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Temporal-spatial interplay in metadiscourse: mapping organizational patterns in research article rhetoric

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This study investigates interactive metadiscourse in quantitative Economics research articles across L1 Chinese, Chinese ESL, and L1 English scholars through a tripartite corpus analysis grounded in Hyland's (2005) framework. By synthesizing the cognitive discourse analysis with the contrastive rhetoric theory, the investigation uncovers how L1-based conceptual transfer mediates spatiotemporal organization in academic texts. Results demonstrate systematic rhetorical preferences and marked frequency divergences across sub-corpora, particularly in Chinese ESL writers' blending of pro-spatial discourse patterns with English pro-temporal sequencing norms. The conceptual duality of Chinese ESL writers' emerges as figure-ground alignment shifts that restructure argumentative logic in L2 texts. The research advances metadiscourse scholarship by modeling L1 cognitive imprinting on disciplinary writing and refining methodologies for the multilingual rhetoric analysis. These insights clarify cognitive constraints in the cross-linguistic knowledge production and equip researchers with diagnostic tools to trace L1 interference in the international academic communication.

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Introduction

The globalization of academic publishing has established English as the primary medium for international knowledge exchange (Hyland et al. 2016). This linguistic reality drives scholarly interest in how non-Anglophone writers negotiate rhetorical strategies in English academic writing while preserving traces of their cultural and disciplinary enculturation. Within this context, metadiscourse functions as both social-pragmatic tools and cultural-rhetorical interfaces (Mauranen, 2023) and reveals language-specific norms and culture-situated values to organize cohesive discourse as well as to engage readers. Academic writers must navigate between globally-recognized conventions and localized rhetorical traditions. And for Chinese ESL writers, the pro-spatial reasoning in Chinese academic discourse often interacts with the linear pro-temporality of English (Zhao and Wang, 2023), creating hybrid organizational patterns. The cross-cultural negotiations ultimately position metadiscourse as both a textual organizer and a cultural mediator.

The conceptual evolution of metadiscourse research has been shaped by foundational frameworks from Williams (1981) and Vande Kopple (1985), who establish its role in textual organization and audience engagement. Hyland's (2005) interpersonal-textual framework of metadiscourse advances Hallidayan systemic-functional linguistics, specifically operationalizing Thompson and Thetela's (1995) and Thompson's (2000) functional dichotomy through corpus-based lexical categorization. His taxonomy reconceptualizes metadiscourse as dual-functional resources: interactive markers scaffolding reader navigation, and interactional markers constructing authorial persona. The framework's rigorous alignment of functional categories with observable linguistic patterns has not only catalyzed the corpus-driven discourse analysis but also enabled multidimensional diagnostics of rhetorical asymmetries in cross-cultural academic exchanges, particularly in tracing epistemic positioning strategies across academic communities.

The scholarship on metadiscourse reveals a persistent disciplinary imbalance although both interactive and interactional aspects of metadiscourse are theoretically recognized as crucial for modeling textual interactions. Empirical studies disproportionately prioritize stance-oriented analyses (Jiang and Ma, 2018; Qiu and Jiang, 2021) while underrepresenting systematic investigations into text-organizing mechanisms (Li and Xu, 2020; Hyland and Jiang, 2020). Existing contrastive studies, though instrumental in identifying L1-L2 divergences in metadiscursive patterns (Mur-Dueñas, 2011; Mu et al. 2015; Wang, 2019), remain constrained by their predominant reliance on uni-dimensional frameworks that isolate linguistic or cultural variables rather than interrogating the interplay. This methodological limitation obscures the complex mediation processes through which L1 rhetorical schemata permeate L2 discourse organization.

Cross-linguistic divergences in discourse organization may originate from theoretical assumptions about temporal-spatial orientations. Wang's (2013) framework characterizes English as temporally-oriented, prioritizing verbal sequencing of actions, while Chinese is described as spatially-oriented, emphasizing chunked representations through nominalization. Previous literature has examined these contrasts through the lens of etymology (Li and Wang, 2020), syntax (Wang and Tao, 2020), and philosophy (Wang and He, 2014), yet discourse-level analyses remain sparse. The predominant focus on lexical-syntactic comparisons obscures deeper discourse-organizational strategies shaped by these orientations. Grounded in the pro-spatiality/pro-temporality continuum that characterizes Chinese and English academic rhetoric, respectively, this paper advances a bidirectional framework and tentatively answers two research questions as follows:

(1) Are there significant cross-linguistic/cross-cultural differences of interactive metadiscourse strategies in academic writing?
(2) If so, how does Chinese writers' prior discursive knowledge converge with and how is it transferred to their L2 practices in organizing the academic discourse?

Research design

This study employs mixed-methods analysis to examine interactive metadiscourse (IM) in research articles, investigating how L1 conceptual patterns influence writers' strategies for guiding readers through academic arguments.

Analytical framework. This study constructs a metadiscourse analytical framework grounded in functional linguistics and addresses the theoretical impasse stemming from tensions between functional and syntactic criteria in traditional classification systems. For instance, some existing scholarship (e.g., Crismore et al. 1993) categorizes coordinating conjunctions as metadiscourse markers while excluding subordinating conjunctions. To address such inconsistencies, this paper proposes a function-driven demarcation principle. That is, linguistic markers that fulfill either textual organization or interpersonal engagement functions should be included in the analysis, irrespective of their syntactic categories. Consider causal relationship markers such as "because" (a subordinating conjunction) and "so" (a conjunctive adverb). Though syntactically distinct, they serve equivalent cognitive-pragmatic functions in constructing argumentative logic (Martin, 1992). Syntax-centric approaches to metadiscourse categorization inherently neglect language users' agency in rhetorical choices—evident in the English "although… but" construction and the Chinese "因为…所以" (yīnwéi…suǒyǐ, because…so…) complex sentence pattern, both of which reflecting writers' intentional shaping of propositional logic.

Building on the typological characteristics of Chinese discourse, this research particularly foregrounds the centrality of topic-chain constructions in the metadiscourse analysis. Given that Chinese discourse organization fundamentally operates at the clausal level (Lv, 1979) through topic-comment progression (Chao, 1955), traditional sentence-based metadiscourse paradigms exhibit limited applicability. To bridge this gap, the current research synthesizes Hyland's (2005) functional framework with Chinese discourse analysis principles (Shen, 2012), proposing a cross-linguistically compatible analytical unit – the clause, which simultaneously accommodates English hypotactic features and Chinese paratactic tendencies (Li and Thompson 1981).

Writing demands metacognitive knowledge and skills to monitor and regulate the writing process (Hacker, 2018). IM operationalizes this relationship by making writers' organizational strategies visible. Through IM, writers connect arguments, align discourse components, situate their work within existing scholarship, and negotiate reader expectations (Hyland and Tse, 2004). This study adopts Hyland's (2005) framework to analyze IM in research articles (RAs) – a genre where these markers systematically structure arguments and mediate writer-reader interactions. Furthermore, it resorts to previous analyses (Mur-Dueñas, 2011; Cao and Hu, 2014) to make some finer distinctions and adjustments, enabling precise comparisons of how IM functions differ across cultural/linguistic contexts (as noted in Table 1).

Transitions, to start with, clarify connections between ideas and guide readers through textual logic. Following Hyland's (2005) functional approach, this paper analyzes transitions as any linguistic features that play a role internal to the discourse, and

Table 1 A scheme of analysis on IM.

Interactive Types	Sub-types	Examples
Transitions	additives	and, in addition, 同样地(similarly)
	contrastives	however, although, 反之(on the contrary)
	consequentials	hence, because, 可见(therefore)
Code glosses	reformulations	that is, namely, 即(i.e.,)
	exemplifications	such as, for example, 一个典型的例子(a typical example)
Frame markers	sequencers	first...second, 一方面...另一方面(on one hand...on the other hand)
	stage labels	thus far, to conclude, 简而言之(to summarize)
	goal announcers	seek to, my purpose is, 本文试图(this paper aims to)
	topicalisers	in terms of, as for, 必须要提及的是(notably)
Endophorics	reviewings	stated above, previously, 如前(as noted above)
	previewings	as follows, following, 在这一部分(in this section)
	visuals	table *, figure *, 本节(this section)
Evidentials	integrals	according to *, * states, 正如*提出的(as argued by *)
	non-integrals	(*, 2019), www.google.com, 参考*的方法(consistent with *)

explicitly enhance readers' interpretation of links between ideas. Therefore, transitions in this scheme include both inter-sentential coordinators (e.g., and, but, so) and intra-sentential subordinators (e.g., although, because, if). Then, transitions are further categorized into three sub-types: additives (expressing relations of addition), contrastives (expressing relations of comparison or contrast), and consequentials (expressing relations of cause-and-effect or condition-and-result).

Code glosses, the second IM main type, refine and clarify the textual content through explanation or elaboration. These markers reflect writers' ongoing evaluation of readers' background knowledge and comprehension, prompting authorial decisions about when to clarify concepts versus assume shared understanding (Hyland, 2007). Functionally, they operate through two mechanisms: reformulations (restating ideas for precision) and exemplifications (providing concrete illustrations). While reformulations (e.g., in other words) direct readers' interpretive focus, exemplifications (e.g., for instance) ground abstract claims in tangible evidence—both bridging the gap between authorial intent and readers' comprehension.

Frame markers, the third IM main type, structurally organize arguments through four sub-type strategies: (1) sequencers establish stepwise progression (e.g., first, next); (2) stage labels demarcate discourse phases (e.g., to summarize, in conclusion); (3) goal announcers signal research objectives (e.g., we aim to); and (4) topicalisers redirect discussion flow (e.g., regarding, turning to). These devices scaffold textual navigation by making conceptual architecture explicit—sequencing ideas temporally, labeling analytical milestones, foregrounding purposes, and managing thematic transitions to optimize reader orientation.

Endophoric markers, the fourth IM main type, create internal text cohesion by cross-referencing content across sections or visual elements (Gai and Wang, 2022). These devices signal authorial evaluation of readers' navigational needs, forging connections between arguments through reviewing markers (e.g., as noted earlier), previewing markers (e.g., discussed below), and visual markers (e.g., see Table X). By strategically directing attention to critical data or logical devices such as appendices, figures, methodological footnotes, they synchronize reader interpretation with textual architecture and ensure complex arguments remain accessible without redundant explanation.

Finally, evidentials strategically integrate external knowledge through citations or attributions (Hyland and Jiang, 2018). These markers serve the purpose of validating arguments through expert consensus, establishing authorial credibility via disciplinary alignment, and demonstrating adherence to academic norms. Extending Swales' (1990) taxonomy, the current scheme differentiates integral citations—where sources shape sentence syntax (e.g., *Smith (1989) argues…*)—from non-integral citations that compartmentalize references (e.g., *(Smith, 1989)*). The former embeds sources as active argumentative agents while the latter separates evidence presentation from the argument flow. This dichotomy reflects competing discursive strategies for negotiating original contributions within disciplinary epistemic boundaries.

Corpus construction. The corpus selection process implemented a three-tier control mechanism to ensure methodological rigor. Firstly, adhering to Moreno's (2008) cross-cultural comparability criteria, dynamic comparability was established among three sub-corpora in terms of disciplinary prestige, journal impact factors, and authorial academic standing. Among them, sub-corpus 1 (S1) consisted of 50 Chinese-medium RAs authored by L1 Chinese scholars in Chinese Social Sciences Citation Index (CSSCI) Economics journals (618,230 words). Sub-corpus 2 (S2) was composed of 50 English-medium RAs produced by Chinese ESL scholars (514,742 words). Sub-corpus 3 (S3) was comprised of 50 English-medium RAs (683,058 words) authored by English L1 scholars. All English-medium RAs were selected from Social Sciences Citation Index (SSCI) Economics journals. Following established methodology (Mu et al. 2015), S1 and S2 authors were affiliated with mainland Chinese institutions and displayed Mandarin naming patterns. Similarly, S3 authors represented Anglophone institutions in the US/UK with characteristic English naming conventions. Researchers' L1 was verified through institutional profiles and email communication, with consistent application of this protocol across all sub-corpora. Compiling S2 and S3 proved particularly challenging given varied co-author language profiles. To maintain consistency, S1/S2 excluded articles containing co-authors from non-target linguistic backgrounds, while S3 removed studies with non-Anglophone collaborators.

Secondly, strict inclusion criteria for quantitative research paradigms were implemented to systematically exclude qualitative or mixed-methods studies that might introduce confounding variables. Adherence to established structural frameworks (IMRAD/IMLRAD; Lin and Evans, 2012) was confirmed through systematic methodology section verification.

Finally, temporal homogeneity was ensured by exclusively including RAs published between 2014 and 2017. This temporal control, combined with the exclusive focus on quantitative Economics studies, mitigates potential metadiscourse variations arising from cross-disciplinary differences (Cao and Hu, 2014).

Notably, quantitative Economics RAs were chosen basically due to the strong grammar involved (Bernstein, 2000). This applied soft science uniquely combines analytical rigor from hard disciplines with interpretive flexibility characteristic of soft sciences (Becher, 1994).

This study centered on Chinese scholars' English academic writing practices and conducted a tripartite comparative analysis of IM strategies. The methodological configuration incorporated two baseline sub-corpora: S1 to capture Chinese discursive patterns and S3 to represent Anglophone disciplinary norms. This design enabled simultaneous examination of cross-linguistic transfer through S1-S2 comparison and cross-cultural adaptation via S2-S3 contrast. Following established corpus compilation protocols in metadiscursive studies, full-length of original RAs were extracted from the selected journals with non-analytical components (titles, abstracts, authorial information, section headings, tables, figures, quotations, references, and acknowledgments) systematically excluded.

Data collection and analysis. Three independent raters, who were PhD students majoring in applied linguistics, participated systematic coder training, which included workshops on IM feature categorization, practice trials using sample texts from excluded RAs, and regular discussions to resolve coding disagreements. After initial independent annotation of 15 stratified RA samples (5 per sub-corpus), Cohen's κ (Cohen et al. 2018) was measured, with scores demonstrating substantial agreement for all categories ($M = 0.87$, range = 0.72–1.0). Cases with lower agreement underwent blind review by an independent expert to finalize coding rules. Then, the whole corpus was manually annotated in Microsoft Word. All IM features were encoded in their contexts, and established criteria throughout the annotation were carried out correspondingly in the three sub-corpora. Quality checks involved random 10% sample reviews, ongoing codebook updates, and group consultations for unclear cases. Frequency comparisons used normalized word counts (per 1000 words) with log-likelihood and χ^2 tests at three significance levels ($p < 0.05$, $p < 0.01$, $p < 0.001$). Finally, textual functions of these devices were qualitatively analyzed.

Results

Table 2 demonstrates consistent distribution patterns of IM main-types across the three sub-corpora, reflecting stable disciplinary norms in Economics RAs. Transitions dominate all IM main-types, followed sequentially by code glosses, endophoric markers, evidentials, and frame markers consistently across the sub-corpora. Statistically significant differences emerge between sub-corpora ($p < 0.001$), with chi-square tests revealing stark contrasts: S1-S2 = 5948.21 vs. S2-S3 = 17.20. Chinese ESL writers use substantially more IM devices than Chinese L1 writers, yet still fewer than English L1 writers. This L1 Chinese < ESL Chinese < L1 English pattern indicates measurable L1 rhetorical transfer. Chinese ESL writers systematically adapt native discourse strategies when constructing L2 academic arguments, and they blend L1 conventions with target language expectations.

Transitions. Normalized transition frequencies per 1,000 words starkly differentiate sub-corpora: S1 at 117.56, S2 at 237.05, and S3 at 268.44 ($p < 0.001$). Cross-linguistic divergence (S1-S2: $\chi^2 = 2374.44$) far exceeds cross-cultural variance (S2-S3: $\chi^2 = 116.41$), signaling Chinese ESL writers' rhetorical convergence toward L1 English norms. Sub-type frequencies words reveal systematic patterns: additives occur at 4.461 (S1), 10.803 (S2), and 11.514 (S3); contrastives at 3.174 (S1), 4.880 (S2), and 5.774 (S3); and consequentials at 4.121 (S1), 8.021 (S2), and 9.556 (S3). All inter-subcorpus differences are statistically significant ($p < 0.001$). Chi-square tests validate stronger cross-linguistic effects than cross-cultural ones on both progressive argumentation (additives) ($\chi^2 = 1550.13$ vs. 13.39) and retrogressive patterns (contrastives + consequentials) ($\chi^2 = 937.20$ vs. 122.10). Despite these variations, all sub-corpora share a unified IM hierarchy: additives > consequentials > contrastives. These findings empirically demonstrate Chinese ESL scholars' dual rhetorical adaptation, which is characterized by systematic retention of

Table 2 Cross-linguistic and cross-cultural statistics for IM.

Main-types	sub-types	S1		vs.	S2		vs.	S3	
		raw no.	1t	p-value	raw no.	1t	p-value	raw no.	1t
Transitions	additives	2758	4.461	<0.001	5561	10.803	<0.001	7865	11.514
	contrastives	1962	3.174	<0.001	2512	4.880	<0.001	3944	5.774
	consequentials	2548	4.121	<0.001	4129	8.021	<0.001	6527	9.556
	total	7268	11.756	<0.001	12,202	23.705	<0.001	18,336	26.844
Code glosses	reformulations	3613	5.844	<0.001	5987	11.631	<0.001	8477	12.410
	exemplifications	321	0.519	<0.001	1028	1.997	0.008	1219	1.785
	total	3934	6.363	<0.001	7015	13.628	0.009	9696	14.195
Frame markers	sequencers	601	0.972	<0.001	790	1.535	0.152	979	1.433
	stage labels	72	0.116	<0.001	169	0.328	<0.001	330	0.483
	goal announcers	16	0.026	<0.001	41	0.080	0.003	26	0.038
	topicalisers	695	1.124	<0.001	738	1.434	0.032	880	1.288
	total	1384	2.239	<0.001	1738	3.376	0.207	2215	3.243
Endophorics	reviewings	431	0.697	<0.001	474	0.921	<0.001	497	0.728
	previewings	439	0.710	<0.001	647	1.257	0.005	737	1.079
	visuals	2776	4.490	<0.001	4892	9.504	0.014	6797	9.951
	total	3646	5.897	<0.001	6013	11.682	0.703	8031	11.757
Evidentials	integrals	679	1.098	<0.001	1031	2.003	<0.001	1022	1.496
	non-integrals	1281	2.072	<0.001	2311	4.490	<0.001	2162	3.165
	total	1960	3.170	<0.001	3342	6.493	<0.001	3184	4.661
	TOTAL	18,192	29.426	<0.001	30310	58.884	<0.001	41462	60.701

Data in the table include actual counts (raw no.) and normalized frequency per 1000 words (1t).

L1 pro-spatial discourse strategies alongside strategic alignment with L2 disciplinary conventions.

(1a) … surplus dissipates *not only* due to …, *but also* due to … (S3-29)

(1b) Returns to owning a ship are …, *but also* predictable. (S3-33)

The text analysis shows that additives facilitate disciplinary identity negotiation within shared epistemological frameworks. As exemplified in (1a), the negated information marked with "not only" anchors disciplinary common ground to activate readers' schemata, while the "but also" part introduces novel claims, creating cognitive potential differentials. This gradient construction essentially constitutes a cognitive process of identity negotiation in which writers extend disciplinary frontiers by building upon established consensus. In contrast, the prevalent standalone "but also" usage (as in (1b)) reveals an alternative cognitive strategy. When front-clause presuppositions are omitted, writers coercively reconstruct readers' interpretive pathways through the unilateral novelty emphasis. While this approach risks perceptions of informational incompleteness, it effectively intensifies claims to scholarly originality.

(2a) *While* much of …, the foregone savings is … (S3-30)

(2b) A standard …, *even if* interest rates … (S3-30)

Contrastive markers similarly function through a dual-phase rhetorical strategy. Writers first establish consensus with readers by grounding arguments in shared disciplinary knowledge within the concessive clauses, and then strategically introduce propositions that subvert anticipated expectations. Within the founding-defeating process of readers' expectations (as in (2a)), the contrastive marker "while" positions unexpected information early in the syntactic structure, priming readers for paradigm-challenging claims through cognitive pre-framing. In clear contrast, "even if" in (2b) reveals concession in the latter part of the sentence for the sake of propositional precision, where the consensus seems to be less effective as readers encounter unexpected claims without adequate schematic scaffolding. As such, this paper proposes that information in (2b) is presented in a somewhat defeating-founding way although one might refute that founding usually occurs prior to defeating.

(3) *Thus*, before turning to …, we first consider … (S3-33)

Consequentials suggest authorial judgment over the shared knowledge of an academic community. As shown in (3), "thus" guides readers through procedural logic, demonstrating why specific methodological steps logically follow prior actions. Conclusions drawn through consequentials rely heavily on writers' disciplinary expertise, which inherently blurs lines between factual evidence and interpretive claims. When writers frame propositions through these markers, the persuasive force of disciplinary conventions makes readers less likely to doubt about the objectiveness of propositions. Namely, the cognition-directing power of consequentials embeds arguments with authoritative logic, which resists critical scrutiny.

Code glosses. Code glosses exhibit significant hierarchical disparities in their distribution across the sub-corpora (S3: 14.195 > S2: 13.628 > S1: 6.363 tokens per 1000 words), with the cross-linguistic differences ($\chi^2 = 1548.95$) substantially surpassing cross-cultural variations ($\chi^2 = 6.86$). This suggests a stronger emphasis among English academic writers on propositional precision and scope generalization in scholarly communication.

Reformulations, a code gloss sub-type, prevail across sub-corpora, reflecting the distinctive cognitive architecture of RAs under investigation. They occur at frequencies of 5.84, 11.63, and 12.41 tokens per 1,000 words in S1, S2, and S3, respectively. As illustrated in (4a), these markers primarily introduce explanatory elaborations of preceding discourse units, whereas (4b)

demonstrates their role in propositional scope restriction through semantic rephrasing. Notably, formulaic epistemic frames (e.g., this means that, suggesting that) exhibit atypical distribution patterns in Chinese ESL writing, with S2 showing marked overuse (0.870/1000 words) compared to S1 (0.710) and S3 (0.586) ($p < 0.001$). This overreliance correlates with ambiguous anaphoric references of "this" (Moreno, 1997), reflecting both strategic text navigation and writers' heightened awareness of reader adaptation. While serving to clarify propositions for international readership, these structures simultaneously project writers' implicit epistemic identities through controlled discourse progression.

(4a) *In other words*, … (S3-14)

(4b) The results include … (*i.e.*, exclude participants with …). (S3-14)

Whereas reformulations optimize informational accessibility through multidimensional semantic processing, exemplifications either provide the previous propositions with specific examples (as in (5a)), or illustrate abstract propositions with more accessible instances (as in (5b)), or elaborate writers' statements with typical instances of the proposed ideas among many others (as in (5c)).

(5a) … a series of measures (*e.g.*, industrial restructuring, …) … (S2-28)

(5b) … offshore havens *such as* the British Virgin … (S3-36)

(5c) … using cross-country data (*e.g.*, Limao and Venables, 2001) … (S3-16)

Frame markers. The density of frame markers across the sub-corpora demonstrates a statistically significant lower occurrence compared to the other four categories of IM, with standardized frequencies recorded as S1: 2.239, S2: 3.376, and S3: 3.243 tokens per 1,000 words. Notably, while S2-S3 frequency discrepancy fails to attain statistical significance ($p = 0.207$), the inter-group variations in S1-S3 and S1-S2 manifest highly-significant differences ($p < 0.001$). This phenomenon finds theoretical grounding in linguistic typology. The linear cognitive patterning of English, conceptualized as a temporally-anchored language (Wang, 2013), interacts reciprocally with the organizational properties of frame markers. Such structural congruence ultimately manifests in elevated frequency patterns within English academic discourse.

As with the densities of the sub-types, frequencies of sequencers reveal distinct patterns across sub-corpora. While no significant difference exists between S2 and S3 ($p = 0.152$), S1 demonstrates a markedly-higher frequency compared to S2 ($p < 0.001$). Functionally, sequencers serve dual purposes by connecting discourse units sequentially and structuring arguments. These operational units differ in scope: phrase/clause-level connections dominate in S2 and S3, whereas S1 primarily employs clause/sentence-level linkages. Specifically in introduction sections, sequencers systematically clarify complex prior studies by disentangling theoretical frameworks and methodological approaches (e.g., (6a)). In discussion sections, they either delineate potential sources of observed differences (e.g., (6b)), or specify solution pathways for identified issues (e.g., (6c)).

(6a) … to reproduce two patterns observed in most present-day settings: (1) … and (2) … (S3-8)

(6b) The difference in results has three likely sources. *First*, … *Second*, … *Third*, …(S3-8)

(6c) Turning these insights toward … *First*, I extract … *Second*, I adopt … (S3-7)

(7a) … and that, *for now*, is assumed to be … (S3-26)

(7b) *Above all*, we confirm … (S2-20)

(7c) The results *so far* suggest that … This section delves into … (S3-8)

Then, statistical analysis reveals significant stage label variations across sub-corpora. All frequency differences reach the 0.1% significance level, though the S2-S3 discrepancy ($\chi^2 = 16.89$) proves substantially smaller than the S1-S2 contrast ($\chi^2 = 59.28$). Labeling discourse stages or the stages of discourse development, these features are able to set conditions for proposition (e.g., (7a)), bring in conclusions (e.g., (7b)), and summarize ideas or point out limitation (e.g., (7c)).

(8) *This article seeks to* fill that gap by … (S3-8)

Goal announcers exhibit notably low frequencies across the sub-corpora, with normalized rates of 0.026 (S1), 0.080 (S2), and 0.038 (S3) tokens per 1000 words. These values position them as the least frequent IM sub-type. Statistical analyses confirm significant cross-cultural ($p = 0.003$) and cross-linguistic ($p < 0.001$) variations, indicating Chinese ESL writers' heightened reliance on this feature. The textual analysis shows that these devices primarily frame research objectives at section openings by defining purposes, contextualizing studies, and demarcating scope to meet disciplinary norms (Bondi, 2010). As shown in (8), they can bridge research gaps by aligning investigation goals with previously-identified academic needs.

(9) 这一点, 在……中得到了验证。(S1-7)

[*(For) this point*, it is proved in …]

Finally, topicalisers show statistically significant frequency variations both cross-culturally ($p = 0.032$) and cross-linguistically ($p < 0.001$), with particularly marked overuse observed in S2. This pattern can be attributed to the fact that Chinese allows implicit topic presentation without explicit markers, whereas English translations often require prepositional cues like "for" (see (9)). Analytical evidence confirms that these markers indicate topic shifts by introducing, changing or resuming a topic, and hence implicitly organize the text.

Endophoric markers. Quantitative analysis reveals significant differences in endophoric marker density across the sub-corpora, with English texts (S2: 11.682; S3: 11.757 tokens per 1000 words) demonstrating over twice the frequency of Chinese texts (S1: 5.897). While S2-S3 comparisons show minimal variation ($\chi^2 = 0.15$, $p = 0.703$), cross-linguistic contrasts exhibit extreme significance ($\chi^2 = 1111.72$, $p < 0.001$). Sub-type analyses further indicate patterned distributions: reviewing markers occur at 0.697 (S1), 0.921 (S2), and 0.728 (S3) tokens per 1000 words (all pairwise $p < 0.001$); previewing markers display progressive increases from 0.710 (S1) to 1.257 (S2) and 1.079 (S3), with S1-S2 ($p < 0.001$) and S2-S3 ($p = 0.0045$) significant differences; and visual markers escalate sharply from 4.490 (S1) to 9.504 (S2) and 9.951 (S3), showing significant inter-group differences (S1-S2: $p < 0.001$; S2-S3: $p = 0.014$). Generally, the current corpus displays disciplinary patterns of both soft and hard fields in the usage of endophoric markers. Soft-field texts strategically guide argument acceptance through integrated textual evidence. Conversely, hard-field writing prioritizes referential precision via systematic links to conceptual frameworks or adjacent visual elements like tables/figures.

(10) *Before turning to* …, we focus first on… (S2-18)

Textual analysis reveals that reviewing/previewing markers systematically contextualize the prior topic, the present topic and the next topic in the same picture, or lead the current topic to a new one. Namely, these linguistic devices can maintain topic continuity across temporal dimensions on one hand, and enable controlled thematic transitions on the other. As illustrated by (10), when "before turning to" previews a new topic, writers strategically establish the immediate context by explicitly stating research focus points.

(11) Table 1 reports … (S3-26)

Then, visuals not only convert textual information into graphic formats but also provide substantive data to enhance comprehension. When integrated with textual components (see (11)), these visual-verbal hybrids engage in the dynamic interplay with both the discourse and the readers, offering diagrammatic representations that reinforce propositions through methodological neutrality and empirical objectivity.

A notable distinction emerges in S1's preferential use of nominal references (such as this paper, this study, this research) when self-referencing research activities. The quantitative analysis reveals marked frequency disparities: 1.676 (S1) vs. 1.358 (S2) vs. 0.673 (S3) per 1000 words ($p < 0.001$) in sharp contrast with the visual/endophoric marker distributions. Notably, the S1-S2 variance ($\chi^2 = 18.55$) proves substantially smaller than the S2-S3 divergence ($\chi^2 = 142.28$), suggesting strong L1 Chinese rhetorical transfer in S2. Chinese writers tend to provide alternative interpretations to pre-exempt potential refutation against the proposed conclusions. Moreover, these visuals constitute an indirect self-positioning mechanism that contrasts with British-American conventions of explicit authorial presence through first-person pronouns.

Evidentials. Table 2 reveals stark contrasts in the density of evidential markers: English corpora (S2: 6.493; S3: 4.661 tokens per 1000 words) significantly exceed Chinese texts (S1: 3.170). The cross-linguistic divergence ($\chi^2 = 665.57$) triples the cross-cultural variation ($\chi^2 = 181.65$), reflecting standardized argumentation norms of the global academia. Sub-type analyses demonstrate systematic impersonality: non-integral citations (S1:2.072; S2:4.490; S3:3.165) consistently surpass integral citations (S1:1.098; S2:2.003; S3:1.496). Integral forms emphasize cited authors via subject positioning, which demonstrates stronger S1-S2 divergence ($\chi^2 = 152.53$) than S2-S3 ($\chi^2 = 44.05$). Non-integral contrasts follow similar patterns, with S1-S2 $\chi^2 = 519.45$ dwarfing S2-S3 $\chi^2 = 138.40$ (both $p < 0.001$).

Evidential markers strategically enhance academic credibility by positioning writers as domain experts through evidence-based discourse. (12a)-(12d) respectively exemplify the rhetorical functions of these markers in terms of *reference*, *evaluation*, *elaboration*, and *alignment with current research objectives*. Example (12d) specifically illustrates how integral citations identify unresolved research gaps, systematically contrast previous findings with the current work, and emphasize original contributions of authorial findings.

(12a) … are conducted by *Zhu, Xu, and Lundin (2006) and Boeing (2014)*, who respectively … (S2-43)

(12b) According to *David, Hall, and Toole (2000)*, studies before 2000 … (S2-43)

(12c) … have also been found. For instance, *Zhu et al. (2006)* …; *Goerg and Strobl (2007)*… (S2-43)

(12d) *Hu and Jefferson (2009)* find … *Dang and Motohashi (2015)* argue … (S3-33)

General comparison of IM across sub-corpora. Figures 1–2 illustrate IM variation patterns across linguistic and cultural dimensions. The term "model" here captures discipline-specific discourse construction dynamics with inherent cross-linguistic/cultural divergences. The quantitative analysis establishes three core patterns: English texts (S2/S3) consistently surpass Chinese texts (S1) in the IM frequency, S3 significantly exceeds S2 across most measures, and Chinese ESL writers exhibit L1-based transfer in using IM strategies. This divergence originates from fundamentally distinct reader engagement paradigms. British-American scholars systematically calibrate text interpretations and writer-reader positioning through precise IM deployment,
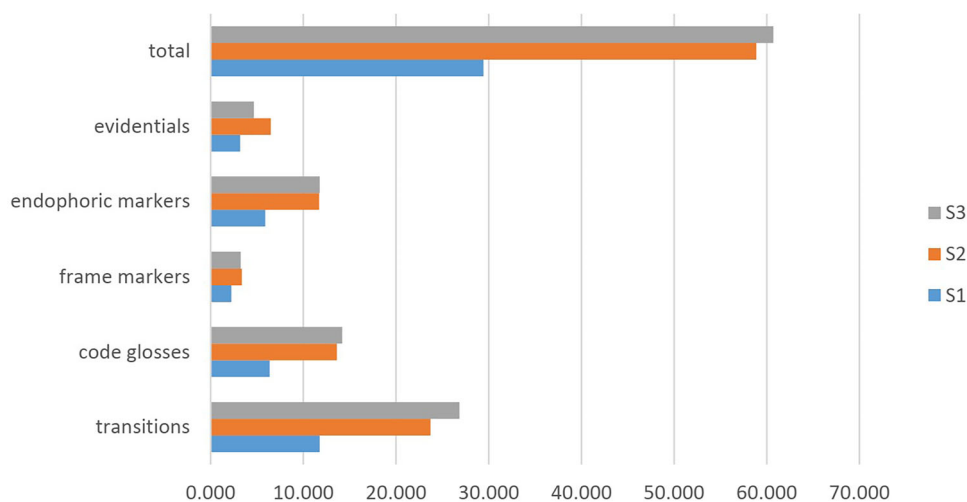
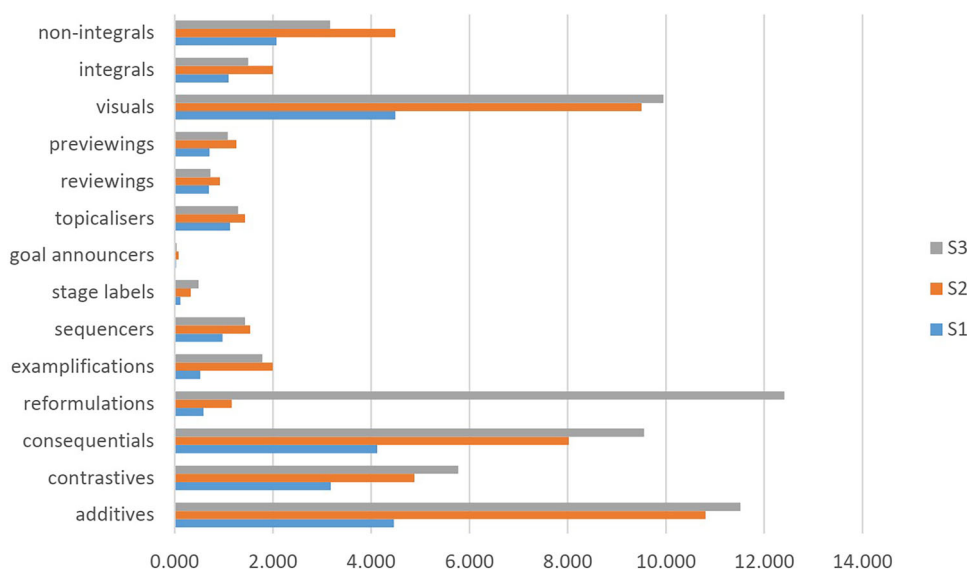**Fig. 1** IM gaps by language and culture based on main types (per 1000 words).

Fig. 2 IM gaps by language and culture based on sub-types (per 1000 words).

while Chinese academics demonstrate divergent assumptions about readers' comprehension capacities, which is evidenced by the substantial cross-linguistic versus cross-cultural contrasts.

Discussion

The observed discursive transfer patterns of Chinese ESL writers partly result from divergent academic conventions across linguistic communities, particularly evident in endophoric and evidential marker usages. As for the former, quantitative evidence demonstrates cross-linguistic variance significantly outweighs cross-cultural differences, principally attributable to institutionalized demands for multimodal argumentation frameworks in British-American academia (Biber, 2006). Chinese ESL scholars' marked overuse of referential devices—particularly preview/review markers and third-person nominalizations (e.g., *this study*) —reveals cognitive interface friction between L1 rhetorical schemata and L2 disciplinary expectations. As for the latter, the overuse of evidential markers by Chinese ESL writers reflects a dual transfer mechanism: preserving Chinese authoritative citation traditions via integral evidentials while adopting non-integral formats to align with international norms. This strategic blending creates 140% higher intertextual density in S2 compared to native

English benchmarks, paradoxically reducing authorial visibility. This credibility construction pattern—combining hypertextual documentation with minimized personal presence – engenders what might be termed *rhetorical identity dissonance* as writers navigate conflicting validation systems.

Beyond cultural memes and institutional norms, this analysis incorporates writers' L1 discursive conceptualization processes when examining discourse-level transfer mechanisms. Investigating how these frameworks shape conceptual discourse transfer patterns, the study subsequently examines the cognitive underpinnings of cross-linguistic influence in IM through two lenses: (1) Chinese spatial versus English temporal orientations; and (2) figure-ground theory and trajector-landmark theory.

Pro-spatiality trait of chinese and pro-temporality trait of English. Building on Wang's (2013) spatiotemporal linguistic typology, this study extends the pro-spatiality/pro-temporality framework to discourse-level analysis by proposing that Chinese ESL writers' discursive transfer stems from entrenched pro-spatial cognitive schemata. This cognitive influence becomes observable in how clause structures and their logical sequencing in L2 writing systematically align with two contrasting organizational

principles, where Chinese pro-spatial holism prioritizes contextual embedding, contrasting sharply with English pro-temporal linearity that foregrounds sequential progression via sustained syntactic connectivity..

(13) ①我国利率工具∅尚未形成市场化机制, ②∅依然处于利率管制状态,   ③中央银行给出对应于不同期限的基准利率, ④而实际交易利率的确定往往是在中央银行基准利率基础上进行一定幅度的上浮或下降。(S1-21)

[*①Interest rate instruments in our country∅ have not developed into marketized operational mechanism, ②∅ are still in the state of interest rate control, ③the central bank provides benchmark interest rate corresponding to different prescribed limits of time, ④but the effective real interest rate is usually decided based on the central bank's benchmark interest rate with an increase or a decrease to a certain degree.]

[Interest rate instruments in our country have not developed into marketized operational mechanism, but rather are in the state of interest rate control, and the central bank provides benchmark interest rate corresponding to different prescribed limits of time, but the effective real interest rate is usually decided based on the central bank's benchmark interest rate with an increase or a decrease to a certain degree.]

Cross-linguistic encoding divergences emerge most saliently in transitions. Grammatical necessities (e.g., and, further) in English contrast with optional explicit/implicit additives between clauses in Chinese. Chinese run-on sentences differ fundamentally from English complex sentences in structure and organization. As core discourse units, Chinese clauses exhibit flexible configurations with frequent multi-clause stacking, typically arranged in chunk-like segments where many lack full syntactic formation as SVO constructs (Xu, 2001). For example, in (13), clauses ①③④ maintain SVO structures while ② employs verb-phrase construction with zero anaphora. This structural pattern manifests pro-spatial discourse characteristics—discrete, chunk-based units with loose interconnections (Wang, 2018). The topic-chain permits clause accumulation without syntactic uniformity (Shen, 2012), yielding extended run-on structures. In contrast, their English translations employ fully-formed SVO clauses connected through conjunctions (but rather, and, but), maintaining equivalent information through tight inter-clausal linkages and discourse continuity.

The cross-corpus divergence in contrastive/consequential markers largely originates from the pro-spatial characteristics of Chinese discourse, too. Logical connectors (e.g., however, thus) signal writers' perceived need to explicitly denote argument relationships. However, the chunk-based organization of Chinese topic-chains disperses logical explicitness requirements, operating on the premise that readers infer relationships through thematic cohesion rather than authorial signaling. As illustrated in (14), the outcome (couldn't be counted as…) is drawn from the analysis in the previous clause (the investment and consumption data … are significantly different from…). The implicit consequential link decreases syntactic obligations while increasing interpretive demands on the readers.

(14) ……如果消费支出……, 那么……的投资支出……。基于……, 我们认为……投资和消费数据……相差甚远, 不宜作为……。(S1-28)

[*… if the consumption expenditure …, then the investment expenditure … According to …, we believe that the investment and consumption data … are significantly different from…, couldn't be counted as …]

Analogously, Chinese L1 writers often restate propositions with discreteness and chunkiness of topic-chains rather than explicit code glosses. As exemplified in (15), "in addition to … value-retained products" holds the same proposition as "many people would … increasing values". The proposition maintains

coherence through topic-chain spatiality (i.e., "house") despite lacking overt markers like "that is" or "in fact". This absence reflects Chinese discourse organization via thematic spatial connections rather than metadiscursive signaling, where chunked topic-chains enable propositional reiteration through implicit lexical networks instead of explicit paraphrastic devices.

(15) ……住房除了居住功能外, 还是一种抗通胀能力强、保值率高的产品, 许多人会在住、用的同时将房屋视为财富保值增值的工具。(S1-49)

[*… in addition to being lived in, houses are highly inflation-protected and value-retained products; many people would live in the houses when taking them as means of preserving and increasing values.]

A distinctive instance of Chinese pro-spatial discourse organization surfaces in the formulaic this-constructions (e.g., this implicates). As revealed in 3.2, Chinese writers employ such deixis with significantly higher frequencies than British-American counterparts. Crucially, these context-bound anaphors diverge from prototypical NP-based reference systems, and the demonstrative "this" indexes not lexical antecedents but propositionally-structured textual spans, anchoring subsequent discourse within multi-propositional thematic frameworks. Prior extended text sections act as conceptual foundations for current topics, which are akin to the mental imagery rather than linear sequences.

To recap, Chinese discourse prioritizes spatial-semantic clustering over explicit connectives and frequently organizes clauses through the implicit conceptual alignment. English conversely employs formalized syntactic devices to establish linear progression, demonstrating temporally-sequenced connectivity. These fundamental divergences explain Chinese chunk-based segmentation versus English sustained inter-clausal linkage. Chinese ESL writers' rhetorical transfer manifests L1 spatial-cognitive schemata that influence L2 textual architecture, particularly evident in reduced explicit connectivity markers and thematic chunking patterns.

Figure-ground shifts in Chinese and English discourse. Cognitive linguistics frequently associates cognitive prominence with the figure-ground distinction. Talmy (2000) characterizes the figure as a mobile or conceptually-displaceable entity whose spatial parameters require contextual determination, while he defines the ground as the referential framework enabling such parameterization. Sentence-initial thematic elements typically assume figural status through positional prominence, with subsequent constituents functioning as grounding elements—a pattern Evans and Green (2006) correlate with visual scene organization across languages. The observed tendency among Chinese ESL writers to minimize explicit logical connectives reflects cognitive transfer mechanisms, wherein L1-based conceptualization patterns persist in their international academic practice. This cross-linguistic influence operates through figure-ground realignment processes that underlie spatial-temporal conceptual mapping variations between language systems.

Figure-ground relations demonstrate dynamic interchangeability and reversibility across cognitive perspectives. This study proposes that English predominantly exhibits such shifts at inter-sentential levels, whereas Chinese permits both inter- and intra-sentential realignment. As illustrated in (16a), "variety bias" transitions from ground to figure through sequential clauses, demonstrating cross-sentential transformation. Conversely, "rigid demand" in (16b) illustrates intra-sentential ground-figure-ground progression within Chinese multi-clausal structures, reflecting its syntactic flexibility. Notably, what is more frequently found in S1 is not cross-clausal figure-ground shifts, but the co-existence of multiple figure-ground pairs within the same

sentence with/without transitions. (16c) exemplifies this pattern, clustering five distinct figures (*the stock market in our country, the number of listed companies, the amount of stock financing in 2011, the market capitalization*, and *the valid stock accounts*) with only one transition marker "也" (*yě, also*) as the connective. Comparatively, as plotted in (16d), figure co-existence (*the role - it - the limited role - it*) entails explicit transition markers (*and, further*) in English.

(16a) … is variety bias. Variety biases arise because … (S3-17)

(16b) ……金融危机同时引发了更大规模的新增刚性需求，因为尚未买房的刚性购房者并不关心资产价格的波动， 退出的投资性需求与新增的刚性需求形成对冲…… (S1-21)

[*… but at the same time, the financial crisis triggers new larger-scaled rigid demand because the purchasers with rigid demand who have not bought houses don't care much about the changes in housing prices, the decrease of investment demand clashes with the increase of new rigid demand …]

(16c) 自……以来, 我国股票市场发展迅速, 上市公司数量已从……增加到 ……, **2011年**的股票筹资额比1991年增加了……, 市价总值也从……增至……, 有效股票投资账户更是高达……。(S1-33)

[*Since …, the stock market in our country has been developing fast, the number of listed companies rises from … to …, the amount of stock financing in 2011 is … as much as that in 1999, also, the market capitalization rises from … to …, the valid stock accounts is as high as …]

(16d) Second, we examine the role of… and find it to be very limited. The limited role is shown …; further, it is shown … (S2-8)

The pro-spatial configuration of Chinese topic-chains permits both explicit and implicit figural realization. As demonstrated in (17a). The initial clause establishes "investment…by expenditure method" as an explicit figure through topicalization, while the subsequent clause reduces it to an implicit figure Ø without a precedent connector, which stays recognizable because of cohesive topic-chain dynamics achieved by the integrated zero-anaphora. It contrasts sharply with English discourse patterns exemplified in (17b), where implicit figure maintenance (*the model*) necessitates obligatory connective markers (*and*) even within the identical topic-chain.

(17a) ……我们认为中国支出法核算**GDP**构成中的投资和消费数据及其相应的比例关系Ø与真实情况相差甚远，Ø不宜作为……的依据。(S1-28)

[*… we believe that the investment and consumption data and the corresponding percentage in GDP by expenditure method Ø are significantly different from the reality, Ø couldn't be counted as the foundation of …]

(17b) The modelØ accounts for …, and Ø allows for … (S3-21)

Comparative analyses demonstrate Chinese achieves figure continuity through spatial zero-anaphora, contrasting with English dependence on explicit grammatical markers for conceptual persistence. English typically aligns sentential subjects with discourse topics, maintaining *cohesion* through nominal/pronominal anaphora or intermediate connectives. Chinese, conversely, distinguishes subject-topic referentiality, employing pro-spatial figure-ground configurations within/between topic-chains as *coherence* mechanisms alongside IM connectors. Consequently, Chinese ESL writers exhibit L1-based figure-ground transfer patterns, deploying substantially fewer IM markers in English communication than native conventions require.

English demonstrates verb-centered conceptualization contrasting with Chinese noun-oriented patterning (Wang, 2013). Langacker (1986) distinguishes nominal units as thing-designating structures versus verbal units as process-denoting systems. Grounded clauses in his framework instantiate temporally-anchored process realizations, characterized by spatiotemporal engagement with dynamic entities. Such processes constitute cognitive domains where moving objects traverse conceptual pathways, forming sequentially arrayed relational configurations within temporal frameworks. Verbal conceptualization thus manifests as a moving imagery, rendering English discourse fundamentally structured through temporal imagery connections. That's why Fig. 3 describes the conceptualization of English clauses as playing a movie, in which films depicted with trajector-landmark[1] (TL) (Langacker, 1987) are displayed frame by frame, i.e., successively and linearly. This horizontal trajector-landmark alignment across clauses reinforces temporally driven logical connections, necessitating frequent intermediate connectives to maintain coherence through linear progression.

By contrast, Chinese discourse organization prioritizes topicalization through nominalization and pro-spatial orientation. Its connective mechanism approximates cognitive *stage models*, as visualized in Fig. 3, where readers are motivated to organize the perceived situations into different settings which are filled by inter-related participants and depicted with TL schemata of particular events/actions. These components may correlate with counterparts in adjacent settings through three types of relational shifts: (1) TL pattern replication, (2) novel TL formation, or (3) trajector-landmark role inversion between settings. Spatial coherence emerges through multi-planar TL realignments rather than linear inter-clausal connections, requiring no additional bridging mechanisms. Temporal sequencing arises secondarily through participant interactions that generate event sequences, contrasting with English temporally-driven progression. The pro-spatial construal principle enables Chinese writers to maintain discourse coherence through implicit TL shifts rather than explicit sequential markers.

Theoretical-pedagogical interface in ESL rhetorical adaptation. The spatiotemporal cognitive shifts underlying metadiscourse deployment in Chinese ESL academic writing reveal critical pedagogical implications. The above findings demonstrate that Chinese scholars' systematic underutilization of temporal organizational markers compared to their British-American counterparts stems fundamentally from the deep-rooted pro-spatial thinking patterns in Chinese rhetorical traditions. To bridge this gap, the disciplinary writing instruction should incorporate cognitive interface calibration modules that explicitly contrast Chinese pro-spatial conceptual mapping with English pro-temporal linear progression patterns. Drawing from Connor's (1996) contrastive rhetoric framework, such training could employ parallel text analyses to help learners adapt their pro-spatial mental models through temporalization exercises such as converting concept maps into linear procedural diagrams. AI writing tools may enhance this process by visually mapping temporal coherence gaps.

This study proposes three-phase intervention to operationalize Flowerdew's (2005) corpus-based genre pedagogy through spatiotemporal cognitive lenses. Phase I engages learners in rhetorical archeology tasks. They are instructed to dissect British-American scholars' temporal argument structures using disciplinary corpora. Phase II implements the critical contrastive analysis (Kubota and Lehner, 2004). Through simulated peer reviews, learners identify temporal coherence issues in ESL drafts. Phase III utilizes corpus-driven comparisons of IM marker densities between Chinese and English academic texts. Learners restructure spiral L1 argumentation into linear temporal chains through "time-anchoring" exercises such as converting implicit causal links to explicit temporal sequences, and temporalizing spatial metaphors
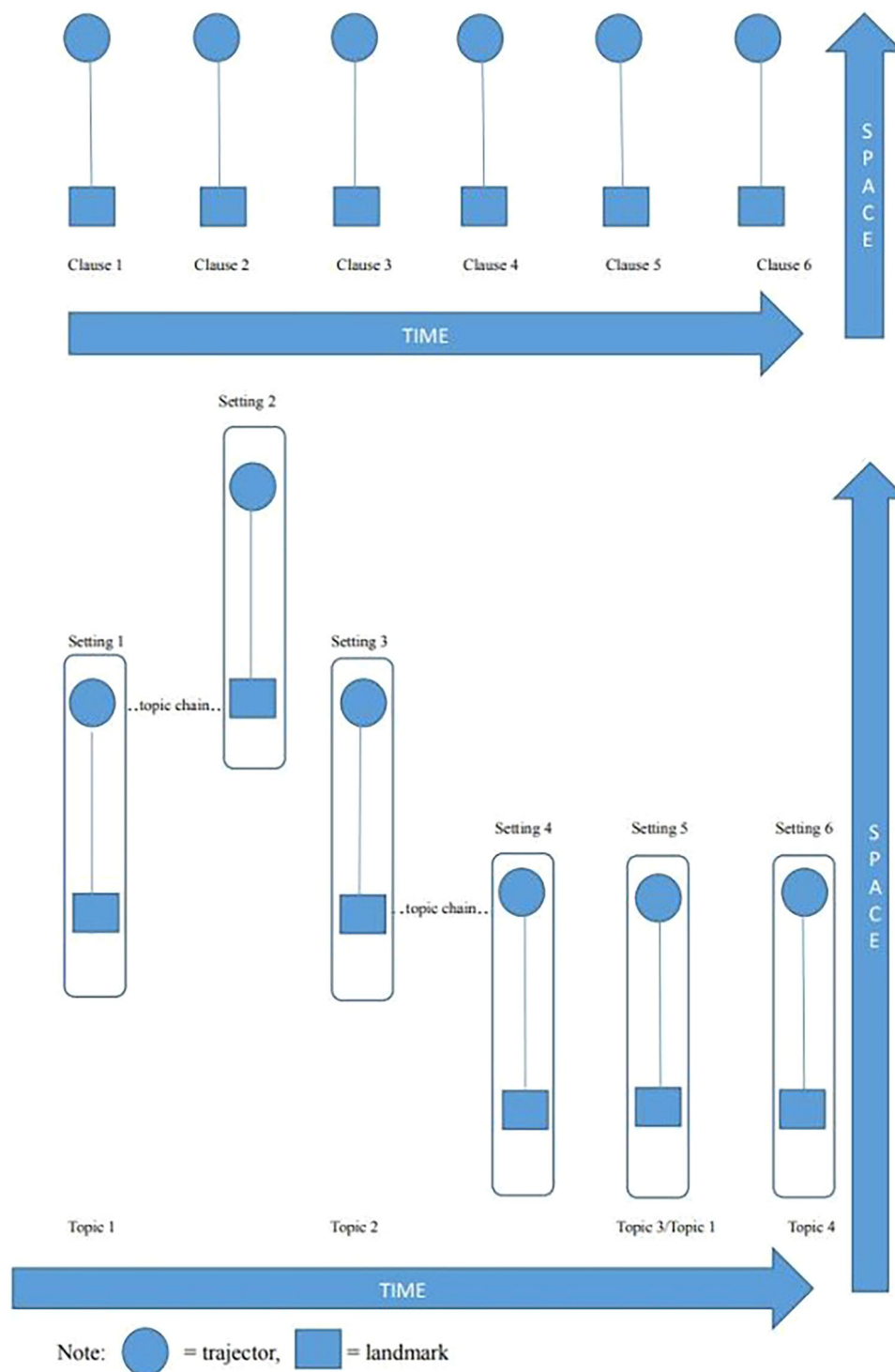
Fig. 3 Pro-temporality of English Discourse and Pro-spatiality of Chinese Discourse.

Conclusion

Methodologically integrating corpus frequency statistics with functional discourse analyses, this paper investigates IM in quantitative Economics RAs across three author groups (Chinese L1 writers, Chinese ESL writers, and English L1 writers). Findings reveal disciplinary homogeneity in IM patterns, evidenced by comparable frequency distributions and rhetorical functions across all sub-corpora. However, significant cross-linguistic and cross-cultural divergences emerge. English-medium RAs demonstrate substantially higher IM densities than Chinese-medium counterparts, and English L1 scholars employ IM more strategically than Chinese ESL writers in discourse organization. Notably, Chinese ESL writers exhibit L1-based conceptual transfer. Textual analysis further identifies language-specific rhetorical preferences, particularly in how writers gauge readers' interpretive needs.

In addition to varied cultural values in different communities, IM discrepancies are attributed to the pro-spatial orientation of Chinese discourse versus the pro-temporal sequencing preference in English. These orientations manifest as distinct figure-ground

perceptual patterns, where Chinese writers prioritize holistic textual chunking while English writers emphasize linear connectivity. Crucially, the study points out that Chinese ESL writers' discursive practices are systematically shaped by their native language's pro-spatial conceptual framework. This L1-based mode of discourse conceptualization persists in their ESL writing and underscores the profound, often subconscious influence of L1 cognitive schemata on L2 rhetorical production.

Three key limitations of the current study warrant attention. First, the exclusive focus on Economics quantitative RAs restricts generalizability, as disciplinary conventions may yield divergent IM patterns. Second, the quantitative limitation of the 150-article corpus constrains its representational scope, as restricted sample coverage may insufficient capture disciplinary variations. Third, while the corpus-based approach effectively identifies textual regularities, it fails to validate the psychological reality of IM strategies. The lack of online experimental paradigms (e.g., EEG metrics for rhetorical processing, eye-tracking patterns during reader-writer interaction, or fMRI evidence of conceptual transfer mechanisms) leaves the cognitive validity of observed patterns less verified. These constraints collectively highlight the necessity of methodological triangulation to ground L2 discursive transfer claims in both textual and psycholinguistic evidence.

Notwithstanding these limitations, the current dual-axis comparison advances metadiscourse research beyond conventional binary contrasts, and models how disciplinary knowledge becomes reconfigured through competing spatiotemporal logics in the international academia. It establishes language-specific conceptualization as a determinant of rhetorical choices, underscoring the necessity of recognizing how L1 conceptual frameworks may invisibly shape L2 rhetorical practices.

The communicative rationality of discourse inherently involves culture-bound logical systems. While this study contrasts Chinese spatial-chunking and English temporal-sequencing patterns, it cautions against value judgments regarding rhetorical efficacy. The spatiotemporal orientations are defined in formalized terms and are compared relatively. IM strategies ultimately function as culturally-coded negotiation tools rather than universal rationality indicators. As academic globalization intensifies, understanding these conceptual divergences becomes crucial for navigating the evolving landscape of transnational scholarship.

Data availability
No datasets were generated or analysed during the current study.

Note
1 Langacker (1987) introduces trajector and landmark into cognitive linguistics. While the trajector refers to the entity serving as a moving figure or as being located relative to the landmark, the landmark means the ground of a moving figure.

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Author contributions

Gai Feihong wrote the main manuscript. Yang Lianrui conducted discourse analysis. Zhang Hui conducted the data analysis. And all authors reviewed the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Additional information

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