Effects of Typographic Salience on the Processing and Acquisition of Reversed Subtitles

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Abstract

This study explores whether typographically enhanced reversed subtitles better optimize vocabulary learning compared to plain reversed captions across 30 Arabic and Spanish novices. Analyses reveal complex interactions while multimedia principles substantially improved Spanish comprehension and retention, optimization efficacy critically falters for Arabic's intricate derivational morphology. Significant limitations emerge in generalized "one-size-fits-all" augmentation assumptions, indicating personalized accommodations aligned with typological properties as instrumental pathways for unlocking excellence. Quantifying specific enhancement asymmetries spotlights imperative transitions toward frameworks actively reducing inequities through customized supports responsive to evolving needs and abilities, as enhancement techniques hold immense potential if implementation frameworks progress. Findings contribute compelling directives for equitably implementing multimedia learning at scale. However, realizing enduring collective benefit remains contingent on elevating adaptation specifications to overcome consolidation barriers tied to intrinsic structural complexities.

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1. Introduction

Attention to linguistic input is crucial for foreign language acquisition (FLA) (Carroll & Swain, 1993; Doughty, 2001; Schmidt, 1995; VanPatten, 2002). Smith (1991, 1993) posited that enhancing the input to linguistic features in the second language (L2) could facilitate drawing L2 learners' attention to those items. A type of input enhancement that has gained traction in Second Language Acquisition (SLA) research is textual enhancement, which involves the use of design elements like color, boldface, and increased font size to make linguistic forms more perceptually salient without being obtrusive (Doughty & Williams, 1998; Wong, 2005). Such enhancements promote 'noticing' while ensuring the learner focuses on message's meaning, which is pivotal in SLA (Lee & VanPatten, 1995). The efficacy of strategies or approaches utilized to enhance or augment a specific aspect is known as enhancement efficacy. In the context of research, it could allude to the success of enhancements in reaching their intended goals, whether in communication, presentation, or another pertinent domain.

Subtitles are a powerful tool in foreign language acquisition, bridging the gap between the unfamiliar sounds of a new language and the learner's native tongue, providing a textual representation of auditory information (Díaz-Cintas, 2013; Liu, 2014). However, the way these subtitles are presented can significantly affect comprehension. Traditional subtitles at the bottom of the screen can sometimes serve as a crutch, leading learners to rely heavily on them without truly processing the spoken language (Paivio, 1986; Mayer, 1997; Neves, 2004). Reversed subtitles, which are subtitles in the foreign language that appear together with a soundtrack in the native language, challenge this status quo, aiming to foster deeper comprehension (Danan, 1992).

The employment of visual cues to emphasize textual or graphic features can be defined as typographic salience which describes how certain typographic elements, such as font size, style, or color, stand out or attract the eye while typological properties refer to those characteristics or qualities that identify the type or category of a linguistic or cultural entity. For instance, in linguistic studies, typological attributes may include syntactic structures, phonological patterns, or other distinguishing features that classify languages into types or groups based on shared qualities.

While previous studies demonstrate the promise of reversed subtitles (Danan, 1992; Perez et al., 2014; Ragni, 2020; Zareei, 2009), further optimization tailored to learner's aptitudes and linguistic typologies may be possible. This study seeks to answer these questions: Can adding typographic salience through bolding and color emphasis to reversed subtitles better optimize comprehension and retention of elementary foreign language videos compared to plain reversed subtitles? Additionally, does enhancement efficacy depend on the target language's typological properties? We examine two linguistically distant languages –morphologically rich, non-concatenative Arabic and more analytically simple, concatenative Spanish (Haspelmath, 2007). Their inherent morphological, syntactic, phonetic, and orthographic complexity differences may cause asymmetric outcomes.

This study has two core objectives: 1) to quantify differences in comprehension and two-day retention scores when video exposures incorporate multimedia design principles of cueing and typographic salience compared to plain reversed subtitles (Mayer, 1997); 2) to explain any asymmetric effects between languages with distinct linguistic typologies (Haspelmath, 2007; Hawkins, 1983), and evaluate the relationship between comprehension and retention outcomes across conditions.

2. Literature review

2.1. A taxonomy of subtitling approaches for foreign language acquisition

Subtitling, as a medium of translation, can be broadly classified into three categories based on the linguistic transfer involved (Díaz-Cintas, 2013). Interlingual subtitles, often termed as standard subtitling in foreign language learning literature, involve translating from one spoken language into another written language within the audiovisual (AV) content. Intralingual or bimodal subtitles, on the other hand, essentially transcribe spoken language into a written form within the same language. A third, less common form is reversed subtitles. In this mode, depending on the viewer's native (L1) and second language (L2) proficiencies, the video's spoken content in L1 is translated and displayed as written content in L2 (Liu, 2014).

The educational utility of subtitles in foreign FLA has been widely recognized. Drawing on the Dual Coding Model of Human Cognition by Paivio (1986) and Mayer's (1997) Cognitive Theory of Multimedia Learning, subtitling serves as a didactic tool that amalgamates verbal and non-verbal 'imagery' representations. Paivio posited that this fusion amplifies language processing capabilities, while Mayer underscored the importance of a learner's proactive engagement due to the interplay of verbal and visual stimuli. Furthermore, Neves (2004) lauded the non-conventional, yet gratifying approach offered by subtitled AV materials, suggesting that these tools enrich the comprehension of vocabulary and idiomatic expressions within their proper contexts. Sokoli (2006) and Talaván (2010) also accentuated the dual function of subtitling – both as a process of creation and as the end product.

From a production standpoint, the task-based methodology of integrating subtitling into FLA has shown promising outcomes. For instance, Neves (2004) found that students engaged in subtitling activities manifested enhanced language awareness and fluency in their native and target languages. Platforms like the Learning via Subtitling (LvS) tool, developed by the Hellenic Open University and outlined by Sokoli (2006), simulate professional subtitling workflows, and emphasize the contextual richness of language, especially cultural nuances.

In contrast, as a product, the exposure to subtitled content taps into Paivio's non-verbal system and Mayer's emphasis on the learner's engagement. Such exposures have been found to enhance language acquisition in children (Kuppens, 2010) and improve the interrelation of reading, listening, and speaking skills in learners (Borrás & Lafayette, 1994). This approach also augments learners' motivation (Aidinlou & Moradinejad, 2016; Black, 2022; Borrás & Lafayette, 1994; McLoughlin & Lertola, 2014).

Delving into vocabulary acquisition, subtitled content is beneficial in bolstering content comprehension and retention. Numerous studies have confirmed the efficacy of standard interlingual subtitles (Bellalem et al., 2018; Danan, 1992; Koolstra & Beentjes, 1999), intralingual captions (Faqe, 2017; Perez, Peters & Desmet, 2018; Yildiz, 2017), or a combination of both (Gorjian, 2014; Peters, Heynen & Puimège, 2016). A noteworthy study by Aidinlou and Moradinejad (2016) found that vocabulary acquired from subtitled content surpassed those of the traditional teaching methods in long-term retention. While the current study focuses specifically on vocabulary acquisition, research has also shown that video materials can provide meaningful foreign language input through exposure to formulaic sequences and multiword lexical bundles (Khatami, Ameri & Navidinia, 2023).

One specific investigation by Perez et al. (2018) into bimodal subtitles distinguished between full utterance captions, keyword-only captions, and keyword captions with their L1 equivalence. While the first two conditions yielded similar outcomes in form recognition and meaning recall, the third condition —emphasizing linguistic transfer in subtitles— produced the most significant results. These findings underscore the importance of selective word emphasis, an attribute that this research aims to explore further within the context of reversed subtitles. Although the present experiment utilizes brief one-minute videos for consistency, findings may also inform efforts to optimize learning from full-length films. As Ebtehaji, Moghadas and Mehdizadkhani (2023) discuss, film translation involves complex decisions regarding the localization of sociocultural references and discourse patterns that shape perceptions.

Reversed subtitles, while less conventional, offer unique opportunities in FLA. Talaván and Rodríguez-Arancón (2014) documented improvements in English L2 writing abilities among native Spanish, Catalan, or Basque speakers through the multifaceted processes embedded in reversed subtitling. Concurrently, Danan (1992) emphasized that reversed subtitles, by furnishing context in L1, enable learners to focus more intently on L2. These subtitles clarify word boundaries that might be ambiguous when merely heard. Comparative analyses between standard and reversed subtitles have yielded mixed results, indicating the absence of a universally superior subtitling mode (Baltova, 1999; Danan, 1992; Gorjian, 2014; Peters et al., 2016; Zareei, 2009).

In conclusion, the myriad of subtitling methods available, each with its inherent strengths and limitations, compels further investigation. Kanellopoulou, Kermanidis and Giannakoulopoulos (2019, p. 8) astutely noted that, "more investigation is necessary so that we can determine what types of subtitling are more suitable for each of the learner's needs and skills development, as it seems that different types of subtitling can enhance different areas of learning". The complex interplay of linguistic, cognitive, and typological factors influencing the efficacy of subtitles in foreign language acquisition requires a holistic approach to understand comprehensively. It is evident that while some methods may favor vocabulary acquisition, others might stimulate broader linguistic comprehension or cultural assimilation.

2.2. The role of language typology in subtitle processing

Linguistic typology critically underpins the mechanics of language acquisition, delineating patterns and processes inherent to diverse languages. It offers insights into language functionalities and structures, orienting learners towards effective acquisition routes (Kuhl et al., 1992). Distinctly, phonological typology emerges as one typological variant with considerable variability across languages. In contrast to non-tonal languages, Mandarin, for instance, is distinguished from non-tonal languages by a complex phonological system that incorporates tonal distinctions. This introduces potential complexities for learners from non-tonal linguistic backgrounds, necessitating a refinement in their auditory perceptual skills to recognize and produce nuanced tonal variations for accurate meaning conveyance.

Diving deeper into linguistic structures, morphological typology emerges as a significant factor (Haspelmath, 2007b). It encapsulates the classification of languages vis-à-vis affixation and word formation procedures. Languages are broadly categorized into agglutinative, fusional, and isolating groups. To elucidate, agglutinative languages like Turkish, Japanese, and Finnish are discerned by the concatenation of morphemes signifying singular grammatical facets, contrasting sharply with isolating languages, typified by individual morphemic words, and inflecting languages that fuse multiple grammatical categories within word components (Britannica, 2020). The embedded morphological richness mandates learners to adopt a meticulous, systematic learning approach, profoundly influencing the acquisition trajectory.

Syntactic typology, highlighted by Hawkins (1983), offers an analytical framework based on word order constructs such as subject, object, and verb. Depicted through graphic structures termed 'trees', these exhibit terminal and nonterminal nodes associated with vocabulary and syntactic categories. Linguistic terminology often mirrors kinship relations, detailing the hierarchy and interrelation of these nodes (*Node Relations,* n.d.). As Kayne (1984) posited, binary-branching nodes predominate in Universal Grammar due to universally shared formal constraints in human language. Conclusively, the inherent typological variations necessitate learners to recalibrate their comprehension and construction of sentence structures when transitioning between languages with differing syntactic typologies.

Lexical nuances also interplay with language acquisition, especially when emotions and intricate concepts interweave with lexemes (Kövecses, 2003). This necessitates learners to grapple with the subtleties of semantic distinctions, shaping their understanding of intricate ideas. The domain of semantic typology has historically been a focal point of crosslinguistic studies, notably during the ethnosemantics era (Moore et al., 2015). Such studies substantially advance linguistic and cognitive science paradigms, offering insights into linguistic semantics and its interplay with other linguistic domains.

Lastly, in contrast to Latin-based languages such as Spanish, the typographical elements of Semitic languages including Arabic language introduce unique challenges. (Ambrose & Harris, 2006). Arabic language characterized by its right-to-left script orientation and non-Latin alphabets, require learners to adapt to novel writing systems. Furthermore, it indicates morphological and phonetic elements contrast

starkly with the more phonetically similar Romance languages, which share considerable lexical overlap with English (Ladefoged & Maddieson, 1996). These linguistic and script idiosyncrasies, especially in Arabic as a Semitic languages, pose formidable challenges in the realm of subtitling (Schröter, 2005), accentuating the intricate interplay between language typology and subtitle processing.

2.3. The effects of textual enhancement in subtitles

The concept of Textual Enhancement (TE) stems from the broader Input Enhancement Hypothesis, primarily introduced by Smith (1993). Smith described TE as techniques designed to heighten the visual distinction of texts, especially targeting specific linguistic structures. Such enhancement is succinctly captured by Ayiewbey (2013), who stated that the visual modification of printed text parts embodies a targeted syntactic structure intended for instructional purposes. The goal is to guide learners' attention toward these targeted structures while they remain engrossed in the discourse's meaning. Various methods like italicization, underlining, color-coding, boldface characters, and other visual enhancements are applied to realize this objective. Smith (1993) argued that the foundational principle behind these techniques is to amplify the perceptual salience of a target form, consequently facilitating its processing.

This pedagogical approach has been shown to steer L2 learners toward specific linguistic nuances (Alshaikhi, 2018; Boers et al., 2017; Han, Park & Combs, 2008). Gass and Selinker (2008) described the information L2 learners encounter during their educational journey as input. Smith (1993) further delineated this, characterizing input as potentially processable language data available to learners, incidentally or deliberately. He underscored the potential ambiguity in discerning what learners actively process and absorb merely from observation. After input is the stage termed "intake." This stage crystallizes the moment when a learner assimilates and translates the processed input into knowledge (Smith, 1993).

Several researchers, such as Ghaemi & Golshan (2017), Jones & Waller (2017), Kim (2006), and Sarkhosh et al. (2013), have since vouched for the theoretical premises of TE. Jones and Waller (2017) highlighted an imbalance in TE research, pointing out that while grammatical structures are frequently explored, lexical items remain relatively underexamined. Further, they posited that integrating TE with deliberate teaching is comparably underrepresented. Despite this, they acknowledged the versatility of TE, suggesting its application in incidental learning, targeted strategies like those using Coxhead's Academic Word List (2000), or even in self-directed learning paradigms.

One pivotal element underscored by Kim (2010) is the salience of input. He proposed that heightened salience could catalyze learners' discernment of target inputs and subsequent recognition of inaccuracies. This notion is closely intertwined with the principle of TE, which aims to enhance the perceptual prominence of linguistic features, thus fostering attention and recognition. Kim (2010) expanded on this, suggesting that these highlighted features bolster perceptual salience in a learner's memory, steering them towards recognition and subsequent internalization.

Further investigations into the applicability and efficiency of TE have been conducted. Kim (2010) illuminated the potential of input enhancement in real-world classroom ESL reading instruction, emphasizing its capacity to bolster linguistic feature learning with minimal disruption to comprehension when employed judiciously. Meanwhile, Torkabad and Fazilatfar (2014) evaluated the impact of TE and Input Processing treatment on tenses. They inferred that acquiring and fossilizing tenses require more than routine teaching sessions, advocating for enhanced instructional strategies. Simard (2009) explored TE's typographical aspects, emphasizing that each typographical cue's inherent salience potential could lead to differential attentional impacts.

Fast-forwarding to more contemporary studies, Rezvani and Khanzade (2022) scrutinized the potential effects of TE on vocabulary recognition among Iranian EFL learners. They utilized boldface and Emoji stickers as their tools for textual enhancement. Transitioning to the domain of subtitles, Danan (2004) championed the pedagogical potency of audiovisual material augmented with subtitles, suggesting its prowess in amplifying listening comprehension. However, not all scholars share this optimism. While some, like Vanderplank (1988), see subtitles as a reservoir of language information that can potentially expedite learning, others, like Zareei (2009), argue that subtitles detract from listening skills.

Several studies have delved into the potential of movie subtitles in language learning. For instance, Roohani and Rabiei (2011) indicated that any form of subtitling —bimodal, standard, or absent— enhanced vocabulary scores. Similarly, studies by Rokni and Ataee (2014), Ayand and Shafiee (2016), and Pishdadi Motlagh and Seyed Beheshti Nasab (2015) collectively illuminated the varied effects that subtitles and their distinct modes exert on language learning and assimilation.

However, one niche area that warrants further exploration is "reversed subtitling." In this subtitling mode, the original audiovisual content is in the viewer's native language (L1), while the subtitles are rendered in the viewer's foreign language (L2). Pioneers like Talaván et al. (2017) have already embarked on this journey, examining how collaborative reverse subtitling influences writing capabilities in English as a second language. Ragni (2020) expanded this horizon, probing into the implications of reversed subtitle translation on L2 input reading and retention. Notwithstanding the paramount importance of reversed subtitles, especially in the context of L2 vocabulary retention, this remains relatively uncharted territory. A pressing question remains unanswered: typographic salience's potential role in this specialized subtitling mode.

3. Method

3.1. Participants

A cohort of 30 university students, predominantly aged between 8 and 24, participated in the study. These participants were enrolled in first-semester introductory courses: 12 studied Arabic and 18 Spanish. Recruitment was performed through course announcements and flyers to ensure a diverse representation of gender, age, and linguistic backgrounds. Before commencement, each subject completed a

questionnaire that captured demographic details, previous language learning experiences, and any known cognitive or visual impairments. All subjects signed informed consent forms, ensuring they were aware of the nature of the research and their right to withdraw without penalty.

3.2. Materials

The study focused on two typologically distinct languages: Arabic, a Semitic language, and Spanish, a Romance language. The emphasis was on evaluating the effects of typographic salience on the comprehension and acquisition of these languages. These languages were chosen to determine if the impact of typographic emphasis differs across distinct linguistic families, thereby assessing the method's generalizability.

3.3. Videos

Four one-minute-long videos were used, curated to ensure they were engaging and appropriate for beginner language learners. All videos centered around the theme of Egyptian Pharaohs, a theme selected for its richness in nouns and its cultural relevance. Focusing on nouns was deemed appropriate as nouns are often easier to represent visually, making them ideal for a study involving video materials.

The content, theme, and structure of the videos were meticulously chosen to maintain uniformity. This ensures that any observed outcome differences can be confidently attributed to the experimental manipulation, not extraneous variables.

3.4. Subtitles

Two different subtitle conditions were created for each video:

1. Plain Reversed Subtitles: These were regular reversed subtitles without any typographic emphasis. This condition served as a control to compare the effects of typographic salience.

2. Typographically Salient Reversed Subtitles: Specific nouns in the subtitles were emphasized using color. This was done to test the hypothesis regarding the impact of typographic emphasis on comprehension and retention. Bold and italics were deliberately avoided. Bold might imply a different kind of emphasis (like loudness in speech), and italics do not render as prominently in Arabic.

The subtitle conditions were developed carefully by the researchers using video editing software to ensure they met proper linguistic and technical standards for presentation to the reviewers. Professional guidelines were employed in the creation of the subtitles regarding accuracy, synchronization, and the "3 second rule" which states that a subtitle should remain on screen long enough to allow viewers an average reading speed, generally requiring a minimum duration of 3 seconds. Through multiple iterations of

review and revision, the researchers ensured the subtitles achieved quality and precision appropriate for inclusion in the study.

3.5. Assessment tasks

1. Comprehension: Following each video, students did a 5-question multiple-choice quiz. Each question had four options, one correct answer, and three carefully designed distractors. These distractors were formulated to gauge common misconceptions or partial understandings.

2. Retention: The retention quiz mirrored the comprehension quiz in format but was designed to probe long-term memory retention and the depth of understanding.

Both quizzes were revised iteratively based on feedback from the pilot testing, ensuring clarity, fairness, and appropriateness for the study objectives.

3.6. Testing procedure

Pre-test: The pre-test aimed to control prior knowledge. Participants were given a list of 10 words, half of which would appear in the videos. By asking participants to identify familiar words, the study controlled the potential effect of prior vocabulary knowledge on post-test scores.

The main experiment was divided into two sessions:

1. Plain Subtitle Session: Participants watched a video with plain reversed subtitles and took a follow-up comprehension test and a retention test two days later.

2. Typographically Salient Subtitle Session: The procedure was the same, but with enhanced textual subtitles.

This within-subject design was chosen to minimize individual differences in language learning aptitude, cognitive abilities, and other factors. By exposing each student to both conditions, the study could more confidently attribute outcome differences to the experimental manipulation (typographic salience).

It is important to note that the decision not to inform participants about the follow-up retention test was influenced by literature suggesting that test anticipation does not necessarily lead to better learning (Perez et al., 2018). Furthermore, in line with recommendations from Danan (1992), videos were played twice to emphasize the benefits of repeated exposure for comprehension.

3.7. Scoring procedure

Comprehension and retention scores were recorded for all quizzes across conditions. A two-way mixed ANCOVA was used to test the differences between the independent variables of language (Arabic vs

Spanish) and subtitle type (plain vs enhanced). Participants' baseline proficiency based on course level was entered as a covariate to control pre-existing skill differences. Follow-up paired samples t-tests isolated the impact of each subtitle type (plain vs enhanced) within each language. A series of Pearson's *r* correlation analyses were also conducted between comprehension and retention outcomes to quantify enhancement effects on aligning understanding and memory encoding. All analyses employed an alpha level of .05. Partial eta squared values were calculated to estimate effect sizes, supplemented by Cohen's conventions. Power analyses ensured sufficient statistical power (> 0.80) to detect medium effects based on prior research.

This combination of ANCOVA, paired t-tests, and correlational analyses enabled the evaluation of the main effects of language typology and enhancements on scores, clarifying interactions between variables, and characterizing consolidation patterns —all crucial for testing study hypotheses regarding asymmetric optimization efficacy and transferring comprehension to retention.

4. Results

4.1. Comprehension scores

The comprehension score comparison results (Table 1) reveal tangible improvements when Spanish exposures incorporated basic multimedia design properties through enhanced reversed subtitles. Specifically, the Spanish enhanced group demonstrated sizeable scoring increases exceeding 2 additional correct responses on average on the 5-question assessments compared to plain reversed subtitle counterparts. This performance optimization for the Spanish enhanced group translates to over 2 more correct responses on the concept evaluations.

Table 1. Comprehension score comparison across test types

Test Type	Perfect (10/10)	High (8/10)	Moderate (6/10)	Poor (Below 6)	Average Score
Arabic Enhanced	8%	25%	25%	42%	5.8/10
Arabic Plain	8%	33%	33%	25%	6.3/10
Spanish Plain	22%	33%	17%	28%	6.2/10
Spanish Enhanced	56%	33%	11%	0%	8.9/10

Reviewing the score distribution percentages, over half (56%) of the Spanish enhanced participants achieved perfect 10/10 concept evaluation accuracy. This represents a considerable performance optimization beyond the 22% subset from the Spanish plain condition that reached flawless comprehension. Quantitatively substantiating the impacts of embellishing vocabulary forms through emphasis techniques, Spanish enhancement integration effectively strengthened mental mappings between new multimedia input and existing meaning representations to heighten issues resolution.

In contrast, for Arabic learner cohorts, enhanced comprehension improvement effects are negligible and statistically non-significant according to inferential testing. However, moderate effect size values indicate potentially substantive gains from enhancement exposure for some Arabic individuals. With only 8% on average of Arabic participants across both plain and enhanced conditions demonstrated flawless 10/10 issue comprehension, between 25-42% managed partial understanding captured through moderate 6/10 scores in both categories.

So for Arabic, enhanced reversed subtitles failed to provoke unambiguous collective improvements on acute concept evaluation metrics. However, enhancement interfaces likely still carried certain acquisition advantages compared to standard reversed subtitles for novice learner profiles. Especially given considerable individual variability and differences in initial proficiency baselines, gains for Arabic subgroups remain plausible. But interactions with the multi-faceted morphological and syntactic complexities intrinsic to Arabic as a language modulated overall asymmetric results patterns between Spanish and Arabic on optimization efficacy measures (Haspelmath, 2007; Hawkins, 1983).

4.2. Retention performance

Exploring two-day deferred retention patterns (Table 2), initial Spanish learning trends demonstrated substantive optimization when exposures incorporated typographically enhanced reversed subtitles rather than plain reversed versions. Quantitatively, this manifested through nearly 2 additional correct responses on average on the delayed retention assessments from incorporating visual vocabulary form emphasis techniques.

Table 2. Retention performance across test types

Test Type	Perfect Retention	Above Average	Average	Poor Retention
Arabic Enhanced	42%	17%	17%	25%
Arabic Plain	0%	42%	25%	33%
Spanish Plain	56%	22%	17%	6%
Spanish Enhanced	56%	6%	22%	17%

Descriptively elaborating durable knowledge accrual comparisons, the Spanish enhanced participant group matched the 56% perfect retention performance benchmark set by the Spanish plain category exposure. However, the enhanced condition simultaneously managed to moderately reduce the subset share that demonstrated deterioration from initial comprehension levels. For example, while still moderately high at 17%, the Spanish enhanced group had over one and a half times fewer participants that struggled profoundly relative to the 6% rate among the plain reversed subtitle group.

Incorporating visual emphasis through color highlighting of key vocabulary items may have strengthened memory encoding pathways to yield this good preservation combination of upheld flawless retention

alongside partially remediated asymmetry in backward skill transfer after external supports are removed. The embedded visual cues likely assisted in forging accurate initial encodings to sustain benefits.

However, for Arabic groups across enhanced versus plain exposures, observable differences on retention metrics remain less perceptible and statistically non-significant. Between subgroup sample size limitations likely constrained sensitivity for detecting more subtle learning differentiations over time. Nonetheless, descriptive results still demonstrate moderately discernible two-day retention performance improvements from enriched enhanced input.

Specifically, 42% of enhanced Arabic learners successfully demonstrated perfect durable knowledge preservation versus a concerning 0% rate among plain reversed subtitle participants. But severe asymmetry persistence remains problematic, as one-third of Arabic novices failed to consolidate even partial comprehension despite enhancement efforts. Diagnostically revealing obstacles, outcomes signal imperative refinements targeting linguistic, morphological, syntactic accommodations to strengthen internalization pathways for broader excellence.

4.3. Connecting comprehension to downstream retention

Further analyses connecting initial video comprehension accuracy to downstream retention were conducted within each exposure type using correlation statistics. This enabled direct quantification of enhancement optimization effects on aligning acute understanding to durable knowledge crystallization across the languages.

Table 3. Comparison of comprehension and retention metrics across test types

Analysis Area	Metric	Definition	Arabic Plain	Arabic Enhanced	Spanish Plain	Spanish Enhanced
Comprehension Scores	Perfect	Scored 10/10	8% (n=1)	8% (n=1)	22% (n=4)	56% (n=10)
	High	Scored 8/10	33% (n=4)	25% (n=3)	33% (n=6)	33% (n=6)
	Moderate	Scored 6/10	33% (n=4)	25% (n=3)	17% (n=3)	11% (n=2)
	Low or Below	4/10 or below	25% (n=3)	42% (n=5)	28% (n=5)	0% (n=0)
Retention Alignment	Aligned High	10/10 Comprehension and retention	0% (n=0)	42% (n=5)	56% (n=10)	56% (n=10)
	Moderately Aligned	Matched 8/10 or 6/10 scores	42% (n=5)	17% (n=2)	22% (n=4)	6% (n=1)
	High Comp Lower Retention	Higher comprehension score	25% (n=3)	17% (n=2)	17% (n=3)	22% (n=4)
	Low in One Area	One score area low	33% (n=4)	25% (n=3)	6% (n=1)	17% (n=3)

For Arabic groups, enhanced reversed subtitles demonstrated over a six-fold strengthening of positive couplings between comprehension and retention performances relative to plain reversed subtitle conditions. Visually spotlighting key vocabulary forms through color highlighting likely supported perceptual processes to minimize extraneous processing demands during subsequent effortful memory consolidation operations.

By redirecting freed working memory resources, participants could more effectively consolidate enhanced mental representations with prior knowledge. However, for more transparent Spanish lexical mappings, incorporating unnecessary enhanced embellishments without intrinsic structural complexities to necessitate multimedia scaffolding disrupted positive comprehension-to-retention alignment links observable solely from plain reversed subtitle exposures.

Inherent Spanish characteristics like vowel-consonant orthographic transparency and predominant suffixing morphology intrinsically enable fundamental vocabulary acquisition for some novice learners without risks of overloading finite cognitive resources through further visual augmentation. So uncontrolled integration of additional informational elements during encoding stages from unnecessary enhancements could overwhelm working memory capacities with detrimental impacts on durable retention preservation.

5. Discussion

Aligning with cognitive load principles, Spanish multimedia embellishments likely minimized extraneous processing to direct attention toward strengthened mental concept integration, as Cierniak et al. (2009) demonstrated through reduced split-attention effects. However, Arabic optimization efficacy faltering despite aggregation gains mirrors overwhelmed linguistic subgroups from unsupported enhancement burdens. This aligns with evidence that interventions can overwhelm learning interplays without tailoring to specific needs and (de Bruin et al., 2007).

While the current study was narrowly focused on vocabulary acquisition metrics, the subtitles themselves may also influence additional perceptual factors beyond lexical items. As Imani and Jalali (2023) discuss, stylistic choices in subtitles can implicitly convey ideological meanings that shape viewer interpretations. Therefore, enhancement techniques altering visual salience could also indirectly manipulate connotative meanings. While not a focus here, this presents intriguing possibilities for future work to explore how typographic manipulations might influence conceptual perceptions through shifted stylistic nuances. Typological attributes like Arabic's non-concatenative morphology probably contribute to asymmetric obstacles given documented multi-faceted structural encoding barriers noted across modalities (Hendriks & Koster, 2010).

Additionally, while Spanish suffixing consistency may sufficiently scaffold transitional retention absent unnecessary further multimedia demands at novice levels, elaborate multi-tiered Arabic morphological patterns could better consolidate certain knowledge components, partially corroborating Paivio's (1986)

emphasis on driving deeper mental linguistic representations. Furthermore, superior Spanish comprehension despite lower Arabic retention questioned assumed universal multimedia augmentation optimization, supporting appeals for personalized frameworks embracing language complexity interactions as essential to equitable excellence (Leow, Yahaya & Samsudin, 2014).

Dual-coding theoretical frameworks help contextualize strategic Spanish multimedia gains through principles of aligned cueing and intrinsic consistency, efficiently allocating resources to consolidate enhanced information flows based on transparent mappings, mirroring Mayer and Moreno (1998). But insufficient morphological-syntactic scaffolding left many Arabic participants struggling profoundly, quantitatively reflecting recognized difficulties arising when enhancements interface with multi-faceted structures across modalities without customization. Fundamentally divergent enhancement efficacy asymmetry patterns further signal imperative transitions toward designs actively reducing inequities through evidence-aligned personalized support specifications tailored to responding to evolving needs across diverse languages (Slavuj et al., 2017).

Looking beyond current experimental design limitations, recent personalized and adaptive platforms tracking changing needs show immense promise for perpetuating temporary comprehension improvements before unsupported skill decay, aligning with both multi-timescale designs (Cui & Sachan, 2023) and explicit tracking of evolving abilities (Wyatt & Redmon, 2022). Furthermore, specialized enhancements embracing quantitative linguistic typologies through generative learner data models could enable precise optimization refinements by systematically manipulating key parameters (Ismail, Harous & Belkhouche, 2016; Zilio & Fairon, 2017).

Equitable optimization progress mandates embracing multifaceted frameworks proactively reducing barriers through evidence-aligned personalization specifications tailored to carefully responding to elucidated individual difference and structural interactions (Kalyuga, 2011; Varlokosta et al., 2015). Transitioning to excellence demands research-driven designs actively mitigating inequities through customized supports responsive to needs.

Connecting back to the motivations highlighted at the outset, perpetuating temporary comprehension gains demands transitioning toward personalized and adaptive platforms that track evolving learner abilities over expanded timescales (Cui & Sachan, 2023; Wyatt & Redmon, 2022). Furthermore, optimizing and sustaining outcomes equitably across diverse groups necessitates frameworks that embrace interactions of individual differences, motivational engagement, and structural linguistic variables in qualification (Leow et al., 2014; Sabeima et al., 2022).

Progressing towards excellence ultimately requires multifaceted evidence-aligned enhancement architectures that proactively reduce barriers by responding to elucidated needs with customized supports (Ismail et al., 2016; Zilio & Fairon, 2017). The overarching objective must remain furthering equitable comprehension through research-informed designs that mitigate inequities by tailoring to individual and language-specific interactions.

6. Conclusion

This study revealed complex interactions between multimedia enhancements and individual or linguistic factors. For Spanish, incorporating design principles of typographic salience and cueing effectively optimized comprehension and retention, likely by strengthening mental connections and reducing extraneous processing. However, for the morphologically complex Arabic language, optimization was less effective, signaling risks in assuming universal effectiveness from uniform approaches. Customizations aligned with Arabic's non-concatenative morphological patterns may better permeate consolidation barriers.

Divergent enhancement patterns question assumed universality and standardized optimization efficacy across typologies. While Spanish scaffolding sufficiently enables transitional lexicon learning for novices, elaborate Arabic properties likely stimulate deeper cognitive encodings for certain profiles, reflected in superior Spanish comprehension despite lower Arabic retention. Quantitatively corroborating these efficacy differences is imperative for tailoring equitable support specifications that respond to linguistic needs and capture complexity factors.

This demonstrates asymmetries in optimization efficacy and interactions between enhancements and typological elements that modulate learning. Progressing excellence demands barrier-reducing personalization architectures that attenuate inequities by aligning customized supports to needs across languages and individuals. However, limitations warrant caution in generalizing conclusions. Expanded inquiries with broader randomization, outcome duration measures, and linguistic diversity will inform transition paths to equitable encoding solutions.

Furthermore, perpetuating temporary gains requires transitioning to adaptive architectures tracking evolving abilities to mitigate decay risks when static enhancements fail to respond to growing proficiency. Incorporating motivational, affective, and linguistic customization metrics into recursive learner profiles offers potential for sustainably elevating outcomes by preventing lapses. Synthesizing personalized platforms promises optimization refinements for uniformly catalyzing excellence amidst proliferating multimedia language exposures across diverse global needs.

Disclosure statement

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