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Exploring the impact of intermodal transfer on simplification: Insights from signed language interpreting, subtitle translation, and native speech in TED talks

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ABSTRACT

This study explores translational simplification in interpreted English from American Sign Language (ASL) and subtitled English from spoken French, compared to native English speech, using a self-constructed TED Talks Comparable Intermodal Corpus. By analyzing both lexical and syntactic complexity, the findings indicate that interpreted English does not exhibit a significant reduction in lexical density compared to native English speech. In fact, interpreted English has a higher lexical density than subtitled English. However, while subtitles are simpler in terms of semantic content, they show a less pronounced reduction in lexical variation and sophistication than oral interpretations, when compared to native speech. These results are attributable to the distinct modality influences of ASL and French, combined with the condensation constraints of subtitling and the real-time processing demands of interpreting. At the syntactic level, interpreted outputs display greater phrasal coordination than subtitles, while both modalities feature higher sentence-level coordination than native speech, likely shaped by the specific constraints of the TED Talk setting. This study contributes to a more nuanced understanding of the simplification phenomenon by highlighting the unique effects of intermodal transfer. It also adds to the knowledge of the distinct constraints of signed language interpreting and subtitle translation, as well as their divergent and shared patterns of information processing.

1. Introduction

Interpreting and translation, though both forms of mediated communication, fundamentally differ in their production modes: interpreting is spoken, whereas translation is written. This distinction has led to the widely held view that interpreting, due to its real-time processing constraints, is inherently more cognitively demanding than translation (Seeber, 2011), potentially yielding simpler language outputs. This assumption has motivated a range of studies comparing the linguistic complexity of interpreted and translated texts with non-mediated texts in the same language. Consistent findings suggest that interpreted texts tend to exhibit lower linguistic complexity or greater simplification than translated ones (Bernardini et al., 2016; Ferraresi et al., 2018; Xu and Li, 2022; Kunilovskaya et al., 2023).

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However, existing research has predominately concentrated on traditional, unimodal forms of interpreting and translation, where both the source and target languages belong to the same modality, either spoken or written. This narrow focus overlooks the effects of intermodal transfer, in which language shifts not only across languages but also between different modalities, potentially shaping linguistic complexity. The present study extends this line of inquiry by exploring signed language interpreting (SLI) and subtitle translation (SUBT), both of which involve shifts across languages and modalities.

SLI, often referred to as bimodal interpreting, facilitates communication between the deaf and hearing by transferring meaning between visual-gestural and auditory-verbal languages (Napier, 2015). On the other hand, SUBT, a form of intersemiotic translation, involves converting spoken language into written text displayed visually on a screen (Díaz-Cintas and Remael, 2014). Drawing on TED Talks as a platform that features both SLI and SUBT, this study investigates whether the patterns of simplification observed in unimodal interpreting and translation are maintained when both processes involve modality shifts. Specifically, it compares interpreted English from American Sign Language (ASL) with subtitled English from spoken French, situating these bimodal outputs alongside native English speech.

This research aims to provide new insights into how intermodal transfer influences translational simplification, advancing our understanding of the linguistic complexities associated with different translation modes. From a linguistic feature perspective, it seeks to consolidate knowledge about the modality-specific constraints of both bimodal interpreting and subtitle translation, while also shedding light on their similarities and differences in information processing. Conceptually, by incorporating SLI and SUBT into a research framework traditionally focused on unimodal interpreting and translation, this study underscores the growing recognition of these practices (Díaz-Cintas and Remael, 2014; Napier, 2015) and contributes to fostering a meaningful dialogue across modalities.

2. Simplification: Translation, interpreting, and intermodal comparison

Simplification, recognized as a key translation universal, refers to the tendency for translators and interpreters to use simpler language compared to native speakers (Baker, 1993). Laviosa (1998) introduced a set of features, including type-token ratio (TTR), lexical density, list head coverage, core vocabulary, and mean sentence length, to compare mediated texts with non-mediated ones using comparable corpora. This pioneering work has inspired numerous studies investigating the potential simplification of translated or interpreted texts relative to comparable written or spoken texts in the same language. Some studies have replicated Laviosa's measures (e.g., Sandrelli and Bendazzoli, 2005; Russo et al., 2006; Kajzer-Wietrzny, 2015; Dayter, 2018), while others have adopted novel measures to operationalize simplification, such as entropy (e.g., Liu et al., 2022; Chen and Chang, 2023), syntactic complexity metrics (e.g., Liu et al., 2023; Chen et al., 2024), and dependency distance (e.g., Xu and Liu, 2023; Fan and Jiang, 2023). These contributions have shaped an understanding of the "dynamic interplay between simplification and complication" in mediated outputs (Xiao and Dai, 2014: 48).

Building on this comparable approach, Shlesinger (2009) proposed an intermodal comparison of interpreted language with both non-interpreted speech and translated language from the same or similar sources. Such a comparable intermodal approach is intended to provide a more nuanced understanding of interpreting by highlighting its similarities and differences with its written counterpart, translation. Though not explicitly focused on simplification, Shlesinger and Ordan (2012) employed measures such as lexical density, TTR, and part-of-speech distributions to distinguish interpreting from translation and non-interpreted speech. Their findings showed a closer resemblance between interpreting and original speech than between interpreting and translation, suggesting that language variation is more influenced by modality (spoken vs. written) than by ontology (translation vs. non-translation). This trend has been reinforced by subsequent studies implementing computational language modeling (Lapshinova-Koltunski et al., 2021; Przybyl et al., 2022) and machine learning techniques (Lapshinova-Koltunski, 2021).

Recent research has increasingly explored simplification from a comparable intermodal perspective, primarily employing Laviosa's measures (Bernardini et al., 2016; Ferraresi et al., 2018; Lv and Liang, 2019; Xu and Li, 2022). A notable exception is the introduction of the concept of "surprisal," an information-theoretic measure that quantifies information content in bits, to analyze this phenomenon (Kunilovskaya et al., 2023). While no definitive trend of simplification has emerged, these studies consistently indicate that interpreters simplify their outputs more than translators. However, these conclusions are drawn exclusively from comparisons of unimodal interpreting and translation, covering language pairs such as Italian-English (Bernardini et al., 2016), French-English (Ferraresi et al., 2018), and German-English (Kunilovskaya et al., 2023) in the context of European Parliament debates, as well as Chinese-English (Lv and Liang, 2019) and Cantonese-English (Xu and Li, 2022) in political or legislative discourse. In all these cases, the language shift occurs within the same modality, either from spoken to spoken or written to written, thus overlooking the added complexity introduced by intermodal transfer.

This study seeks to address this gap by incorporating SLI and SUBT into the intermodal comparison framework, exploring the impact of modality shifts on linguistic complexity in both interpreting and translation. The ongoing endeavor is of particular significance, as scholars have called for further research to "consider and compare various factors, supportive or subversive, to reach a more detailed and hence more profound understanding of simplification" (Xiao and Hu, 2015: 159).

3. Measuring lexical and syntactic complexities

Lexical and syntactic complexities are essential in evaluating language performance, particularly in assessing the diversity and sophistication of vocabulary and syntactic structures used by speakers and writers (Laufer and Nation, 1995; Ortega, 2003). These constructs are widely utilized in Second Language Acquisition (SLA) research to differentiate between L2 English learners and native English speakers in terms of their produced lexical patterns (e.g., Engber, 1995; Foster and Tavakoli, 2009; Lu, 2012) and syntactic structures (e.g., Lu, 2011; Ai and Lu, 2013; Lu and Ai, 2015; Mancilla et al., 2017; Wu et al., 2020). The primary objective is to inform L2 pedagogy by assessing English learners' language proficiency and tracking their progress through these two key dimensions.

To assess lexical and syntactic complexity, Lu (2010, 2012) synthesized an extensive set of operational measures derived from prior research (e.g., Engber, 1995; Wolfe-Quintero et al., 1998; Ortega, 2003). These measures effectively capture the multidimensional nature of lexical and syntactic complexity (Lu, 2017). Table 1 presents the lexical complexity metrics, which include 25 indices across three dimensions:

(1) Lexical density: "the ratio of the number of lexical (as opposed to grammatical) words to the total number of words in a text" (Lu, 2012: 191);
(2) Lexical sophistication: "the proportion of relatively unusual or advanced words in the learner's text" (Read, 2000: 203), where sophisticated words are identified if they are absent from the 2000 most frequent words in the British National Corpus (BNC) or American National Corpus (ANC), depending on the spelling convention used;
(3) Lexical variation: "the range of a learner's vocabulary as displayed in his or her language use" (Lu, 2012: 192), measured through indices such as the Number of Different Words (NDW), traditional TTR, and its transformed versions to reduce sample size effects (Wolfe-Quintero et al., 1998), along with TTR applied to specific content word classes.

Similarly, syntactic complexity, as shown in Table 2, is measured through 14 indices across five dimensions: (1) Length of production unit; (2) Overall sentence complexity; (3) Degree of subordination; (4) Degree of coordination; (5) Phrasal complexity.

Table 1
Lexical complexity metrics based on Lu (2012).

Measures	Codes	Formula
Dimension 1: Lexical density		
Lexical density	LD	${}^{N}\mathrm{lex}/{}^{N}$
Dimension 2: Lexical sophistication		
Lexical Sophistication-I	LS1	${}^{N}\mathrm{slex}/{}^{N}\mathrm{lex}$
Lexical Sophistication-II	LS2	T_s/T
Verb sophistication-I	VS1	${}^{T}\mathrm{sverb}/{}^{N}\mathrm{verb}$
Verb sophistication-II	VS2	${}^{T2}\mathrm{sverb}/{}^{N}\mathrm{verb}$
Correlated VS1	CVS1	$\mathrm{T}_{\mathrm{sverb}}/\sqrt{2N_{verb}}$
Dimension 3: Lexical variation		
Number of different words	NDW	T
NDW (first 50 words)	NDW-50	T In the first 50 words of sample
NDW (expected random 50)	NDW-ER50	Mean T of 10 random 50-word samples
NDW (expected sequence 50)	NDW-ES50	Mean T of 10 random 50-word sequences
Type/Token ratio	TTR	T/N
Mean segmental TTR	MSTTR	Mean TTR of all 50-word segments
Corrected TTR	CTTR	$T/\sqrt{2N}$
Root TTR	RTTR	$T/\sqrt{N}$
Bilogarithmic TTR	LogTTR	$LogT/LogN$
Uber index	Uber	$Log^2N/Log(N/T)$
Verb variation-I	VV1	${}^{T}\mathrm{verb}/{}^{N}\mathrm{verb}$
Squared VV1	SVV1	${}^{T2}\mathrm{verb}/{}^{N}\mathrm{verb}$
Corrected VV1	CVV1	$\mathrm{T}_{\mathrm{verb}}/\sqrt{2N_{verb}}$
Lexical word variation	LV	${}^{T}\mathrm{lex}/{}^{N}\mathrm{lex}$
Verb variation-II	VV2	${}^{T}\mathrm{verb}/{}^{N}\mathrm{lex}$
Noun variation	NV	${}^{T}\mathrm{noun}/{}^{N}\mathrm{lex}$
Adjective variation	AdjV	${}^{T}\mathrm{adj}/{}^{N}\mathrm{lex}$
Adverb variation	AdvV	${}^{T}\mathrm{adv}/{}^{N}\mathrm{lex}$
Modifier variation	ModV	$({}^{T}\mathrm{adj}+{}^{T}\mathrm{adv})/{}^{N}\mathrm{lex}$

Table 2
Syntactic complexity metrics based on Lu (2010).

Measures	Codes	Definitions
Dimension 1: Length of production unit		
Mean length of clause	MLC	# Of words/# of clauses
Mean length of sentence	MLS	# Of words/# of sentences
Mean length of T-unit	MLT	# Of words/# of T-units
Dimension 2: Sentence complexity		
Sentence complexity ratio	C/S	# Of clauses/# of sentences
Dimension 3: Subordination		
T-unit complexity ratio	C/T	# Of clauses/# of T-units
Complex T-unit ratio	CT/T	# Of complex T-units/# of T-units
Dependent clause ratio	DC/C	# Of dependent clauses/# of clauses
Dependent clauses per T-unit	DC/T	# Of dependent clauses/# of T-units
Dimension 4: Coordination		
Coordinate phrases per clause	CP/C	# Of coordinate phrases/# of clauses
Coordinate phrases per T-unit	CP/T	# Of coordinate phrases/# of T-units
Sentence coordination ratio	T/S	# Of T-units/# of sentences
Dimension 5: Particular structures		
Complex nominals per clause	CN/C	# Of complex nominals/# of clauses
Complex nominals per T-unit	CN/T	# Of complex nominals/# of T-units
Verb phrases per T-unit	VP/T	# Of verb phrases/# of T-units

While these metrics are valid for assessing linguistic complexity, recent SLA research has advocated for more fine-grained measures that can pinpoint specific syntactic constructions and structural features in language use (e.g., Kyle and Crossley, 2018; Biber et al., 2020). Given that both holistic and fine-grained measures offer value depending on the research focus (Kim and Lu, 2024), this study, being the first to compare the linguistic complexity of signed language interpreting and subtitle translation, will employ Lu's holistic metrics to provide an initial overview of the broad linguistic patterns in these two distinctive forms of communication.

The interdisciplinary nature of translation studies has prompted some scholars to apply syntactic complexity measures originally developed in SLA to analyze either translated (Liu and Afzaal, 2021; Xu and Li, 2021; Wang et al., 2023; Chen et al., 2024) or interpreted (Liu et al., 2023) texts. This integration can be further extended to the lexical domain and to intermodal comparisons. Recognizing that simplification is a multifaceted phenomenon (Xiao and Dai, 2014; Liu et al., 2022), the current study adopts a systematic set of both lexical and syntactic complexity measures to provide a relatively comprehensive account of the linguistic patterns emerging from SLI and SUBT.

This study aims to address the following research questions:

RQ1 : To what extent is simplification evident in interpreted and subtitled English, compared to original English speech, across lexical and syntactic dimensions?
RQ2 : How do English interpretations from ASL and English subtitles translated from spoken French differ in terms of lexical and syntactic complexity?
RQ3 : Can the observed linguistic patterns indicate the effects of source language modality (signed vs. spoken) on mediated English? How do these patterns reflect the distinct constraints of SLI and SUBT within the TED Talks context, and what do they reveal about the similarities and differences between the two practices in information processing?

4. Corpora and methods

4.1. Data collection and description

To address our research questions, we constructed the TED Comparable Intermodal Corpus (TEDCIC), comprising three language varieties: native English speech (L1E), English interpreted simultaneously from American Sign Language (SLI), and English subtitles translated from spoken French (SUBT).

TED Talk was selected as the object of study due to its provision of both SLI and SUBT, along with open accessibility. Although TED presentations cover a wide range of topics, they consistently aim to convey innovative ideas, positioning TED as a composite genre of "highly-prepared, perfectly-delivered oral performances" characterized by recurring thematic and rhetorical patterns (Ludewig, 2017: 8). By focusing exclusively on TED Talks, we aim to control for genre-related variables that may influence the linguistic complexity of interpreting versus translation.

At TED events, signed language interpreting is provided for prominent deaf professionals, such as lawyers, educators, and CEOs, who are invited to speak. These professionals typically work with designated or highly trained interpreters (Hauser et al., 2008). To ensure the accuracy of their signed messages, they often brief interpreters on the content and context of their presentations, with some even rehearsing their entire signed performance (e.g., Napier et al., 2008; Dickinson, 2017).

Although TED claims that its interpreting services are delivered live without rehearsal[1], it is likely that interpreters receive some form of briefing from deaf presenters. This preparatory work is vital for maintaining interpretation quality, particularly as TED's SLI is presented as a "voice-over" (Nilsson, 2016: 20), wherein only the deaf presenter is visible on stage.

Additionally, TED provides subtitling services to enhance content accessibility across languages and borders. The subtitles are created through the TED Translators program[2], a crowdsourcing initiative that engages motivated volunteers worldwide. To ensure quality, TED implements a multi-stage quality assurance process and provides volunteers with subtitling guidelines and training (Karakanta and Orrego-Carmona, 2023). Volunteers must be fluent in both source and target languages and familiar with subtitling constraints, including segmentation, reading speed, and subtitle length. Newly created subtitles need to be reviewed by more experienced volunteers and require further approval from a language coordinator before being published on the website. This collaborative process is facilitated by a cloud-based subtitling editor, which has transitioned from Amara to the current CaptionHub platform[3].

The TEDCIC corpus is well-suited for intermodal comparison, as it draws from a unified genre and high-quality renditions. Although an ideal intermodal comparison would involve interpreting and translation derived from the same source language, TED does not provide direct English translations of ASL speeches. Consequently, the English subtitles in our corpus were translated from spoken presentations, with French selected as the source language due to its frequent use on the TED platform. This configuration allows us to consider how different source language modalities (signed vs. spoken) impact the linguistic characteristics of the resulting English texts, whether interpreted or translated. To ensure data consistency, all materials—subtitles, interpretations, and original speeches—were collected from talks delivered after 2012, following TED's adoption of the Amara platform (Karakanta and Orrego-Carmona, 2023).

Table 3 provides an overview of the corpus. While L1E materials were sourced from TED, the data for SLI and SUBT were collected from TEDx, a community-focused offshoot of TED designed to foster dialogue through localized events. The three subcorpora are comparable in terms of size, genre, and target language, providing a solid basis for intermodal linguistic analysis.

Table 3
An overview of the TED Comparable Intermodal Corpus (TEDCIC).

Sub-corpora	Source	Text count	Overall size	Mean size	Modality	Language
L1E	TED	61	58,055	952	Spoken	English
SLI	TEDx	61	54,628	896	Signed to spoken	English
SUBT	TEDx	61	53,865	883	Spoken to written	English

4.2. Data transcription and processing

To investigate the linguistic complexity of the three language varieties, we utilized the Lexical Complexity Analyzer (LCA) and the Second Language Syntactic Complexity Analyzer (L2SCA). These computational tools automate the analysis of lexical and syntactic complexity, offering a robust solution for processing large batches of language samples. Their operation in Python 3.0 enhances analytical efficiency and reduces inconsistencies typically encountered in smaller-scale studies. As noted by Lu (2010, 2012), higher numeric scores in the lexical and syntactic metrics indicate greater complexity within their respective dimensions.

Given that LCA and L2SCA were originally designed for analyzing written data, special care is required when applying them to spoken language. Spoken discourse frequently contains disfluencies, such as hesitations, false starts, fillers, and repetitions, which can introduce noise and skew the accuracy of automated analyses (Alexopoulou et al., 2021). Kim and Lu (2024) emphasize the importance of removing these disfluencies, demonstrating that an automatic preprocessing script written in Python 3.0 can yield results comparable to manual transcript cleaning. Regardless of the method used, eliminating such textual noise is critical to ensuring the accurate identification of relevant linguistic features.

In this study, the spoken data (native and interpreted English) already conformed to the clean-text requirements specified by TED's strict transcription guidelines[4]. Nevertheless, to verify the accuracy of the transcripts, we cross-checked them against the original recordings, ensuring that disfluency features such as hesitations, false starts, and unnecessary repetitions had been removed. During this process, we also observed that TED transcribers typically retain conjunctions and mark sentence boundaries based on pitch, pauses, and content shifts, adhering to established transcription criteria for spoken language (Hwang et al., 2020). Specifically, TED transcribers often segment clauses into separate sentences when a falling pitch precedes a conjunction (e.g., "and", "or", "so"), accompanied by a noticeable pause and a distinct shift in content.

[1] This information is provided at the start of each TED presentation video featuring a deaf speaker.
[2] TED Translators program can be accessed at https://www.ted.com/participate/translate, where detailed subtitling guidelines are available.
[3] From 2012 to 2020, TED subtitling was performed in the Amara subtitle editor. As of early 2021, the project transitioned to CaptionHub.
[4] Transcriptions for English TED Talks are provided by TED, while TEDx Talks are transcribed by volunteers following the same guidelines, which can be accessed at https://www.ted.com/pages/transcribe. Volunteer transcriptions undergo review and approval before being published on the website.

Once verified, the transcripts were organized into 61 texts for each subcorpus and processed in batch mode using LCA and L2SCA. The resulting scores for the 25 lexical and 14 syntactic complexity metrics for each text were subsequently exported to Microsoft Excel for further statistical analysis using the R package.

5. Results

This section presents the statistical results regarding linguistic complexity across L1 English, signed language interpreting, and subtitle translation in TED Talks, focusing on both lexical and syntactic dimensions.

5.1. Lexical complexity across L1E, SLI and SUBT

Table 4 summarizes the mean values and standard deviations for the 25 lexical complexity indices across the three subcorpora. Notably, the non-mediated production (L1E) displays higher mean values than both mediated modalities (SLI and SUBT) in 18 out of the 25 indices. One-way ANOVA tests reveal a significant corpus effect across 23 of the measures, with two verb-related indices (VS1 and VV2) showing no significant differences.

Table 4
Mean values for 25 metrics of lexical complexity.

Measure	Code	SLI Mean (SD)	SUBT Mean (SD)	L1E Mean (SD)
Dimension 1: Lexical density				
Lexical density	LD	0.489 (0.020)	0.479 (0.024)	0.489 (0.023)
Dimension 2: Lexical sophistication				
Lexical Sophistication-I	LS1	0.496 (0.039)	0.502 (0.053)	0.522 (0.049)
Lexical Sophistication-II	LS2	0.416 (0.026)	0.417 (0.037)	0.448 (0.038)
Verb sophistication-I	VS1	0.322 (0.042)	0.334 (0.062)	0.344 (0.065)
Verb sophistication-II	VS2	18.218 (4.420)	18.824 (6.376)	21.752 (8.135)
Correlated VS1	CVS1	2.995 (0.367)	3.023 (0.528)	3.238 (0.626)
Dimension 3: Lexical variation				
Number of different words	NDW	341.950 (25.986)	365.737 (30.071)	390.049 (32.750)
NDW (first 50 words)	NDW-50	39.032 (3.444)	38.213 (3.474)	40.016 (3.133)
NDW (expected random 50)	NDW-ER50	41.159 (1.205)	41.434 (1.197)	41.967 (1.084)
NDW (expected sequence 50)	NDW-ES50	38.585 (1.667)	38.409 (1.663)	39.641 (1.409)
Type/Token ratio	TTR	0.366 (0.026)	0.400 (0.035)	0.391 (0.029)
Mean segmental TTR	MSTTR	0.770 (0.027)	0.774 (0.022)	0.793 (0.021)
Corrected TTR	CTTR	7.913 (0.557)	8.547 (0.714)	8.739 (0.676)
Root TTR	RTTR	11.191 (0.788)	12.087 (1.010)	12.360 (0.956)
Bilogarithmic TTR	LogTTR	0.853 (0.010)	0.865 (0.013)	0.863 (0.011)
Uber index	Uber	20.276 (1.392)	22.122 (2.049)	22.162 (1.811)
Verb variation-I	VV1	0.535 (0.054)	0.573 (0.063)	0.567 (0.069)
Squared VV1	SVV1	50.248 (9.497)	54.409 (10.690)	57.548 (13.629)
Corrected VV1	CVV1	4.989 (0.477)	5.190 (0.525)	5.323 (0.660)
Lexical word variation	LV	0.561 (0.044)	0.624 (0.055)	0.609 (0.049)
Verb variation-II	VV2	0.204 (0.026)	0.215 (0.029)	0.206 (0.031)
Noun variation	NV	0.592 (0.058)	0.647 (0.061)	0.636 (0.065)
Adjective variation	AdjV	0.082 (0.013)	0.098 (0.018)	0.103 (0.016)
Adverb variation	AdvV	0.027 (0.007)	0.032 (0.008)	0.032 (0.007)
Modifier variation	ModV	0.109 (0.015)	0.131 (0.021)	0.135 (0.018)

To further examine the significant differences between any two of the three groups, Tukey's post-hoc tests were conducted, as outlined in Table 5. From a comparable perspective, both SLI and SUBT exhibit lexical simplification relative to native English. However, the extent and patterns of this simplification vary between the two mediated modalities. In general, SUBT demonstrates simplification across all three lexical dimensions, while SLI does not show a statistically significant difference in lexical density when compared to L1E, as illustrated in Fig. 1.

Table 5
Tukey's post-hoc test results of the lexical metrics with significant cross-corpus difference.

Measure	Code	SLI vs L1E	SUBT vs L1E	SLI vs SUBT
Dimension 1: Lexical density				
Lexical density	LD	< -	< *	> *
Dimension 2: Lexical sophistication				
Lexical Sophistication-I	LS1	< *	< -	< -
Lexical Sophistication-II	LS2	< *	< *	< -
Verb sophistication-II	VS2	< *	< *	< -
Correlated VS1	CVS1	< *	< -	< -
Dimension 3: Lexical variation				
Number of different words	NDW	< *	< *	< *
NDW (first 50 words)	NDW-50	< -	< *	> -
NDW (expected random 50)	NDW-ER50	< *	< *	< -
NDW (expected sequence 50)	NDW-ES50	< *	< *	> -
Type/Token ratio	TTR	< *	> -	< *
Mean segmental TTR	MSTTR	< *	< *	< -
Corrected TTR	CTTR	< *	< -	< *
Root TTR	RTTR	< *	< -	< *
Bilogarithmic TTR	LogTTR	< *	> -	< *
Uber index	Uber	< *	< -	< *
Verb variation-I	VV1	< *	> -	< *
Squared VV1	SVV1	< *	< -	< -
Corrected VV1	CVV1	< *	< -	< -
Lexical word variation	LV	< *	> -	< *
Noun variation	NV	< *	> -	< *
Adjective variation	AdjV	< *	< -	< *
Adverb variation	AdvV	< *	> -	< *
Modifier variation	ModV	< *	< -	< *

>* indicates the former is statistically higher than the latter (adjusted $p < 0.05$).
<* indicates the former is statistically lower than the latter (adjusted $p < 0.05$).
-indicates no statistically significant difference ($p > 0.05$).

When examining lexical sophistication and variation, bimodal interpretation exhibits more substantial simplification than subtitle translation. Specifically, in terms of lexical sophistication, Fig. 2 indicates that SLI uses considerably simpler language than L1E, as evidenced by both the token-count (LS1) and type-count (LS2) measures of sophisticated lexical words, as well as by both the squared (VS2) and transformed (CVS1) verb sophistication indices. In contrast, SUBT shows a notable reduction compared to L1E only in the type-count measure of sophisticated lexical words (LS2) and the squared verb sophistication index (VS2).

Regarding lexical variation, 17 out of the 18 measures show a pronounced simplification in SLI compared to L1E. These include the NDW measure and its two standardized versions designed to control for sample size effects (Lu, 2012), as shown in Fig. 3; the six TTR measures (including both the original and transformed versions) applied to the total vocabulary, as seen in Fig. 4; and the TTR measures applied to individual word classes (verbs, nouns, adjectives, adverbs, and modifiers), as well as to the entire set of lexical words encompassing all five content word classes, shown in Fig. 5. In contrast, SUBT demonstrates simplification in all NDW-based measures but only in one TTR measure, namely MSTTR, which is computed by dividing a sample into successive segments of a fixed length and calculating the average TTR across segments.

Direct comparisons between SLI and SUBT reveal that SLI shows a simpler lexical variation, with significant differences in the original NDW measure (see Fig. 3), five TTR measures applied to the total vocabulary (see Fig. 4), and the six TTR measures applied to one or more content word classes (see Fig. 5). These differences indicate a narrower lexical range in the interpreted output. However, no statistically significant differences are found between the two modalities in any of the four lexical sophistication measures (see Fig. 2). Additionally, the results related to lexical density are particularly noteworthy. SLI not only exhibits a higher mean value than SUBT, but this difference is statistically significant ($p < 0.05$). This suggests that spoken interpretation, especially when derived from a signed language, may convey more information than written subtitles translated from a spoken source.

5.2. Syntactic complexity across L1E, SLI and SUBT

Table 6 presents the descriptive statistics for syntactic complexity across the three subcorpora. As shown, SLI exhibits lower mean values in 11 out of the 14 syntactic complexity indices compared to L1E, while SUBT shows lower mean values in only nine indices relative to L1E. When comparing the two mediated modalities, counter to initial expectations, the interpreted output demonstrates higher mean values in 12 indices, spanning global, clausal, and phrasal dimensions of syntactic complexity.

To determine statistically significant differences among the three groups, a one-way ANOVA was conducted, followed by post-hoc multiple comparisons. However, in contrast to the clear differences observed at the lexical level, syntactic

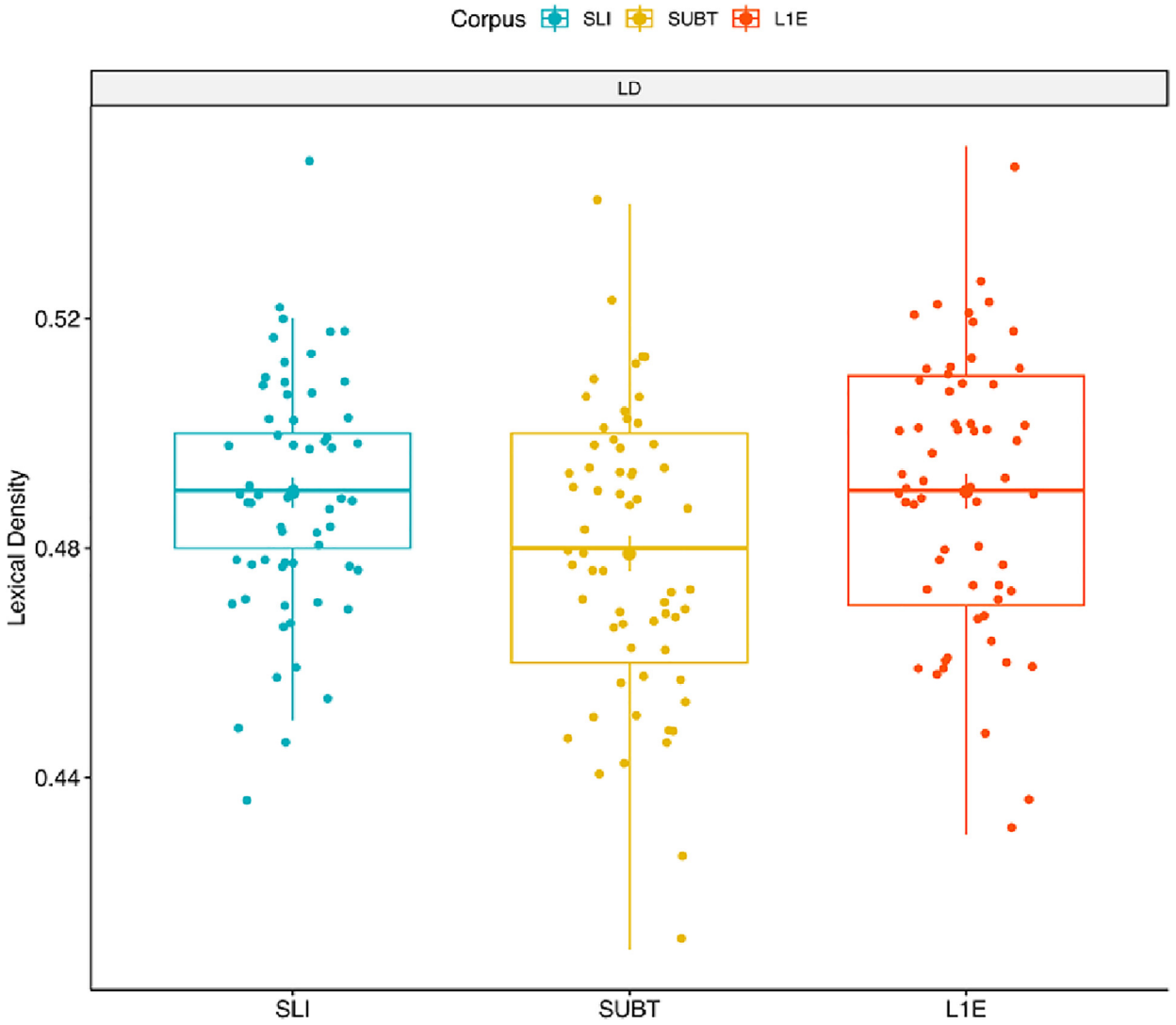

Fig. 1. Lexical complexity in lexical density.

differences only reached statistical significance ($p < 0.05$) in three indices, all related to coordination. Tukey's post-hoc tests were subsequently performed on these coordination measures to examine specific group differences. The results, presented in Table 7 and Fig. 6, reveal no consistent patterns in the mediated outputs when compared to native speech.

Specifically, SLI shows significantly greater sentence-level coordination (T/S) than L1E, although no significant difference is observed between the two groups in terms of phrasal coordination (CP/C and CP/T). For SUBT, a significant reduction in phrasal coordination is found compared to L1E, although similar to SLI, it shows a tendency towards increased sentence-level coordination.

From an intermodal perspective, the syntactic patterns between SLI and SUBT warrant particular attention. As illustrated in Fig. 6, the significant differences in CP/C and CP/T suggest that interpreters engaged in bimodal transfer (from signed to spoken language) tend to employ more coordinated phrases to link information than translators working within the constraints of a multimedia subtitling context.

6. Discussion

6.1. Influence of source language modality on linguistic complexity

This study examined the impact of intermodal transfer on simplification by comparing the linguistic complexity across interpreted English from ASL, subtitled English from spoken French, and native English speech in TED Talks. A key finding is

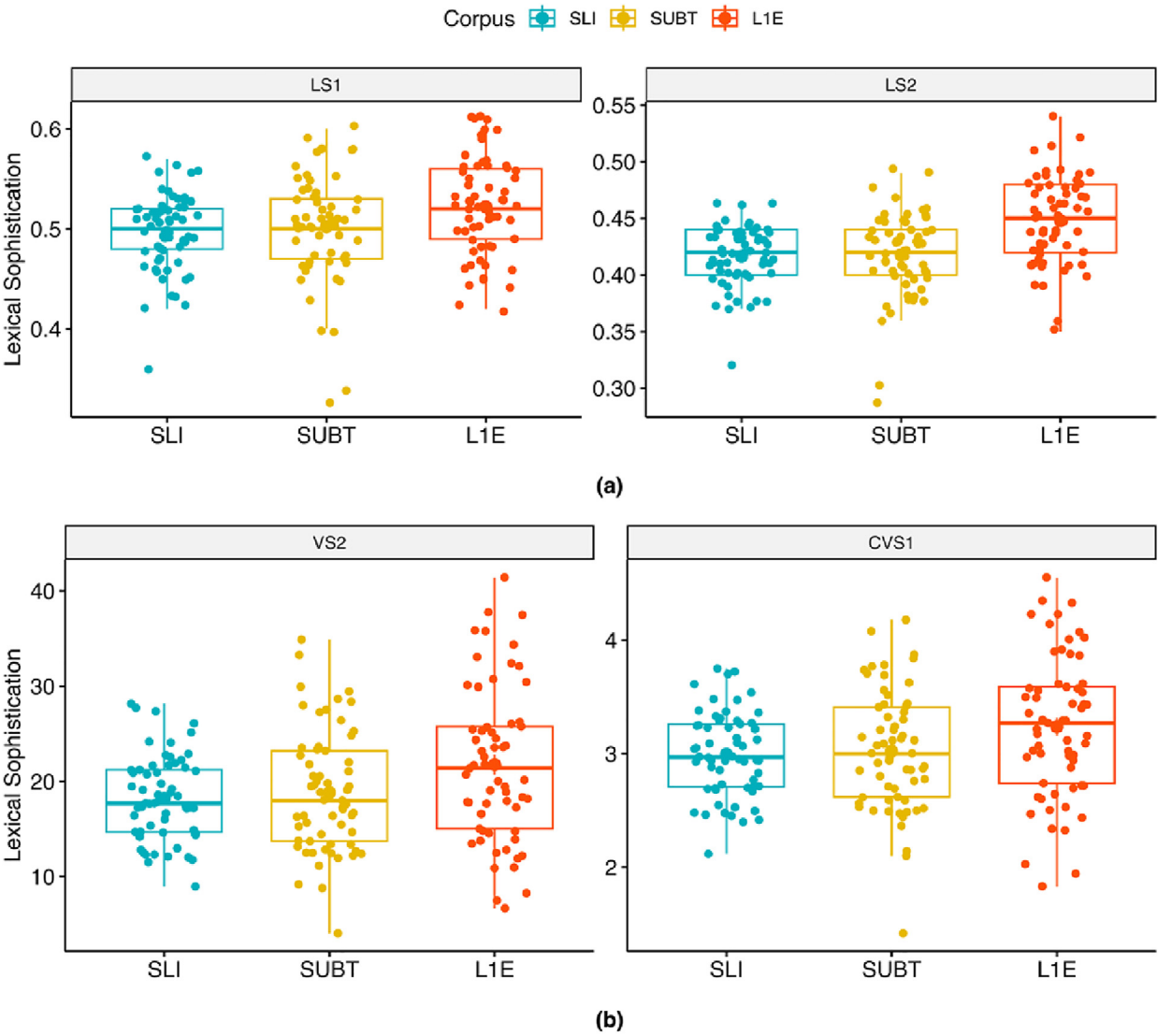

Fig. 2. Lexical complexity in lexical sophistication: (a) Lexical Sophistication-I, Lexical Sophistication-II; (b) Verb sophistication-II, Correlated VS1.

that interpreted English does not exhibit a significant reduction in lexical density compared to native English. In fact, it demonstrates higher lexical density than subtitled English. This suggests that the modality of the source language, whether signed or spoken, plays a crucial role in determining the informativeness of the target English through the mediation process.

Previous studies have identified that interpreting can lead to higher lexical density than native speech, influenced by factors such as the distinctiveness of language pairs (Sandrelli and Bendazzoli, 2005; Russo et al., 2006), genre variations (Xu and Li, 2022), the direction of interpreting (Dayter, 2018), and interpreters' tendencies to explicitly articulate pro-forms and ellipses in the source text (Kajzer-Wietrzny, 2015). However, these studies have all focused on unimodal spoken language interpreting, leaving the specific challenges of signed-to-spoken language transfer largely unexplored. In our study, the fundamental difference in modality between ASL and French is posited as a key factor influencing the lexical density of both interpreted and translated texts.

ASL, as a visual-spatial language, is capable of conveying multiple layers of meaning simultaneously by integrating manual signs with non-manual features such as facial expressions and body movements, which serve to express grammatical relationships (Liddell, 2003; Sandler and Lillo-Martin, 2006). This multimodal nature allows ASL to encode a substantial amount of information using relatively few signs. Consequently, interpreting from ASL into English often requires a greater number of English lexical items to fully capture the meanings encapsulated in the fewer ASL signs (Padden, 2000). This may explain why interpreted English from ASL, despite the cognitively demanding process of interpreting, does not exhibit a reduction in lexical density compared to native English speech. In contrast, French, as an auditory-verbal language, is produced and heard

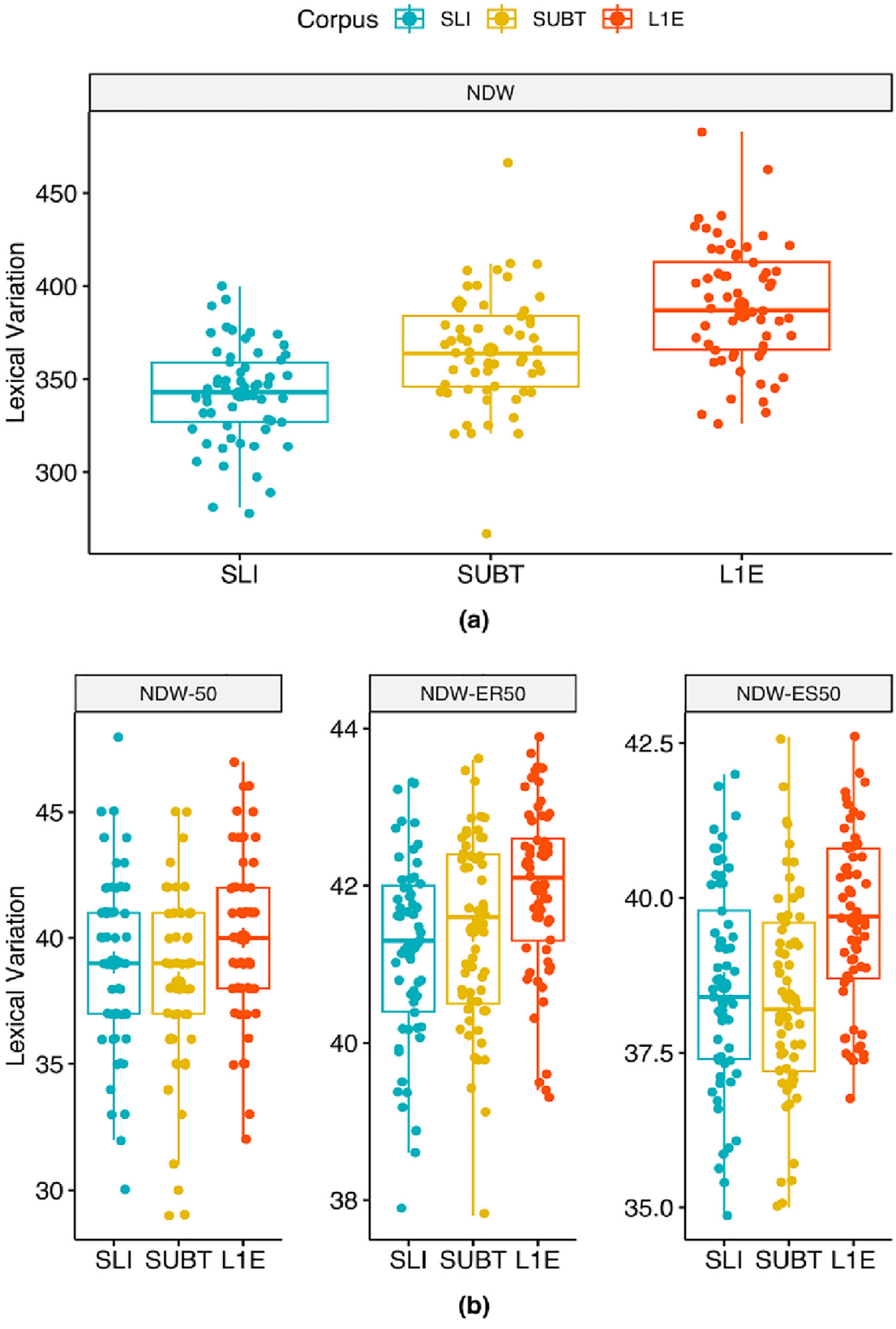

Fig. 3. Lexical complexity in lexical variation I: (a) Number of different words; (b) NDW (first 50 words), NDW (expected random 50), NDW (expected sequence 50).

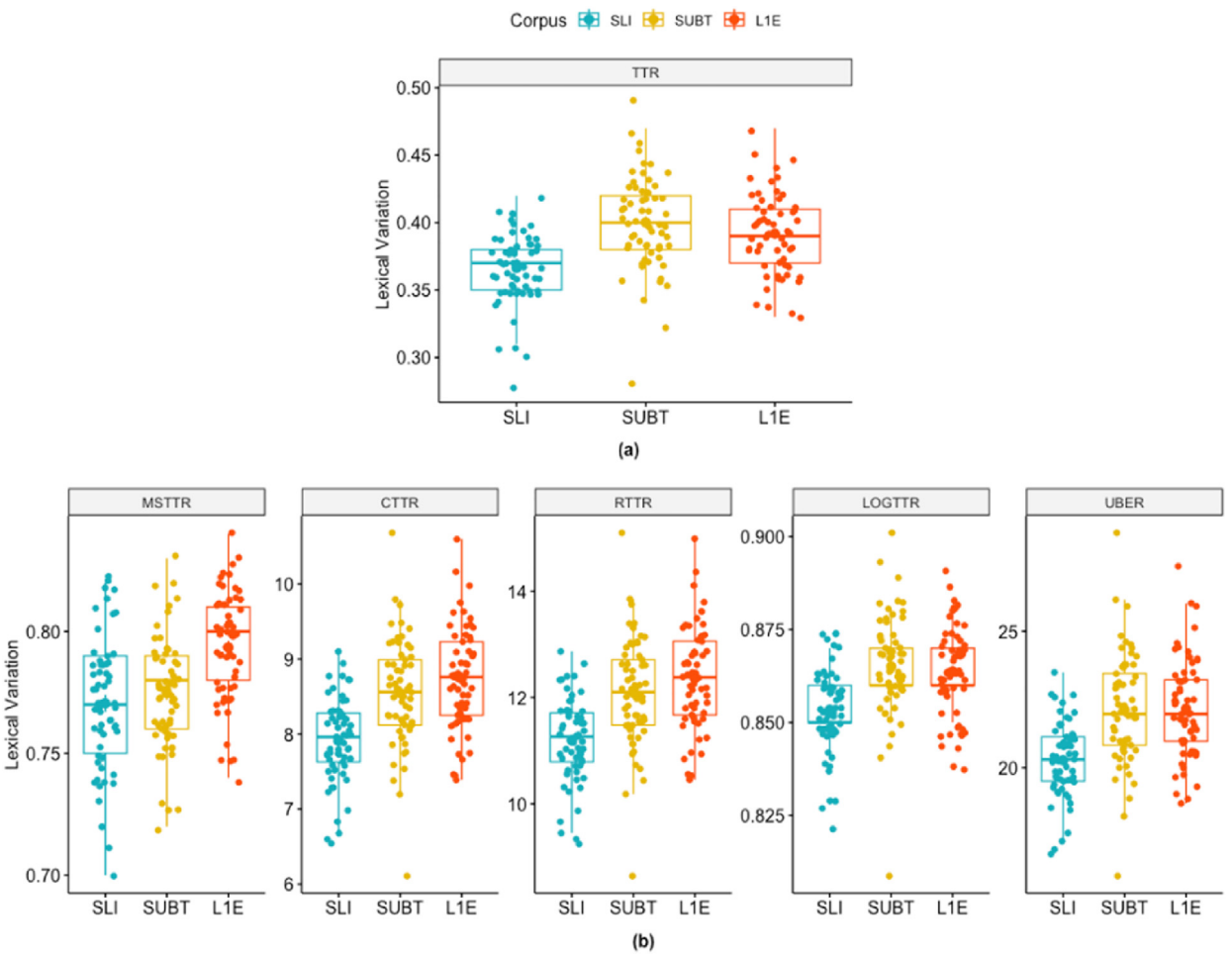

Fig. 4. Lexical complexity in lexical variation II: (a) Type/Token ratio; (b) Mean Segmental TTR, Corrected TTR, Root TTR, Bilogarithmic TTR, Uber Index.

one word at a time. The sequential nature of French limits the number of lexical items expressed in oral communication, leading to a further reduction in lexical density when translated into subtitles.

In addition to structural differences, certain linguistic habits among signed language users may also contribute to the higher lexical density observed in interpreted outputs. Deaf presenters in formal settings often engage in fingerspelling spoken words and combine signs with iconic gestures, frequently using two signs to express the same concept (Napier et al., 2010). These practices can introduce informational redundancy into signed discourse, potentially hindering interpreters' preference for interpreting from signed language to spoken language (Nicodemus and Emmorey, 2013). The findings of this study, particularly the high lexical density in interpreted English from ASL, point to the unique challenges involved in signed-to-spoken language interpreting—an area that remains under-researched in interpreting studies (Wang, 2021).

From a functional perspective, higher lexical density often necessitates greater use of phrasal coordination, relying on conjunctions such as "and" or "or" to structure dense information into cohesive and parallel phrasal units (Biber et al., 1999). In this regard, since interpreted and native English exhibit comparable lexical density, it is not surprising that they also display a similar degree of phrasal coordination. In contrast, the lower lexical density in subtitled English leads to a significantly reduced use of coordinated phrases compared to L1 English. These distinct linguistic patterns further reflect the influence of the source language modality—signed versus spoken—in shaping the mediation processes of SLI and SUBT.

6.2. Constraints in SLI and SUBT within TED contexts

Previous studies have consistently demonstrated that interpreting is typically less lexically dense and informative when directly compared to translation (Bernardini et al., 2016; Ferraresi et al., 2018; Xu and Li, 2022; Kunilovskaya et al., 2023). However, this trend does not extend to bimodal interpreting and subtitle translation, both of which operate under distinct

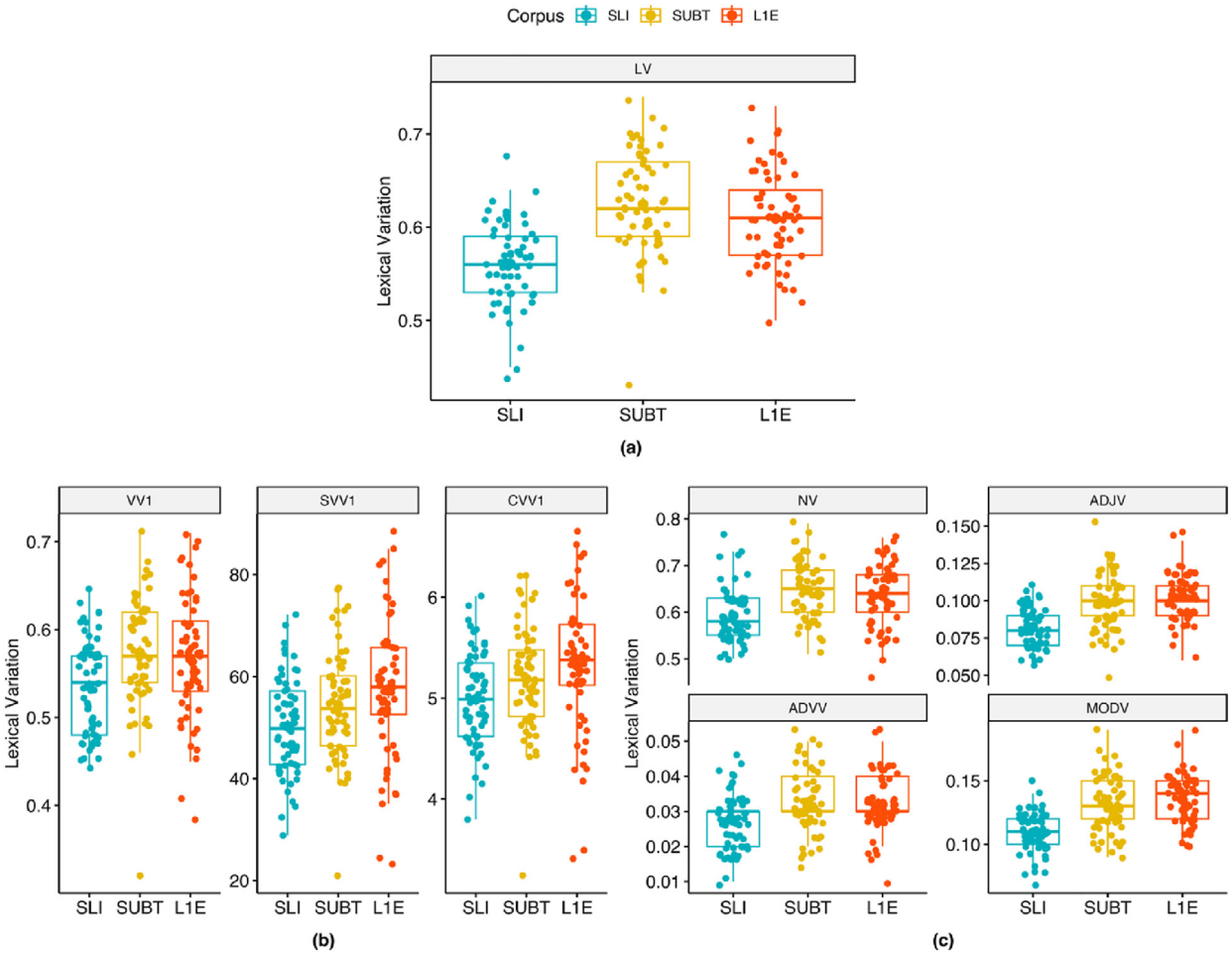

Fig. 5. Lexical complexity in lexical variation III: (a) Lexical word variation; (b) Verb variation-I, Squared VV1, Corrected VV1; (c) Noun variation, Adjective variation, Adverb variation, Modifier variation.

Table 6
Mean values for 14 metrics of syntactic complexity.

Measure	Code	SLI Mean (SD)	SUBT Mean (SD)	L1E Mean (SD)
Dimension 1: Length of production unit				
Mean length of clause	MLC	8.401 (1.043)	8.224 (1.188)	8.691 (1.064)
Mean length of sentence	MLS	16.978 (4.202)	16.964 (4.941)	16.791 (3.053)
Mean length of T-unit	MLT	14.027 (3.203)	13.915 (2.868)	14.790 (2.865)
Dimension 2: Sentence complexity				
Sentence complexity ratio	C/S	2.013 (0.417)	2.066 (0.559)	1.937 (0.297)
Dimension 3: Subordination				
T-unit complexity ratio	C/T	1.659 (0.269)	1.693 (0.267)	1.701 (0.250)
Complex T-unit ratio	CT/T	0.446 (0.138)	0.424 (0.114)	0.440 (0.103)
Dependent clause ratio	DC/C	0.371 (0.097)	0.367 (0.076)	0.385 (0.077)
Dependent clauses per T-unit	DC/T	0.639 (0.257)	0.639 (0.228)	0.673 (0.235)
Dimension 4: Coordination				
Coordinate phrases per clause	CP/C	0.169 (0.053)	0.109 (0.050)	0.168 (0.067)
Coordinate phrases per T-unit	CP/T	0.283 (0.100)	0.185 (0.087)	0.288 (0.128)
Sentence coordination ratio	T/S	1.207 (0.117)	1.205 (0.167)	1.139 (0.073)
Dimension 5: Particular structures				
Complex nominals per clause	CN/C	0.827 (0.247)	0.785 (0.231)	0.878 (0.214)
Complex nominals per T-unit	CN/T	1.401 (0.536)	1.334 (0.452)	1.500 (0.449)
Verb phrases per T-unit	VP/T	2.182 (0.417)	2.165 (0.355)	2.236 (0.427)

Table 7
Tukey's post-hoc test results of the syntactic metrics with significant cross-corpus difference.

Measure	Code	SLI vs L1E	SUBT vs L1E	SLI vs SUBT
Coordinate phrases per clause	CP/C	> -	< *	> *
Coordinate phrases per T-unit	CP/T	< -	< *	> *
Sentence coordination ratio	T/S	> *	> *	> -

>* indicates the former is statistically higher than the latter (adjusted $p < 0.05$).
<* indicates the former is statistically lower than the latter (adjusted $p < 0.05$).
-indicates no statistically significant difference ($p > 0.05$).

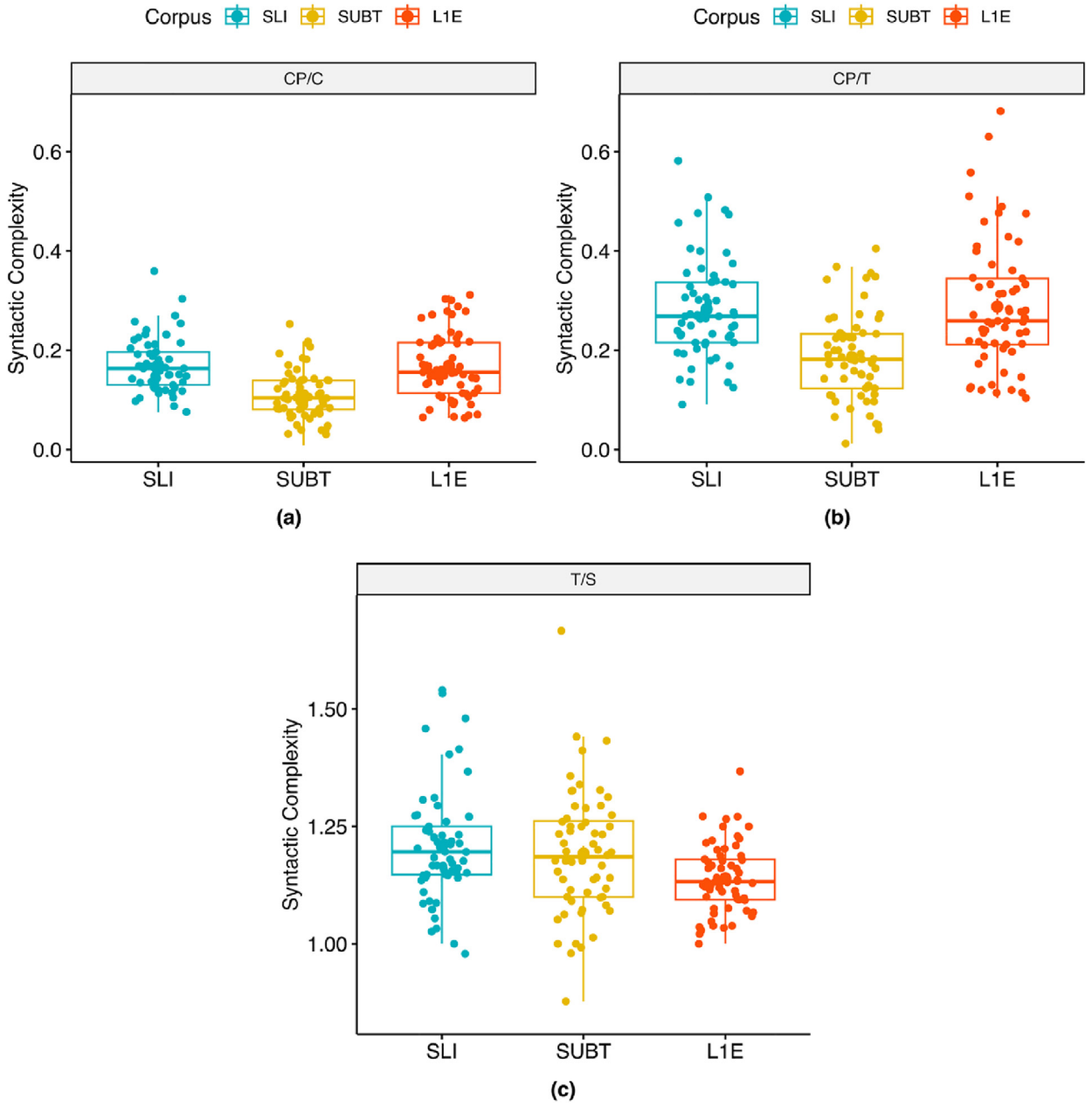

Fig. 6. Syntactic complexity in the amount of coordination: (a) Coordinate phrases per clause; (b) Coordinate phrases per T-unit; (c) Sentence coordination ratio.

Fig. 7. The format of signed presentation at TED.

constraints. We argue that the higher lexical density in SLI versus SUBT is not solely attributable to the modality differences between source languages, but also to the specific condensation constraints inherent in subtitling.

TED's subtitling guidelines impose strict limitations on subtitle length, pacing, and segmentation, all of which affect the linguistic characteristics of the target text. For instance, TED subtitles are restricted to 42 characters per line, with no more than two lines per subtitle, and a maximum reading speed of 21 characters per second. These constraints necessitate considerable condensation of the original content (Georgakopoulou, 2010). This is driven not only by the limited time and space available for subtitles but also by the need to reduce cognitive load for the viewers, considering that they must process subtitles in sync with the audio and visual elements of the speech (Gottlieb, 1998). Deaf and hard-of-hearing viewers, in particular, spend more time reading subtitles and often exhibit lower comprehension levels than hearing viewers (Szarkowska et al., 2016). Given these factors, it is understandable that "a subtitled audiovisual text is a substantially altered product from a cognitive perspective" (Kruger et al., 2015: 12).

Focusing on the linguistic features of the output, our study reveals that subtitles exhibit significantly lower lexical density and reduced phrasal-level coordination compared to both native speech and bimodal interpretation. This further substantiates the claim that "the written version of speech in subtitles is nearly always a reduced form of the oral ST" (Díaz-Cintas and Remael, 2014: 145). It is important to note that all TED Talk data for this study were collected after 2012, the year when the Amara subtitling tool was introduced. Karakanta and Orrego-Carmona (2023) observed a marked increase in the compression of spoken text following this transition, suggesting that the Amara tool plays a pivotal role in shifting the subtitling process from a mere translation of source transcripts to the creation of well-formed subtitles that adhere to the length and pacing constraints of this translation mode.

Moreover, the subtitling process requires careful segmentation of long sentences across multiple subtitle blocks to maintain clarity and coherence (Díaz-Cintas and Remael, 2014). TED's translation guidelines, in particular, mandate segmentation at the highest syntactic nodes (Karamitroglou, 1998), which likely results in a higher degree of sentence coordination in the subtitled output compared to the original speech. For example, in Excerpt (1), an English sentence translated from French[5] is split across six subtitle flashes. Conjunctions like "and" are inserted at T-unit boundaries to facilitate segmentation. This segmentation strategy, which ensures each subtitle block is semantically self-contained, has been shown to

[5] The original video titled "Serious games—Faites vos jeux" can be accessed at https://www.youtube.com/watch?v=uBLH5aw1Ves.

assist viewers' cognitive processing by reducing the frequency of shifts between text and visual images (Rajendran et al., 2013).

Excerpt (1):

(1)	3:54	Because in fact there aren't
(2)	3:56	just researchers lacking inspiration there,
(3)	3:58	there are not just marginalised male teenagers,
(4)	4:01	**and** in fact there are people of all socio-professional categories,
(5)	4:04	of all ages, of both genders,
(6)	4:07	**and** these people come to look for several things.

Turning to SLI, the unique constraints of interpreting in TED may contribute to a similar pattern of increased sentence-level coordination in the interpreted English from ASL. As illustrated in Fig. 7[6], while the deaf presenter communicates visually with the audience, the interpreter, who remains unseen, provides a voice-over from an offstage location. In more traditional SLI contexts, such as academic (De Meulder et al., 2018) or workplace (Dickinson, 2017) settings, the interpreter often stands near the deaf presenter, enabling them to make use of visual cues, typically the "look-pause-nod" strategy (Napier et al., 2008), to coordinate their actions. Specifically, the deaf presenter makes eye contact with the interpreter to monitor whether they are keeping pace, and the presenter pauses every now and then to allow the interpreter to catch up. In turn, the interpreter signals understanding through a nod, which the presenter reciprocates before resuming the communication. However, in TED Talks, the lack of such cooperative strategies forces the interpreter to manage a continuous flow of signed discourse without the usual opportunities for pauses, thus increasing the risk of cognitive overload (Wang, 2021).

In response to these constraints, interpreters at TED often decompose continuous discourse into finite, clause-like units, a strategy known as the "add-on" technique (Biber et al., 1999: 1068). As illustrated in Excerpt (2), the interpreter breaks the original input into more digestible chunks, using conjunctions like "and" and "so" to demarcate distinct ideas within a primary subject-verb structure.

Excerpt (2):

I was trying to catch my connecting flight **and** I had a suitcase with a defective wheel, **so** I'm really booking it, struggling with this damn suitcase, **and** I finally get to the gate **and** one of the airline agents comes up to me **and** tells me that I can't bring my bag onto the plane because it's so small, **so** I have to stow the baggage.

The add-on technique, commonly used in oral communication, facilitates syntactic processing by avoiding deeply embedded clauses that demand more cognitive resources (Biber et al., 1999). When applied to real-time interpretation, this approach is integral to reducing cognitive load on the interpreter. It enables them to transform dense and lengthy discourse into linear sequences that are easier to process, both for the interpreter and the audience.

6.3. Insights into information processing in SLI and SUBT

As Shlesinger and Ordan (2012) emphasize, a comparable intermodal approach can inform both translation and interpreting scholars regarding the inner workings of these two translational modalities. This comparison framework is exemplified in the present study, whose findings on lexical variation and sophistication can offer valuable insights to the information-processing demands of signed language interpreting and subtitle translation.

Regarding processing differences, SLI operates in a real-time, "online" manner (Wang, 2021). This characteristic imposes great cognitive demands on interpreters, compelling them to rely heavily on high-frequency vocabulary to reduce cognitive load (Gile, 2009). In contrast, SUBT benefits from a reflective, "offline" process, in which translators have ample time to carefully select and refine their lexicon. For instance, TED translators are typically allotted up to 30 days to render an 18-minute talk into subtitles. This extended timeframe, followed by multiple rounds of editing and quality assurance (Karakanta and Orrego-Carmona, 2023), allows for the inclusion of more nuanced and diverse vocabulary choices. As a result, the subtitled texts show a modest reduction in only five out of 18 lexical diversity metrics when compared to native speech. In stark contrast, the interpreted English from ASL exhibits a more pronounced reduction in lexical variation, with simplification evident across 17 metrics. The only lexical diversity metric showing no significant difference between interpreted and native English is NDW-50 (number of different words within the first 50 words). This may be attributed to the coherence-building strategies of ASL users in establishing the temporal and participant context early in the discourse (Taylor, 2002; Napier et al.,

[6] The screenshot in Fig. 7 and the transcribed interpretation in Excerpt (2) are selected from the signed presentation accessible at https://www.youtube.com/watch?v=pLBw9nYI_Ks.

2010). Such a preference for early contextual setup could prompt interpreters to use richer lexical choices at the outset of the interpreted discourse.

When considering both lexical density and variation, the results suggest that SLI is more information-dense but less lexically diverse than SUBT. In this study, lexical density is calculated by dividing the number of content words by the total running words (Lu, 2012). The higher lexical density in SLI reflects a greater proportion of content words relative to the total word count, indicating that more semantic information is conveyed in the interpreted output. However, this does not necessarily imply the use of a more diverse or richer vocabulary. In fact, the subtitled texts exhibit a broader range of content words across all categories (see Table 5). These findings support the notion that lexical density and lexical variation are essentially different constructs, as particularly emphasized by Lu (2012: 203), who noted that measures within the same dimension tend to correlate much more strongly than those across different dimensions. Although SLI carries a higher semantic load, it still features a more limited vocabulary range, which is considered an inevitable consequence of the real-time demands of interpreting, distinguishing it from written forms of translation.

Despite the differences in the immediacy of information processing required, both SLI and SUBT share the cognitive challenge of managing multiple streams of information concurrently. In SLI, interpreters must simultaneously process signed input, generate spoken output, temporarily memorize information, and divide their attention among these tasks (Wang, 2021). This concurrent processing, further complicated by intermodal transfer, imposes a heavy cognitive load on interpreters (Swabey et al., 2016), leading them to prioritize simpler words than native speakers. Similarly, subtitle viewers must divide their attention between reading subtitles, processing visual cues, listening to spoken dialogue, and attending to background sounds (Gottlieb, 1998; Kruger et al., 2015). Research has shown that increased lexical complexity in subtitles can lengthen the time viewers spend reading them (Lång et al., 2021). Therefore, to ease viewers' comprehension, TED's translation guidelines encourage the use of colloquial and universally accessible terms, contributing to a reduction in lexical sophistication in subtitled texts.

However, when comparing SLI to SUBT, the former displays a greater degree of simplification in lexical sophistication. This is evident in the substantial reduction observed across all four relevant metrics in the interpreted texts, relative to native speech (see Table 5). These patterns of lexical variation and sophistication lend support to the view of interpreting as an "extreme case of translation" (Shlesinger and Ordan, 2012: 54). Several studies on unimodal interpreting have noted a tendency for the interpreted output to overly emphasize spoken production features (Bernardini et al., 2016; Ferraresi et al., 2018; Lapshinova-Koltunski et al., 2021; Przybyl et al., 2022). This phenomenon holds true for bimodal interpreting as well, particularly when interpreting from signed language into spoken language. The high cognitive demands of intermodal transfer, coupled with the necessity for real-time processing, likely drive interpreters to favor repetitive and simplified vocabulary, resulting in an output that is, in a sense, "more spoken than spoken" (Przybyl et al., 2022: 211).

7. Conclusion

This study is the first to analyze linguistic complexity across interpreted English from ASL, subtitled English translations, and native English speech, using a self-constructed TED Talks Comparable Intermodal Corpus. By integrating SLI and SUBT into Shlesinger's (2009) intermodal comparison framework, we provide new insights into translational simplification, particularly regarding the effects of intermodal transfer on both interpreted and translated texts.

At the lexical level, our findings reveal that interpreted English from ASL does not exhibit a significant reduction in lexical density compared to native English; in fact, it shows higher lexical density than English subtitles translated from spoken French. This phenomenon may stem from the multi-layered structure of ASL, which facilitates the transmission of more information within the same timeframe, as opposed to the linear structure of French. In contrast, subtitle production inherently involves some degree of condensation, likely accounting for the observed reduction in lexical density. However, while interpreters transferring from a signed to a spoken language can convey substantial semantic information, they fall significantly behind subtitle translators in terms of vocabulary range. This discrepancy in lexical variation highlights the temporal constraints that set interpreting apart from translation. In terms of lexical sophistication, both interpreted and subtitled English use simpler vocabulary than native speech, reflecting the cognitive limitations associated with processing multiple streams of information simultaneously in both interpreting and subtitle viewing.

At the syntactic level, bimodal interpreting displays greater phrasal coordination than subtitle translation. However, both modalities show greater sentence-level coordination compared to native English, contrary to the patterns usually observed in unimodal interpreting and translation (Liu et al., 2023; Chen et al., 2024). The increased sentence coordination in SLI and SUBT is attributable to their specific operational constraints, particularly the segmentation requirements for subtitle blocks and the lack of visual interaction between interpreters and deaf presenters, as seen in TED Talks.

Several limitations of this study must be acknowledged. Firstly, the absence of a direct comparison between the lexical density of ASL and French restricts our ability to ascertain whether signed languages convey more information per unit of time than spoken languages. Such a comparison would clarify whether the modality of the source language influences the higher lexical density observed in interpreted versus subtitled texts. As noted by Kunilovskaya et al. (2023), the informativeness of source texts directly impacts the amount of information transmitted in target texts. Future research should address this gap, despite the transcription challenges posed by signed language data. Secondly, the broad linguistic metrics employed, particularly lexical density (the ratio of content words to total words), may yield seemingly contradictory results when considered alongside measures of lexical variation. Future studies should adopt more robust metrics, such as "surprisal" from information

theory (Kunilovskaya et al., 2023), to provide a more accurate assessment of the informativeness of mediated products. Additionally, applying advanced language modeling techniques (e.g., Lapshinova-Koltunski et al., 2021; Przybyl et al., 2022) could yield deeper insights into the linguistic patterns in SLI and SUBT. Finally, the findings of this study are derived exclusively from the TED Talks context. Future research should explore SLI and SUBT in diverse contexts and investigate English interpretation from other signed languages (e.g., Australian or British Sign Language) as well as English subtitles from spoken languages beyond French. This would enhance the generalizability of the simplification patterns resulting from intermodal transfers.

CRediT authorship contribution statement

Ruitian Li: Writing – original draft, Investigation, Formal analysis, Data curation. **Kanglong Liu:** Writing – review & editing, Visualization, Validation, Supervision, Investigation, Data curation. **Andrew K.F. Cheung:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Author notes

Data concerning the study are publicly available on Open Science Framework (https://osf.io/mdg9f/).

Data availability

Data concerning the study are publicly available on Open Science Framework (https://osf.io/ukh76/).

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