

Holistic Prosodic Examination of Mandarin *Wh*-indeterminates

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[Introduction] Mandarin Chinese *wh*-words are indeterminates in that they are ambiguous between *wh*-question readings and *wh*-indefinite readings, and this ambiguity can be resolved prosodically (Hu 2002, Dong 2009, Liu et al. 2016, Yang 2018, Hsu and Xu 2020, Wang and Wang 2020, Wu and Yun 2023). However, existing studies report divergent findings on the prosodic features of *wh*-indeterminates, with the only consensus pointing to the pitch prominence of the *wh*-region for *wh*-question readings (Table 1). Potential shortcomings in experimental design in the previous studies include i) the unbalanced positioning of *wh*-words within sentences, ii) the use of non-identical strings for interrogative and indefinite readings, and iii) oversight of sentential prosody beyond the *wh*-word itself. In this study, we balanced the position of *wh*-words (both as subjects and objects) and utilized identical strings, aiming at a comprehensive examination of various prosodic features (pitch, intensity, duration) of *wh*-indeterminates as well as the global prosodic characteristics of sentences containing them.

[Experiment 1] We created 12 pairs of sentences, aligning subject and object *wh*-words in a mirror image fashion (1). The type (e.g., *which student* vs. *who*) and the animacy (e.g., *what* vs. *who*) of the *wh*-word were varied across the stimuli. Participants ($N=34$) were instructed to say aloud each target sentence with two different readings of the *wh*-word. They were given the option to refrain from recording the sentence if they thought the intended reading was not available. For 31 participants who accepted the ambiguity of *wh*-intermediates, we compared the prosodic properties of indefinite and interrogative readings, using a mixed linear regression model. In the *wh*-region, we found a longer duration for *wh*-question readings ($p < .05$, Figure 1), consistent with Yang (2018), Hsu and Xu (2020), Wu and Yun (2023), as well as a greater intensity for *wh*-question readings ($p < .001$) (Figure 2) as in Hsu and Xu (2020). However, no significant difference in pitch was observed in the *wh*-region, contrary to the consensus in previous studies. Outside the *wh*-region, we noted a lower pitch in the pre-*wh* region ($p < .05$, Figure 3) and a greater intensity in the post-*wh* region ($p < .05$, Figure 4) for *wh*-question readings: These novel findings suggest that global prosodic features are also employed for prosodic disambiguation beyond the local prosody of the *wh*-word itself.

[Experiment 2] The absence of a pitch effect in the *wh*-region in Experiment 1 is surprising, given the common findings on *wh*-pitch prominence in prior studies. To investigate whether this was partly influenced by the subject *wh*-word being in sentence-initial position, where intonational prominence at the beginning of the sentence might have overridden the anticipated pitch effect, we created 18 pairs of sentences based on (1a) and varied the presence and length of adverbial phrases before the subject *wh*-words (2). Analysis of production results from the same speakers confirmed the lack of a pitch effect in the *wh*-region. Overall, Experiment 2 exhibited a pattern closely resembling that of Experiment 1 (Figures 5, 6, 8) in the *wh*-region and post-*wh* region, with the only divergence being the extended duration observed in the post-*wh* region for *wh*-question readings ($p < .001$, Figure 7). No prosodic differences were observed in the pre-*wh* region in Experiment 2, possibly due to the peripheral role of the sentence-initial adverb in shaping the overall meaning of the sentence.

[Conclusion] The results call for a holistic approach to the prosodic disambiguation of *wh*-indeterminates, i.e., both the local prominence of *wh*-question readings and the broader sentential prosody work together. Notably, our findings suggest that achieving pitch prominence of *wh*-words in interrogative readings is not strictly confined to local prosody. Instead, global prosodic factors, such as pitch compression in the pre-*wh* region (when the *wh*-word is in the object position), can play a significant role in attaining relative pitch prominence of *wh*-words.

Table 1. Summary of the literature regarding their reported prosodic cues for *wh*-question readings

	Hu 2002	Dong 2009	Liu et al. 2016	Yang 2018	Hsu and Xu 2020	Wang and Wang 2020	Wu and Yun 2023
Stimuli	Only some were identical strings	Non-identical strings	Identical strings	Identical strings	Non-identical strings	Non-identical strings	Identical strings
Readings	<i>wh</i> -questions, yes/no-questions, echo questions	<i>wh</i> -questions, statements	<i>wh</i> -questions, statements	<i>wh</i> -questions, statements	<i>wh</i> -questions, yes/no-questions, statements	<i>wh</i> -questions, statements	<i>wh</i> -questions, statements
Position of <i>wh</i>	Sentence-boundaries (subject, object), sentence-internal	Sentence-boundaries (subject, object), embedded subject	Sentence-boundary (object)	Sentence-internal (direct object)	Sentence-internal (object)	Sentence-boundaries (subject, object)	Sentence-internal (subject)
Speakers	4	4	8	40	20	8	10
Pre- <i>wh</i> region	Info not clearly provided	Info not clearly provided	No prosodic differences	Shorter duration	Info not clearly provided	Info not clearly provided	Longer duration
<i>Wh</i> -region	Pitch prominence	Pitch prominence for subject- <i>wh</i> , but not always for object- <i>wh</i>	Pitch prominence	Pitch prominence, longer duration, greater intensity range	Pitch prominence, longer duration, higher intensity	Pitch prominence	Pitch prominence, longer duration
Post- <i>wh</i> region	Info not clearly provided	Info not clearly provided	Info not clearly provided	F0 range compression	longer duration, higher intensity	Info not clearly provided	F0 range compression
Notes	No statistical report for high speaker variance No consistent data on duration and amplitude	No statistical report	Local and global prosodic features both play a role in disambiguation, while local features are more important	Pitch is not the only factor that differs in the two readings	Sentence-final particles were found to influence focus prosody	Subject and object <i>wh</i> -words show different intonation patterns for <i>wh</i> -questions	Findings align with previous studies on other <i>wh</i> -in-situ languages

(1) **Stimuli example of Experiment 1:** mirror image between subject *wh* and object *wh*

- a. [*wh*-region] [post-*wh* region]
Shui ye mei jian-guo LiMing
 who also not meet-ASP LiMing
 ‘No one met LiMing.’ // ‘Who did not meet LiMing as well?’
- b. [pre-*wh* region] [*wh*-region]
LiMing ye mei jian-guo Shui
 LiMing also not meet-ASP who
 ‘LiMing did not meet anyone.’ // ‘Who did not LiMing meet as well?’

(2) **Stimuli example of Experiment 2:** subject *wh* being sentence boundary or not

- a. same as (1a)
- b. [pre-*wh* region] [*wh*-region] [post-*wh* region]
Zuotian Shui ye mei jian-guo LiMing
 yesterday who also not meet-ASP LiMing
 ‘No one met LiMing yesterday.’ // ‘Who did not meet LiMing yesterday as well?’

