal activity. Congruency did not robustly affect fluency, whereas structure affected rate and pausing. Together, syntactic structure and lemma-related information jointly constrain the scope and timing of grammatical encoding across planning efficiency, pre-articulatory processing, and fluency.

## References


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## Figures and Tables

Figure 1: Stimulus example

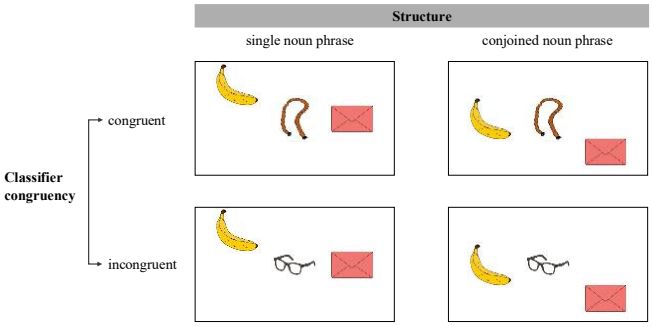



Figure 2: Onset latencies

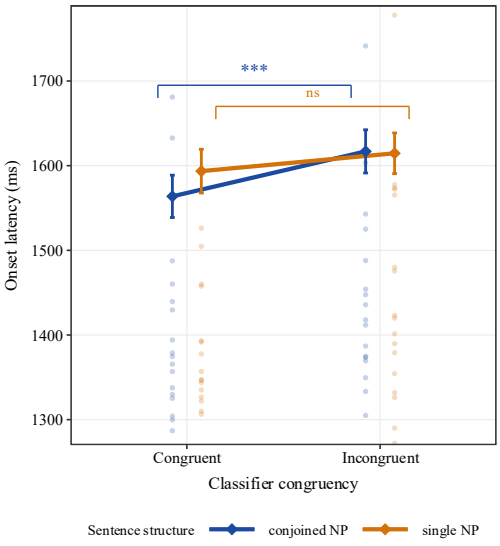



Figure 3: Centro-parietal ROI ERPs: Structure × Congruency interaction. Shaded: 500–700 ms primary analysis window.

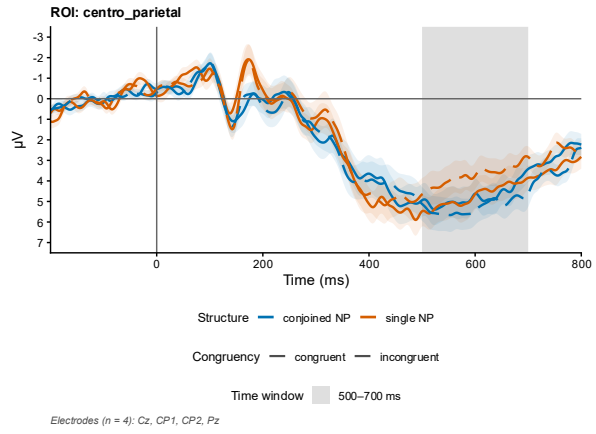
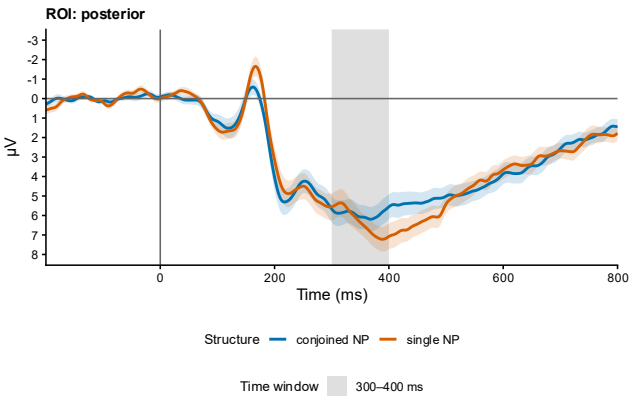



Figure 4: Posterior ROI ERPs: Structure main effect. Shaded: 300–400 ms primary analysis window.



## Supplemental Information

### a. Brief introduction to the classifiers in Mandarin Chinese

In Mandarin, a classifier is obligatory between a noun and a preceding numeral, demonstrative, or quantifier. For example, "one rope" cannot be expressed as yì shéngzi (one-rope) but must be yì gēn shéngzi (one-CL-rope), where gēn is the dominant classifier for elongated objects. Classifier choice is only partly related to referent properties (e.g., shape, animacy); for most nouns, the dominant classifier must be learned as part of the lexical representation, with no one-to-one mapping between nouns and classifiers. Classifier features are therefore treated as lemma-level lexico-syntactic properties, comparable to grammatical gender in Indo-European languages.

### b. Target sentences across the four conditions in Mandarin Chinese

**Condition a: *Single NP + Congruent***

| 一 | 根 | 香蕉 | 在 | 一 | 根 | 绳子 | 和 | 一 | 个 | 信封 | 上边/下边 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| yì | gēn | xiāngjiāo | zài | yì | gēn | shéngzi | hé | yí | ge | xìnfēng | shàngbian/xiàbian |
| one | CL | banana | be.at | one | CL | rope | and | one | CL | envelope | top/bottom |

*One banana is above/below one rope and one envelope.*

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**Condition b: *Conjoined NP + Congruent***

| 一 | 根 | 香蕉 | 和 | 一 | 根 | 绳子 | 在 | 一 | 个 | 信封 | 上边/下边 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| yì | gēn | xiāngjiāo | hé | yì | gēn | shéngzi | zài | yí | ge | xìnfēng | shàngbian/xiàbian |
| one | CL | banana | and | one | CL | rope | be.at | one | CL | envelope | top/bottom |

*One banana and one rope are above/below one envelope.*

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**Condition c: *Single NP + Incongruent***

| 一 | 根 | 香蕉 | 在 | 一 | 副 | 眼镜 | 和 | 一 | 个 | 信封 | 上边/下边 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| yì | gēn | xiāngjiāo | zài | yí | fù | yǎnjìng | hé | yí | ge | xìnfēng | shàngbian/xiàbian |
| one | CL | banana | be.at | one | CL | glasses | and | one | CL | envelope | top/bottom |

*One banana is above/below one (pair of) glasses and one envelope.*

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**Condition d: *Conjoined NP + Incongruent***

| 一 | 根 | 香蕉 | 和 | 一 | 副 | 眼镜 | 在 | 一 | 个 | 信封 | 上边/下边 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| yì | gēn | xiāngjiāo | hé | yí | fù | yǎnjìng | zài | yí | ge | xìnfēng | shàngbian/xiàbian |
| one | CL | banana | and | one | CL | glasses | be.at | one | CL | envelope | top/bottom |

*One banana and one (pair of) glasses are above/below one envelope.*

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*Note.* Conditions a and c begin with a single-noun subject; conditions b and d begin with a conjoined-NP subject. The first two nouns share the same dominant classifier in conditions a and b (*xiāngjiāo* "banana" and *shéngzi* "rope" both take *gēn* as their dominant classifier), whereas they take different classifiers in conditions c and d (*xiāngjiāo* takes *gēn*; *yǎnjìng* "glasses" takes *fù* as its dominant classifier). The third noun (*xìnfēng* "envelope") consistently takes the general classifier *ge* as a control. Each noun is produced as a full *yī* + CL + N phrase, making classifiers obligatorily encoded. Localizers (*shàngbian* “above” and *xiàbian* “below”) were randomly assigned to trials with the constraint that they occurred equally often within each condition.