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A Research on Mandarin Processing Mechanism of Wh-questions in Island

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ABSTRACT

The theoretical status of wh-in-situ elements in Mandarin syntactic islands remains a central debate in linguistics. This study provides an empirical evidence from online processing to adjudicate between these theories, employing a self-paced reading (SPR) task with 42 native Mandarin speakers. Results revealed a distinct reading delay pattern extending both within and subsequent to the wh-element inside complex NP islands—a profile that can be systematically explained by Fiengo et al.'s (1988) pied-piping mechanism as well as by Chomsky's (2013, 2015) Label Theory. These findings demonstrate that processing wh-dependencies in islands incurs distributed cognitive costs, supporting the existence of covert syntactic operations. The study establishes a native processing benchmark with dual implications: for syntactic theory, it validates analyses incorporating quantifier raising and labeling-driven movements; for applied linguistics, it provides a psycholinguistic basis for diagnosing L2 acquisition challenges and designing cognitively-grounded pedagogical interventions for complex question structures.

KEYWORDS

Mandarin Wh-questions; Syntactic islands; Label theory; Psycholinguistics; Second language acquisition

1 Introduction

1.1 Background of the Study

Theoretical research on Mandarin wh-in-situ has consistently been a focal point in syntactic studies. Prevailing analyses generally posit a covert connection between the in-situ wh-phrase and a left-peripheral operator position (e.g., SpecCP) (e.g., Huang 1982a,b; Tsai 1994). However, a key theoretical controversy remains: unlike English, which disallows extraction from islands altogether, Mandarin permits the interpretation of argumental wh-phrases within islands while restricting adjunct wh-phrases. This asymmetry lacks both theoretical consensus and direct empirical validation.

1.2 Problem Statement

This phenomenon can be seen clearly in the sentence group (1) below. The research on syntactic island could be traced back to Ross(1967).

a.*What$_i$ do you like [the man who fixed t$_i$]?

b.*What$_i$ did you feel satisfied [after he fixed t$_i$]?

c.*What$_i$ would [for him to fix t$_i$] be nice?

While in Mandarin, although it is impossible to interpret a wh-phrase that functions as an adjunct within an island by placing it outside the island, interpreting a wh-phrase that functions as an argument is quite straightforward. For example, in the following sentence (2) from the syntax of Chinese(Huang et al. 2013), wh-questions are able to get the full-sentence semantic scope in LF under the theory of Huang(1982b).

a.Ni zui xihuan [mai shenme de ren]?

（你 最 喜欢 [买 什么 的 人]）

You most like buy what DE person

The person who buys what — that's who you like the most?

b.[Shenme]i [ni zui xihuan [mai ti de ren]]?

[什么 i [你最 喜欢 [买 ti 的 人]]]?

（[What]i [you most like [buy ti DE person]]?）

The person who buys what — that's who you like the most?

c.For which x, x is a thing, you like most person who have bought x?

A series of scholars have attempted to explain these contradictions syntactically. For instance, Huang (1982b) proposed that movement constraints fall into two categories: the Empty Category Principle restricts movement output at S-structure and Logical Form, while Subjacency and the Condition on Extraction Domain constrain overt syntax only. However, this fails to fully explain why overt and covert movement differ so markedly with respect to these constraints.

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Nishigauchi (1986) and Fiengo et al. (1988) argued that movement in Logical Form also obeys Subjacency and CED. Due to the possibility of pied-piping in LF, however, some island effects become invisible. Fiengo et al. (1988) further assumed that every quantificational NP undergoes Quantifier Raising in LF; thus, wh-phrases also undergo both QR and wh-movement. This gives pied-piping a new theoretical motivation within frameworks like Labeling Theory.

An alternative approach, developed by Aoun & Li (1993a,b) and Tsai (1994), posits that in-situ wh-phrases do not move in LF (and thus show no island effects) but are instead bound by abstract operators—a strategy of "unselective binding" in the sense of Heim (1982).

Paradoxically, despite its central role in theoretical debates on Mandarin syntax, the island sensitivity of wh-in-situ lacks direct empirical support. This empirical gap necessitates the present study, which aims to provide the first systematic evidence to adjudicate between these competing theoretical accounts.

1.3 Research Questions

This study is guided by this central research question: Does a Mandarin in-situ wh-phrase within a syntactic island establish a dependency with the left periphery? To answer this central question, the following sub-questions were developed:

(1) Do wh-questions in island contexts require more processing effort for Mandarin native speakers compared to their declarative counterparts during self-paced reading studies?

(2)If there is an extra cost shown in the form of reading delay, what is the delay pattern for Mandarin native speakers when they process L2 Mandarin wh-questions in island contexts?

1.4 Significance of the Study

This study provides valuable insights for several key stakeholders in International Chinese Language Education:

Chinese Language Curriculum Designers and Material Developers: It establishes a psycholinguistic benchmark for native-like processing of complex syntax, informing the design of evidence-based curricula and targeted pedagogical materials that reflect authentic cognitive demands.

Second Language Acquisition Researchers and Assessment Specialists: The detailed mapping of native processing patterns provides a diagnostic standard for evaluating L2 proficiency, enabling precise identification of learner difficulties and supporting the development of implicit knowledge assessment tools beyond conventional methods.

Theoretical Linguists and Syntacticians: This study operationalizes a longstanding debate by supplying critical processing evidence to adjudicate between movement and non-movement accounts of Mandarin wh-questions within islands, thereby directly advancing syntactic theory on this constrained construction.

1.5 Scope and Delimitation

This study investigated the cognitive mechanisms underlying the processing of wh-questions within syntactic islands by native Mandarin speakers. The participant pool was delimited to undergraduate and graduate students enrolled at a public university in Guangzhou, China. To examine the real-time sentence processing mechanisms, participants completed a self-paced reading task (SPR), a time-sensitive methodological paradigm well-established in psycholinguistic research for capturing online processing effects.

2 Literature Review

2.1 Mandarin Wh-questions in Island

The phenomenon of wh-questions in Mandarin, particularly those involving syntactic islands, presents a theoretically significant divergence from patterns observed in languages like English. While English uniformly disallows extraction from islands (Ross, 1967), Mandarin shows a nuanced acceptability gradient, where argument wh-phrases within islands are interpretable, whereas adjunct ones are not.

This asymmetry has motivated various theoretical proposals—such as covert movement (Huang, 1982), unselective binding (Tsai, 1994), and operator-variable linking mechanisms (Bayer & Cheng, 2017)—which generally posit a non-overt connection between the in-situ wh-element and a left-peripheral operator position (e. g., SpecCP). Despite sustained scholarly debate, the underlying mechanisms remain contested, and a crucial empirical gap persists in the processing evidence needed to evaluate these competing accounts.

a.Ni zui xihuan [mai shenme de ren]?
（你 最 喜欢 [买 什么 的 人]）
You most like buy what DE person
The person who buys what — that's who you like the most?
b.[Shenme]$_i$ [ni zui xihuan [mai t_i de ren]]?
[什么$_i$ [你最 喜欢 [买 t_i 的 人]]]?

（[What]$_i$ [you most like [buy t_i DE person]]?）

The person who buys what — that's who you like the most?

c.For which x, x is a thing, you like most person who have bought x?

2.2 Theoretical Accounts of Mandarin *Wh*-Questions in Islands

A number of scholars (Huang, 1982b; Aoun & Li, 1993a, 1993b; Tsai, 1994) have offered competing syntactic accounts for these contrasts. Fiengo et al. (1988), for instance, posit that all quantified noun phrases (QNPs) undergo Quantifier Raising (QR) at Logical Form (LF). This extends to wh-phrases, which are argued to undergo both QR and wh-movement. Consequently, when a QNP (e.g., everybody or who) is embedded within another NP (such as pictures of everybody), the entire containing NP must raise and be interpreted as a quantificational unit—a classic instance of pied-piping.

From the perspective of Labeling Theory (Chomsky, 2013, 2015), this pied-piping operation finds a distinct formal rationale. The theory requires every syntactic object to receive a clear label. If only the embedded QNP (e.g., everybody) were extracted from a structure like this, the resulting mother node would lack an unambiguous head, leading to labeling failure. Pied-piping the entire NP circumvents this problem and ensures syntactic legibility.

Despite these theoretical developments, a decisive body of empirical evidence remains lacking, leaving the debate among these accounts unresolved.

2.3 Mandarin Wh-question Processing Mechanism

Empirical studies on the processing of Mandarin wh-questions remain scarce. Only three SPRT studies (Xiang et al., 2014, 2015; Yang et al., 2023) have been conducted, all reporting increased reading times for in-situ wh-questions compared to declaratives—indicating additional processing cost. Following this paradigm, the present study employs a similar contrastive design in its experiment.

Further evidence comes from Chacón et al. (2024), who used RPVP and also found that wh-constructions impose higher cognitive load. This aligns with Wurmbrand ' s (2018) observation that covert operations like Quantifier Raising (QR; Fiengo et al., 1988) are cognitively costly. Together, these findings justify the use of time-sensitive methods in the present research to test whether the QR-based account—integrated with Labeling Theory—adequately explains the processing of Mandarin wh-in-situ.

2.4 Synthesis and Research Gap

The syntactic analysis of Mandarin wh-in-situ within island has reached considerable theoretical depth, from LF movement and QR to Labeling Theory. Concurrent empirical studies confirm that processing such structures involves measurable cognitive costs. Yet, a critical gap persists between theoretical predictions and real-time processing evidence, particularly regarding how the mind implements the mechanisms for argument extraction during online comprehension.

To address this, the present study employs a self-paced reading experiment designed to test competing theoretical accounts directly. By examining Mandarin wh-in-situ in island contexts, it aims to provide evidence-based insights into the cognitive reality of these syntactic operations.

3 Methodology

3.1 Research Design

This study utilizes the Self-Paced Reading Task (SPR) to compare the reading times of adult native Mandarin speakers processing wh-questions within syntactic islands and their declarative counterparts, thereby investigating the online processing mechanisms of such structures. To ensure participants' sustained attention to sentence content, comprehension questions targeting specific key lexical items were integrated after each trial, encouraging holistic engagement with the full sentence rather than selective reading.

3.2 Research Setting and Participants

24 sets of target stimuli were organized into two lists using a Latin Square design, with each list containing 24 sentences. Each set comprised two conditions: a wh-question embedded in a Complex NP island and its declarative counterpart. These were distributed across lists to ensure no participant encountered the same semantic content twice. The stimuli followed the fixed structure: "Proper Noun + Intensional Verb + Verb + nǎge (which) / nàge zuòjiā (that author) + NP + Verb + de (possessive) + NP" Additionally, 60 filler sentences of varied structures were included to minimize strategic task processing. Each participant therefore read a total of 84 sentences.

Forty-two native Mandarin speakers—all female, aged 18–30 (mean = 20, SD = 2.13)—were recruited from Guangdong University of Foreign Studies. Three participants were graduate students; the remainder were undergraduates.

3.3 Data Collection

A word-by-word moving-window self-paced reading task (Just, Carpenter, and Wooley 1982) will be administered on a PC using PsychoPy (Peirce 2007) , driven by python3. There will be an eight-minute practice before the formal experiments. The whole experiments took around 25 minutes to accomplish. All of their reading times(RTs) will be collected automatically by the program.

3.4 Data Analysis

The initial analysis of reading times (RTs) began with a logarithmic transformation of the raw data for each region to address the pronounced skewness in the distribution, following established practices in prior Mandarin processing studies (e.g., Wu et al., 2012; Xiang et al., 2015; Yang et al., 2023). Data points exceeding ±2 standard deviations from the mean for each region were excluded to minimize the influence of outliers.

Subsequently, the log-transformed RTs for each region were analyzed using linear mixed-effects models in R with the lmerTest package (Kuznetsova et al., 2017). Condition was included as a fixed effect, while participants and items were incorporated as random effects, with random intercepts and slopes allowed for all factors.

Statistical comparisons were performed across all sentence regions; however, detailed interpretation will focus only on those regions where significant differences between conditions were reliably observed.

4 Findings

Raw reading times were log-transformed to correct for skewness, following established Mandarin processing studies (Wu et al., 2012; Xiang et al., 2015; Yang et al., 2023). Outliers exceeding ±2 SD from each region's mean were removed (Marsden, 2018), with 264 of 6048 data points trimmed (<5%), preserving validity. Analyses were conducted using linear mixed-effects models in R (lmerTest; Kuznetsova et al., 2017).

Experimental sentences followed a fixed structure across six regions: R1 (proper noun, e.g., Zhāng Sān), R2 (intensional verb, e.g., zuì xiǎng), R3 (verb, e.g., gòu mǎi), R4 (determiner: nǎge or nàge zuòjiā), R5 (noun phrase, e.g., zuòjiā), and R6 ([verb + de + NP], e.g., zhuàn xiě de xiǎo shuō).

Paired *t*-tests revealed no significant RT differences between declaratives and wh-questions in regions R1 – R4 (all $p > .05$). Significant effects emerged in R5, where declaratives were read faster ($t(41) = -3.453$, $p = .001$), and in R6, where wh-questions elicited longer RTs ($t(41) = -3.501$, $p < .001$). These results indicate spill-over processing costs for wh-questions, with difficulty accumulating after the critical region (R4) rather than within it.

Table 1 Participants' mean RTs in the SPRT in Experiment

Region	Declarative	Wh-Ques	t-value	p-value
R_1(Zhāng Sān)	2.81392	2.79561	1.221	>0.05
R_2(zuì xiǎng)	2.644639	2.65207	0.984	>0.05
R_3(gòu mǎi)	2.615	2.6188	0.527	>0.05
R_4(nǎ ge)	2.618297	2.629326	-1.497	>0.05
R_5(zuò jiā)	2.644369	2.672027	-3.453	<0.01
R_6(zhuàn xiě de xiǎo shuō)	2.7933	2.83054	-3.501	<0.01

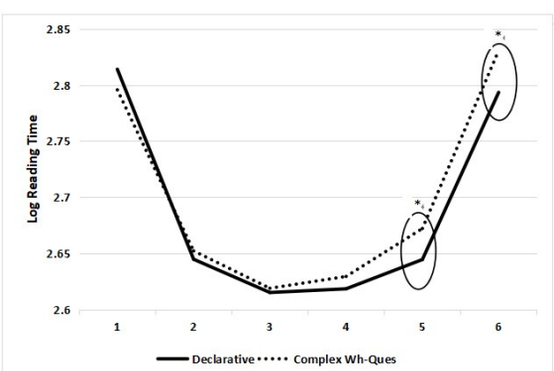

Figure 1 Participants' mean RTs in the SPRT in Experiment

The self-paced reading results provide empirical support for the pied-piping account proposed by Fiengo et al. (1988), which predicts processing delay across the entire complex NP island structure. Consistent with this, significant reading delays in the present study emerged not at the critical wh-region (R4), but in later regions (R5 and R6). This pattern diverges from Yang et al. (2023), who observed delay localized within the wh-word itself (corresponding to R5 in the

current design). Here, significant slowdown also extended to the final segment of the island (R6), a finding that aligns with the quantifier raising (QR) mechanism described by Fiengo et al. (1988) and can be further motivated within a Labeling Theory framework (Chomsky, 2013, 2015).

Additionally, comprehension accuracy across all trials—including fillers—averaged 91.8%, confirming that participants maintained attentive engagement throughout the self-paced reading task.

5 Discussion

This study advances the theoretical understanding of Mandarin wh-questions by investigating their processing within syntactic islands, providing pivotal evidence for syntactic inquiry. The findings critically engage with existing scholarship and extend its theoretical implications.

The first theme addresses the syntactic architecture underlying processing. While prior work (e.g., Yang et al., 2023) explained reading delays within wh-questions using Huang's (1982) framework, the current study reveals a distinct pattern: delays extend beyond the wh-region into subsequent constituents. This pattern aligns more closely with the pied-piping mechanism proposed by Fiengo et al. (1988), as formalized within Chomsky's Labeling Theory (2013, 2015). Only through such movement can the structure satisfy both island constraints and labeling requirements, enabling successful parsing by native speakers.

The second theme concerns implications for second language acquisition. A refined understanding of how native speakers process island-sensitive wh-structures provides a psycholinguistic benchmark for L2 pedagogy. By comparing native and learner processing patterns, instructors can develop more targeted teaching strategies, ultimately enhancing instructional effectiveness and learning outcomes.

In synthesizing these themes, this research bridges theoretical modeling with empirical benchmarks. It not only challenges existing accounts through novel processing data but also establishes a cognitively grounded profile of native comprehension. This profile offers a diagnostic foundation for understanding learner difficulties and supports the design of more principled pedagogical interventions.

6 Conclusion

6.1 Summary of Findings

This study, examining Mandarin wh-questions within islands through processing data, yields two key findings. First, it reveals a distinctive reading delay pattern—spanning both inside and beyond the complex wh-region—which challenges existing syntactic accounts (e.g., Huang, 1982) yet aligns with the pied-piping mechanism formalized within Labeling Theory (Fiengo et al., 1988; Chomsky, 2013, 2015). Second, it establishes a native-speaker processing profile that serves as a diagnostic benchmark for L2 pedagogy, enabling a principled understanding of learner difficulties without prescribing specific instructional methods. Together, these results advance both syntactic theory and empirically informed language teaching.

6.2 Implications

For Syntacticians: This study supplies robust empirical evidence for refining movement theory in Mandarin. The observed delay pattern—extending across and beyond wh-islands—challenges purely structural accounts while supporting analyses that incorporate pied-piping and labeling mechanisms. These results advocate for integrating processing data into formal syntactic models to develop a more psycholinguistically grounded theory of wh-dependencies.

For L2 Mandarin Learners: The findings reveal the cognitive underpinnings of processing complex wh-questions. Learners can enhance comprehension by recognizing that native-like interpretation requires integrated processing across clausal boundaries, not merely local analysis. This awareness encourages a more strategic and patient approach to parsing long-distance dependencies, facilitating progress toward native-like reading proficiency.

For L2 Mandarin Instructors: This research highlights the pedagogical value of psycholinguistic insights. Using the native processing profile as a diagnostic benchmark, instructors can design targeted, hierarchical training that develops both structural knowledge and incremental parsing skills. Such an approach supports learners in gradually attaining native-like efficiency, especially when processing syntactically complex questions.

6.3 Limitations of the Study

While this study provides meaningful insights into Mandarin wh-island processing, several limitations should be noted. First, the analysis focused primarily on complex wh-questions within islands. Future work could examine a wider range of structures—such as adjunct islands or non-island wh-dependencies—to determine whether the observed processing

patterns are configuration-specific or reflect more general mechanisms in dependency resolution.

Second, the participant sample, though adequate for an initial investigation, remains relatively small. Expanding the sample size and including a more diverse range of proficiency levels among L2 learners would enhance the generalizability and allow for more nuanced subgroup comparisons.

Third, the study relied exclusively on reading times as a behavioral index. While informative, this measure offers only an indirect view of underlying cognitive processes. Complementing such data with eye-tracking or neuroimaging methods could provide finer-grained evidence about the real-time spatial and temporal dynamics of sentence processing in these constructions.

6.4 Recommendations for Future Research

This study opens several productive avenues for future inquiry. First, comparative research could systematically examine processing across different island types—such as adjunct and complex NP islands—to test whether the observed delay pattern generalizes as a cognitive signature of island constraints. Second, real-time methodologies like eye-tracking or neuroimaging could offer finer-grained spatiotemporal evidence of the underlying processes. Third, longitudinal studies tracking L2 learners' acquisition of wh-dependencies could reveal developmental trajectories and inform timing for syntactic intervention. Lastly, pedagogical applications could be developed and evaluated—designing teaching materials that explicitly target the identified processing challenges.

In conclusion, the native processing profile established here provides an essential benchmark for both syntactic theory and language pedagogy. This work highlights that advancing formal theory and improving language education are mutually reinforcing endeavors. Impactful research must sustain a dialogue among theoretical linguistics, experimental psycholinguistics, and evidence-based teaching—bridging the gap between abstract insight and human learning.

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