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Cognitive Constraints on Sentence Processing: Evidence for an Interface between Working Memory and Grammar

*Ebtisam Fathi Eqnejewa

University of Alasmarya, Faculty of Humanities, Department of English, Libya

*Ebtisamegnejewa90@gmail.com

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Abstract

Sentence processing refers to the ability to understand language, a complex cognitive activity that allows humans to produce an unlimited number of sentences. This ability is closely linked to working memory, a system with limited capacity that temporarily stores and processes information during comprehension. This study explores the relationship between working memory and grammar by reviewing key theoretical models related to working memory and sentence processing. Unlike previous research that has mainly relied on laboratory tasks and focused on native speakers, this study examines English as a Foreign Language (EFL) of 30 university students' own experiences with understanding complex sentences. It followed a mixed method research design. Data were collected through a questionnaire and semi-structured interviews. The study results reveal that there are several factors affecting the comprehension of complex structure. For instance, comprehension, attention and contextual clues. The findings discuss in light of existing theories, highlighting how cognitive constraints influence sentence comprehension. Given its exploratory nature and sample size, the study provides preliminary insights intended to inform future large-scle research on cognitive constraints in L2 processing.

Key words: *working memory, grammar, sentence processing, cognitive constraints, language comprehension*

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1. Introduction

Sentence processing is the ability to comprehend language, as Clark & Clark (1977, p.3) stated it "involves multiple interacting mechanisms". This process is a complex procedure of human cognition. The human capacity for language is fascinating, as it utilizes an infinite number of sentences from a finite number of rules. However, this procedure is connected with working memory, which is defined as a limited-capacity system for the temporary storage and manipulation of information. Just & Carpenter (1992, p.123) stated that "sentence comprehension places heavy demands on working memory resources, particularly when processing complex syntactic structures". The study aims to analyze how working memory, attention, and contextual clues affect the ability to comprehend complex sentences. This paper is organized to start with reviews of critical theoretical debate on the interface between working memory and grammar. It presents models that emphasize this interface while reviewing major theoretical approaches to working memory. After collecting data by questionnaire and interview, the findings will be discussed in the data analysis section. Moreover, this paper discusses the implications of cognitive constraints for teaching English as a foreign language. Although many studies have studied the interface between cognitive constraints and sentence comprehension, they relied on laboratory experience or sentence processing tasks. Less attention has been given to learners' self-reported experience. Furthermore, the existing research focuses on native speakers, leaving a gap in understanding how EFL university students proceed to comprehend complex sentences.

1.2 Research problem

This paper focuses on investigating how cognitive constraints affect sentence processing. It aims to understand how limitations in working memory influence the comprehension of sentences.

1.3 Research questions

1. How do working memory constraints affect the comprehension of syntactically complex sentences?
2. How do attention mechanisms influence the processing of complex and ambiguous sentences?
3. How does contextual information facilitate the comprehension of syntactically complex sentences?

1.4 Research objectives.

The research aims to

1. Analyze working memory effects on the ability to comprehend sentences with various complexities,
2. Assess how attention mechanisms affect the processing of complex and ambiguous sentences.
3. And investigate how contextual information helps in the comprehension of complex sentences.

1.5 The significance of the research

It provides deeper insights into language education as it aims to enhance teaching and learning language processing.

1.6 Literature review.

Memory systems in second language processing are divided into three. The first one is short-term memory has been

conceptualized as a limited-capacity system responsible for the brief, passive strong information. Aktinson & Shiffrin (1968, p. 89) defined it as a temporary buffer that holds information for a short duration. In the language processing context, short-term memory allows learners to retain surface-level information as phonological sequences. Baddeley (2000, p.418) emphasized that short-term memory alone cannot account for complex language comprehension. Baddeley stated that short-term memory functions as a storage mechanism rather than a processing system.

The second type of memory system is working memory. Newell (1973, p.297) defined it as the responsible system to maintain information during ongoing cognitive activity. Unlike short-term memory, working memory includes executive control processes. Working memory is the temporary storage for language comprehension and production (Baddeley, 2012, p.7). Working memory enables learners to understand semantics and pragmatic with holding syntactic and lexical items in the second language processing.

Long-term memory refers to the permanent storage of knowledge and skills as vocabulary and grammatical features. Long-term memory is difference to short-term memory and working memory in that it is not constrained by immediate capacity limitations and operates on a different temporal scale. Carroll (1981, pp. 105-106) stated that learning a language depends on the learner's ability to retrieve this knowledge during the process, noting that aptitude differences may reflect "the ability to store and retrieve information from memory systems under processing demands". From this perspective, long-term memory provides the representational foundation upon which working memory operates during real-time language use. It supplies the knowledge that must be accessed rather than temporarily stored during comprehension and production.

1.6.1 Working memory

The working memory is divided into two parts: visual and auditory. The visual is related to the image in the mind, while the auditory is related to the words, language, and sounds. Baddeley (1992, p.556) defines working memory as "a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning". The second type of memory system is working memory. Newell (1973, p.297) defined it as the responsible system to maintain information during ongoing cognitive activity.

Working Memory in Carroll's Aptitude Framework

Carroll's (1981) conceptualization of language learning aptitude anticipated later in working memory research. Carroll emphasized learners' differential ability to recognize grammatical function and map these functions to sentence structures rather than treating aptitude as a fixed linguistic trait (Carroll, 1981, pp. 105-106). Such variability in a working memory perspective reflects differences in how learners can coordinate storage and processing demands while accessing linguistic representations. In

second language learning processing, this distinction becomes important as learners may learn the grammatical knowledge in long-term memory but still fail to use it due to limitations in working memory capacity or executive control.

The Multi-Component Model of Working Memory: An Overview of the Baddeley and Hitch Framework

Baddeley developed a framework to explain how working memory functions in the brain. He proposed that working memory is a multi-store system. It is a set of separate "containers" that hold temporary information.

The first component is the phonological loop. It deals with auditory and verbal material. It includes two parts, which are the phonological store and the articulatory rehearsal process. The phonological store is a short-term storage space that holds speech-based information. While the articulatory rehearsal process is an active mechanism that refreshes the stored information through subvocal repetition or "inner speech."

The second component is the visuospatial sketchpad. It manages visual and spatial information. Both the phonological loop and the sketchpad are described as slave systems because they operate under the direction of the central executive. Logie (1995) suggested that the sketchpad can be divided into two subcomponents: the visual cache (visual features as form and color), and the inner scribe (processes spatial and movement-related information). The central executive works as the control center system. Its work is to organize, direct, and coordinate the slave systems' activities. It is also responsible for directing higher-level cognitive tasks.

Baddeley (2010) introduced the episodic buffer. The Episodic buffer links the long-term memory with the working memory. Baddeley (2010, p.66) describes it as "capable of holding multi-dimensional episodes or chunks which may combine visual and auditory information, possibly also with smell and taste." In short, it integrates information from the phonological loop, the visuospatial sketchpad, and long-term memory under the guidance of the central executive. This integration is important for forming long-term learning as the episodic buffer links the working memory and conscious awareness. (Baddeley and Hitch, 1974).

Cowan's Embedded-Processes Model: Linguistic Theories of Complexity

Cowan presents working memory as the temporary activation of information within long-term memory. According to Cowan (1999, 2010), working memory is connected to the storage system. Cowan's model distinguishes itself from other models in conceptualizing the working memory, as he considers the working memory as an active subset of long-term memory. Cowan believes attention plays a central role. Attention determines that the activated information is available for immediate processing. This model provides a more comprehensive understanding of how working memory operates.

By emphasizing the interaction between attention, long-term memory, and working

memory, Cowan's model offers valuable insights into how learning occurs. Effective learning is not only about storing information; it requires focused attention. In short, attention enhances learning outcomes, shapes educational processes, and contributes to stronger cognitive performance.

The following five principles of highlighting the relation between memory and attention, as Cowan outlines in his model:

1. Hierarchical Structure: Working memory works hierarchically with layers in a system of cognitive resources.
2. Distinct Limitations: Each level has its own constraints. The focus of attention has a very limited capacity. It means activated memory fades quickly. These limitations become clear in demanding tasks, for example, in processing multiple similar items.
3. Control of Attention: Attention can be directed through executive control through the orienting system.
4. Habituation: When stimuli remain unimportant, the brain stops bringing them into conscious awareness. The brain allows attention to shift to more relevant information.
5. Role of Awareness: Conscious awareness plays an essential role in the formation of memory. Information must reach awareness to become encoded and later retrieved.

Filler-Gap Dependencies and Syntactic Movement

Generative Grammar accounts for various intricate structures by the movement mechanism, which establishes filler-gap dependencies (Chomsky, 1981, 1995). A constituent (the filler, such as a wh-word or a topicalized phrase) is perceived as being shifted from its usual argument location (the "gap"). The processing suggested that the cognitive load grows with the structural distance separating the filler from the gap. For example: 1. The journalist (whom the senator criticized) acknowledge the mistake. 2. The journalist (who the senator criticized) acknowledge the mistake. In (1), the filler "whom" serves as the object of criticized, whereas in (2), the filler functions as the subject of criticized.

The Syntactic Prediction Locality Theory (SPLT) and the Dependency Locality Theory (DLT)

Gibson provides the linking hypothesis between linguistic structure and processing cost, formalizing the concepts of storage and integration.

The Syntactic Prediction Locality Theory (SPLT - Gibson, 1998): It views that the primary source of cost is the memory required to maintain unfulfilled syntactic predictions (e.g., a verb predicting a direct object). The cost is proportional to the number of predictions and the locality of their resolution. On the one hand, the Dependency Locality Theory (DLT - Gibson, 2000): The DLT refined the SPLT by distinguishing two primary components of computational load:

1. Integration Cost: The cost of connecting a new word into the existing syntactic structure. This cost increases with the distance between the new word and the head it depends on. Distance is measured

in the number of new discourse referents (e.g., NPs introducing a new entity).

2. Storage Cost: The cost of maintaining syntactic predictions that have not been fulfilled. Each anticipated head (e.g., a verb, a noun) that has not been closed off consumes resources.

Linguistic theories have evolved from simple lists of transformational rules into sophisticated models. These models quantify the cost of maintaining and integrating dependencies across structural distances, and factoring in interference from similar elements. These formal models provide the necessary grammatical foundation to study how the specific linguistic demands are constrained by the general cognitive system of working memory.

1.6.2 The interface between working memory and grammar

Gibson's Dependency locality theory

The costs of processing a sentence can be measured by two different components (i.e., integration and storage (Gibson, 2000). As the number of new discourse referents between elements of a sentence (e.g., a verb and its direct object) increases, the cost associated with integrating those two pieces of information increases (i.e., integrating the verb and its object becomes more difficult). In addition to the integration cost, there will need to be a storage cost associated with keeping track of all of the syntactic heads needed to complete the present sentence. Therefore, DLT accounts for the difficulty associated with processing long-distance dependencies and center-embedded sentences, through both integration and storage costs.

Frazier's 'Sausage Machine'

The Sausage Machine from Frazier is a two-stage model of sentence parsing (1978) whereby an initial parser groups approximately six words into phrases and a second-stage parser builds the full syntactic structure. In the first stage of processing, which is limited in capacity, structural ambiguity may arise while also being misanalysed. This model introduces a modular and syntax-driven architecture, with clear constraints on parsing regarding structure and capacity.

Basically, Frazier and Fodor's "Sausage Machine" from 1978 posits that when we read or hear a sentence, our mind tackles it in two distinct phases. The first part is pretty quick and simple. It builds small word-groups (around six words) and then hands them over to the second, more global part of the brain. The cool thing is that because this first part has such a small capacity, it accounts for those small, silly mistakes our brains sometimes make when parsing. Their biggest contribution was suggesting that the sentence-processing system has a very specific, small-capacity architecture.

Lewis's Computational theory of working memory in parsing

Think of sentence parsing not as following complex grammar rules, but as your brain trying to dig up information from memory—specifically, from its working memory. Simple Memory is activated; every word or phrase you hear or read is stored in your

memory with a certain level of "activation" (like a light switch being on). Next, it is the Retrieval Cue. When you hit a keyword, like a verb, your brain says, "Hey, I need my subject!" This verb acts as a cue to retrieve the correct subject from memory. Then, in The Race to Retrieve, the item that has the highest activation (the brightest light switch) gets retrieved the fastest.

The brilliant part of this model is that it explains processing difficulty using two very human, general principles of memory, not just syntax rules: a. Decay (The Forgetfulness Problem): Over time, the activation of memory traces fades. If the cue has to wait too long to retrieve the item (a long distance in the sentence), the item's activation might have dropped, leading to a "retrieval failure." b. Interference (The Too-Similar Problem): If the cue is looking for a subject, but there are other, similar-looking words (maybe another noun with the same grammatical features) floating around in memory, they get in the way. This "similarity-based interference" gums up the works and slows down retrieval. This approach is powerful because it uses these simple, well-known issues with human memory to explain almost all of our sentence processing strengths and weaknesses, without having to invent new, complicated grammar-specific rules.

1.6.3 Previous Studies

Previous research has demonstrated that our ability to process complex sentences is constrained by our cognitive capacity, specifically the limits of our working memory and attentional focus. Studies grounded in psycholinguistics (e.g., Baddeley, 1992; Just & Carpenter, 1992; Lewis, Vasishth, & Van Dyke, 2006) have shown that syntactically complex structures (for instance, embedded clauses or long-distance dependencies) demand these resources. This leads to slower processing and compromised comprehension accuracy.

However, the majority of the insights generated have come from highly controlled laboratory experiments, utilizing methods like self-paced reading and eye-tracking measures. While these techniques are excellent for capturing real-time performance, they tend to emphasize performance-based outcomes and do not fully capture the subjective experience—the strategies, perceptions, and self-reported sense of cognitive difficulty. Furthermore, existing research has been focused on native speakers of English or individuals with high bilingual proficiency. This leaves a notable gap in understanding how English as a Foreign Language (EFL) university students manage these established cognitive constraints while tackling complex and ambiguous sentences in their learning environment.

There is a distinct need to integrate empirical findings with learners' self-reported experiences, particularly within the EFL context. Our present study aims to directly address this gap by using a mixed-methods approach (combining questionnaires and semi-structured interviews) to investigate the interface between working memory, attention, and grammar comprehension among this specific population of EFL learners.

Recent Empirical Studies on Working Memory in L2 learning

Recent empirical research has investigated the role of working memory in various aspects of second language learning. It has demonstrated its significant influence on learners' linguistic development. For example, a study by Alshehri (2024) examined the relationship between working memory capacity and vocabulary acquisition among 100 Saudi EFL university students. Using the Automated Operation Span Task as a measure of working memory. The research found significant correlations between working memory capacity and vocabulary relations. This suggests that enhanced working memory capacity may facilitate vocabulary learning in L2 contexts and points to the potential benefits of incorporating working memory-based exercises in language instruction. Completing this, research by Gui & Ismail (2024) explored how planning time interacts with working memory and individual cognitive styles during task-based communicative activities. Their quasi-experimental design showed that learners with higher working memory capacity outperformed their peers in language production tasks, particularly when given pre-task planning time, underscoring the dynamic interplay between working memory and task planning in communicative language performance.

Another research has examined the conceptual and methodological issues surrounding working memory measurement in L2 contexts. A 2025 article in Applied Psycholinguistics evaluated the reliability and validity of different working memory tasks, such as sentence recall or listening span. It has reported that certain measures, like the Sentence Recall Task, show strong correlations with L2 listening proficiency. This methodological insight contributes to improving the precision of working memory research in second language acquisition. Despite the empirical research on working memory and L2 learning, little attention has been paid to the interaction between working memory, language learning aptitude, and syntactic comprehension among EFL learners in Libya.

2. Methodology

2.1 Research Design

A mixed-method research design was used for this study to combine quantitative and qualitative approaches to investigate the cognitive factors that influence complex sentence comprehension. The quantitative data were collected by a structured questionnaire, while the qualitative data were obtained by semi-structured interviews.

The methods were used to understand how working memory capacity, attention mechanisms, and contextual information interact.

2.2 Participant

The participants of this research were 30 university students. They were studying in the eighth semester in the Faculty of Languages at the University of Tripoli. Only fifteen students were interviewed. The participants were selected through convenience sampling, based on their availability and accessibility to the researcher. Although convenience sampling limits the generalizability of the findings, it was commonly employed in

preliminary SLA research aiming to examine processing patterns rather than to make population-level claims.

2.3 Instruments

- **Questionnaire**

A structured questionnaire was designed to measure three main constraints (working memory and sentence processing, attention, and contextual information). The questionnaire consisted of Likert scale questions. The Likert scale items ranged from 1, strongly agree, to 5, strongly disagree.

The questionnaire was distributed electronically via Google Forms. The purpose of the questionnaire was written above the questions. Responses were collected within a week.

- **Interview**

The interviews were semi structured interview. The interview was used to collect a deeper understanding of the cognitive process that students use when dealing with sentence complexity. Open questions were used in the interviews to address strategies and techniques that students use to understand long and complex sentences. Interviews were also used to address factors affecting attention during reading complex sentences and the role of contextual clues in resolving ambiguity. The interviews were conducted online for 15 minutes.

2.4 Data analysis

Descriptive methods were used to analyze the questionnaire data. The descriptive method helped to determine the extent to which the working memory, attention, and contextual information influence sentence comprehension. On the other hand, thematic analysis was used to analyze the interview transcripts by coding ideas, grouping codes into themes, and linking themes to the research objects. Themes may influence difficult information, loss of focus, ambiguity, or reliance on context.

2.5 Ethical consideration

Participants were informed about the purpose of the study. They were informed that they can withdraw at any time. All data collected was used for academic purposes.

The sample size was limited to one university context, which may affect the generalizability of the findings.

3. Results

3.1 Questionnaire results

The data collected from the questionnaire (Appendix 1) were analyzed using descriptive statistical methods. Frequencies and percentages were calculated to identify patterns in students' responses related to working memory, attention, and contextual information during sentence processing. The analysis revealed that many students experience difficulty understanding complex sentences, particularly when the sentences are long or contain unfamiliar vocabulary. These results provide insight into the cognitive factors affecting sentence comprehension among EFL university students.

The data were obtained through a self-report questionnaire administered to EFL university students. A total of 30 questionnaires were collected, and all responses were found to be complete and suitable for analysis. Each questionnaire item was coded numerically to facilitate analysis. The questionnaire was on Google Form. It analyzed the questionnaire by showing the frequency and percentages.

Descriptive statistics, including frequencies and percentages, were used to summarize students' responses .Table 1). These measures were selected to provide a clear overview of participants' experiences and perceptions related to sentence comprehension difficulties.

Table 1. *Students' perceptions of working memory*

Questions	scale	1	2	3	4	5
Q1	Frequency	5	5	14	5	1
	Percentages	16.7%	16.7%	46.7%	16.7%	3.3%
Q2	Frequency	5	8	11	3	3
	Percentages	16.7%	26.7%	36.7%	10%	10%
Q3	Frequency	3	7	5	11	4
	Percentages	10%	23.3%	16.7%	36.7%	13.3%
Q4	Frequency	14	7	5	1	3
	Percentages	46.7%	23.3%	16.7%	3.3%	10%
Q5	Frequency	4	17	3	3	3
	Percentages	13.3%	56.7%	10%	10%	10%
Q6	Frequency	8	9	9	3	1
	Percentages	26.7%	30%	30%	10%	3.3%

The analysis focused on three main areas. The first area examined students' perceptions of working memory limitations during sentence processing. The results indicated that a large proportion of students reported difficulty understanding long and syntactically complex sentences, suggesting that limited working memory capacity affects their comprehension performance.

Table 2. *The role of attention*

Questions	scale	1	2	3	4	5
Q1	Frequency	8	3	15	2	2
	Percentages	26.7%	10%	50%	6.7%	6.7%
Q2	Frequency	9	2	17	1	1
	Percentages	30%	6.7%	56.7%	3.3%	3.3%
Q3	Frequency	20	5	4	1	0
	Percentages	66.7	16.7%	13.3%	3.3%	0%
Q4	Frequency	16	5	3	4	2
	Percentages	53.3%	16.7%	10%	13.3%	6.7%
Q5	Frequency	4	16	5	3	2
	Percentages	13.3%	53.3%	16.7%	10%	6.7%
Q6	Frequency	16	7	2	4	1
	Percentages	53.3%	16.7%	6.7%	13.3%	3.3%

The second area investigated the role of attention in sentence processing. The Table 2 showed that many students experienced problems maintaining attention when processing sentences containing unfamiliar vocabulary or complex structures. This indicates that attentional demands increase when sentence complexity rises.

The third area explored students' use of contextual information to support sentence comprehension. The results revealed that (Table 3) most students relied on contextual clues to infer meaning, especially when encountering difficult or ambiguous sentences. This suggests that contextual information plays an important compensatory role in sentence processing for EFL learners.

Table 3: *Students' use of contextual information*

Questions	scale	1	2	3	4	5
Q1	Frequency	11	5	7	6	1
	Percentages	36.7%	16.7%	23.3%	20%	3.3%
Q2	Frequency	8	5	11	3	3
	Percentages	26.7%	16.7%	36.7%	10%	10%
Q3	Frequency	8	15	5	1	1
	Percentages	26.7%	50%	16.7%	3.3%	3.3%
Q4	Frequency	7	17	6	0	0
	Percentages	23.3%	56.7%	20%	0%	0%
Q5	Frequency	12	6	3	5	4
	Percentages	40%	20%	10%	16.7%	13.3%
Q6	Frequency	5	10	10	3	2
	Percentages	16.7%	33.3%	33.3%	10%	6.7%

Overall, the descriptive analysis demonstrates clear patterns in students' responses, highlighting the influence of working memory capacity, attentional resources, and contextual support on sentence processing.

3.2 Interview results

The interview data were analyzed thematically to explore students' experiences with sentence processing. Difficulties related to working memory were reported by 12 out of 15 participants (80%), especially when they are processing long or complex sentences. One participant (P4) explained, "When the sentence is very long, I forget the beginning before I reach the end". Also Challenges in attention were stated by 11 participants (73%). They believed they lost attention when sentences contained unfamiliar vocabulary or grammatical structures. As participant 9 stated, "If there are many new words in one sentence, I cannot keep my focus." In contrast, the use of contextual information as a support strategy was reported by 13 participants (87%). For example, participant 13 said, "I try to follow the context clues and pay extra attention". Participant 2 noted, "I understand the sentence better when I look at the sentences around it, even if I don't understand every word." While participant 7 stated "I try to connect the ideas to each other to remember". Overall, these findings suggest that limitations in working memory and attention affect sentence processing, while contextual cues play an important compensatory role for most EFL learners.

These findings of the analysis of questionnaire data and interview data directly address the research questions and provide a

foundation for further interpretation in the discussion section.

4. Discussion

Discussion of the findings with connecting them to research questions will be presented in this part.

- How do working memory constraints affect the comprehension of syntactically complex sentences?

The findings indicate that limited working memory affects the comprehension ability of learners of complex sentences. Participants find difficulty in processing complex sentences with multiple clauses. This suggests that learners struggle during sentence comprehension. The explanation for this finding is that learners are required to store earlier parts of the sentence while processing elements in complex sentences. This process becomes demanding for EFL learners that having limited working capacity. This process leads to slower processing and misunderstanding. Baddeley's model (1992) of working memory, which was mentioned in the literature review part, aligns with this in emphasizing the limited capacity of temporary storage systems.

The findings are related to previous research (Just & Carpenter, 1992; Baddeley, 2010) in that working memory constraints play a crucial role in sentence processing.

- How do attention mechanisms influence the processing of complex and ambiguous sentences?

The results of data collected reveal that attention mechanisms play an important role in processing complex and ambiguous sentences. From the questionnaire and interviews, collected data, participants stated that focus was challenging when sentences contained ambiguous structures or unfamiliar words, which reduced comprehension. The finding emphasizes that not only does memory capacity affect the comprehension of the sentence process, but also the learners' ability to allocate attentional resources effectively. This result supports cognitive models that state that attention is one of the central components of language processing (Van Der Meer et.al. 2012). For EFL learners, understanding complex sentences can be more effortful because of the limitation of automaticity in language processing, which, as a result increases the attentional demands.

- How does contextual information facilitate the comprehension of syntactically complex sentences?

From the data analysis, contextual information facilitates the comprehension of syntactically complex sentences. Participants believed that their comprehension of sentences is easier within a clear context with a familiar topic and familiar vocabulary.

Semantic and contextual clues help to reduce cognitive load, which helps learners anticipate meaning and resolve syntactic complexity. This process encourages learners to avoid relying on syntactic analysis and focus more on overall meaning construction. Contextual information supports learners to understand meaning when working memory and attention are limited.

The results related to the contextual clues are in line with previous studies emphasizing the role of context in sentence processing and

comprehension (Kintch, 1998). Contextual support may be important for EFL learners, as it connects lines in linguistic knowledge and facilitates the processing of complex structures.

In conclusion, the findings of the research suggest that EFL university students' comprehension is shaped by the interaction between working memory constraints, attention, and contextual information. Working memory and attention impose cognitive limitations on processing syntactic complexity, while contextual information enhances comprehension. The findings highlight that teaching complex sentence structures for EFL learners could be easier when considering the cognitive constraints.

Interplay Between Lexical Knowledge and Syntactic Possessing

The finding revealed a strong influence of vocabulary comprehension on the syntactic comprehension of complex sentences. This suggests that difficulties in sentence parsing may not stem from syntactic complexity. It may be attributed to lexical processing demands. When learners encounter unfamiliar or ambiguous vocabulary, working memory resources may be disproportionately allocated to lexical retrieval, leaving fewer resources available for syntactic integration. This pattern does not necessarily indicate deficient grammatical knowledge; it reflects limitations in online processing under cognitive load, where access to syntactic representations stored in long-term memory becomes less efficient. This interaction highlights the role of working memory as a mediating factor between lexical knowledge and syntactic processing, and underscores the importance of controlling lexical difficulty when examining syntactic complexity. Future studies should employ complex sentence structures with semantically transparent vocabulary to more effectively isolate syntactic processing demands.

The present study revealed that working memory capacity significantly influenced both morphosyntactic processing and incidental vocabulary acquisition among Libyan EFL university learners. These findings align with previous research (Durand-López, 2024), demonstrating that individual differences in working memory reliably predict performance in cognitively demanding language tasks. Specifically, learners with higher working memory capacity exhibited more accurate morphosyntactic judgments and faster lexical retrieval, consistent with the role of cognitive fluency in real-time L2 processing.

However, unlike some prior studies conducted in more resource-rich or immersive L2 contexts, the effect of working memory on incidental vocabulary acquisition was somewhat attenuated in the present sample. This discrepancy can be explained by the particular educational context in Libya, where English instruction is predominantly teacher-centered, with limited opportunities for authentic communicative practice. Consequently, learners may not fully leverage their working memory resources for incidental learning during sentence processing. Additionally, the influence of Arabic as the first language, with its distinct morphosyntactic and lexical structures, may impose additional cognitive load when

integrating syntactically complex English sentences, thereby affecting real-time comprehension.

These results not only corroborate the centrality of working memory in L2 processing but also highlight the importance of contextual and pedagogical factors in shaping cognitive outcomes. By linking cognitive capacity with instructional environment, the study extends prior research and addresses the previously underexplored gap concerning how working memory interacts with syntactic and lexical processing in Libyan EFL learners. Future instructional designs should consider incorporating tasks that promote active use of vocabulary and syntactic structures in meaningful communicative contexts to optimize.

Limitation of the study

The relatively small sample size constitutes a methodological limitation and should be taken into account when interpreting the findings. The present study is best viewed as an exploratory or pilot investigation aimed at identifying cognitive processing patterns related to working memory constraints in L2 sentence comprehension. The results are therefore intended to inform future large-scale studies rather than support population-level generalization.

5. Conclusion

This study examined how working memory, attention, and contextual information influence sentence processing among EFL university students. The findings from both the questionnaire and interview data indicate that many students experience difficulty understanding long and complex sentences due to cognitive limitations. As one participant clearly expressed, “When the sentence is long, I lose the beginning before I reach the end” (P4). Attentional challenges were also evident, particularly when unfamiliar vocabulary was present, which caused learners to lose focus during reading. However, the study also revealed that most students actively rely on contextual cues to support comprehension. One participant noted, “I understand better when I use the sentences around it, even if I don’t know all the words” (P2). Overall, these findings highlight the importance of considering cognitive constraints in EFL instruction and suggest that teaching strategies that reduce memory load and encourage the use of context may improve students’ sentence comprehension.

6. Implications for English as a foreign language learning and teaching

Findings of this research offer guidance for adapting instructional practices to align with the learners' cognitive realities.

1. Curriculum Design and Content Sequencing: Educators should rethink the traditional sequence of grammar instruction. Instead of organizing content by its grammatical difficulty, it should also be sequenced based on the cognitive load a structure imposes. , such as relative clauses with long-distance dependencies, should be introduced incrementally. Teachers need to ensure sufficient spacing and repetition to prevent overwhelming the student's working memory capacity.
2. Instructional Strategies and Support (Scaffolding): Teaching methods must

incorporate strategies that help students manage the burden placed on their working memory when processing long or complicated sentences. For instance, teachers should train students to break down complex sentences into smaller and meaningful phrases. This prevents learners from attempting to hold the entire sentence structure in temporary memory.

3. Learner Metacognition and Awareness: It is important to educate students about the cognitive constraints they face. Learners need to understand why certain sentences are difficult. They should have Self-Monitoring. Students should be taught to recognize signs of cognitive overload, the moment they feel "lost" or struggle to track a sentence's meaning. They can then be encouraged to slow down, re-read the segment, or pause to summarize the meaning so far.

4. Assessment and Contextualization: The results underscore the need for sensitive assessment and effective use of context in teaching materials. Teachers must learn to differentiate between a comprehension failure caused by a lack of grammatical knowledge and one caused by cognitive overload. A student may understand a rule but still fail to apply it within a complex structure.

Conflict of Interest:

The authors declare no conflict of interest.

Declaration of AI Use

The authors declare that AI tools (e.g., ChatGPT) were used for linguistic assistance and searching for related references. AI tools were used as a supportive tool during the early stages of the research process. They are also used to direct me in making the questionnaire and interview questions. The authors also confirm that no AI tools were used for data collection, analysis, discussion, or conclusions.

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Appendices

Appendix 1

Please indicate your level of agreement with each statement using the Likert scale below:

1 = Strongly Agree

2 = Agree

3 = Neutral

4 = Disagree

5 = Strongly Disagree

Working memory & sentence Processing

1. I often find it difficult to remember complex sentences while reading.
2. I forget parts of a sentence when it contains multiple pieces of information.
3. When listening to long sentences, I lose track of their meaning.
4. I often need to reread sentences to fully understand them.
5. I can maintain multiple ideas in mind while reading a paragraph.
6. I think my memory capacity limits my ability to process complex sentences.

Attention

1. I lose focus quickly when reading sentences with a complex structure.
2. I get distracted easily when trying to understand long sentences.
3. I find it difficult to stay focused when a sentence contains unfamiliar grammar.
4. My attention decreases when a sentence has unusual word order.
5. I need to pause or slow down to stay focused when reading complex sentences.
6. I notice grammatical errors easily when reading or listening.

Contextual Information

1. I can predict upcoming words in a sentence based on context.
2. I understand sentences better when I know the general topic beforehand.
3. I rely on surrounding sentences to interpret the meaning of complex sentences.
4. My understanding improves when a sentence appears in a meaningful context.
5. My understanding of a sentence decreases if it has unfamiliar words.
6. I can guess the meaning of difficult words using context clues.

Appendix 2

Interview Questions

Part 1: Working Memory (Remembering Sentences)

1. What do you do when a sentence is long?
2. Is it hard for you to remember the beginning of a sentence when you read the end?
3. What kind of sentences are difficult for you?

Part 2: Attention

1. What do you focus on when you read English?
2. Does noise or tiredness make reading difficult for you?
3. What happens when you lose focus while reading?
4. Are long sentences harder to focus on?

Part 3: Context (help from meaning)

1. Does knowing the topic help you understand sentences?
2. Do sentences become easier when they are in a paragraph?
3. Can you understand a sentence better when you read the sentences before it?
4. Is it difficult to understand a sentence alone?

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القيود المعرفية على معالجة الجمل: دليل على تداخل بين الذاكرة العاملة والقواعد النحوية

ابتسام فتحي اقنيجيوة

الجامعة الاسمرية، كلية العلوم الانسانية، قسم اللغة الانجليزية، ليبيا

*ebtisamegnejewa90@gmail.com

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ملخص البحث:

تشير معالجة الجمل إلى القدرة المعرفية المعقدة التي تُمكن البشر من إنتاج وفهم عدد لا نهائي من الجمل باستخدام مجموعة محدودة من القواعد النحوية. ترتبط هذه القدرة ارتباطا وثيقا بالذاكرة العاملة، وهي نظام ذو سعة محدودة يقوم بتخزين ومعالجة المعلومات مؤقتا أثناء عملية الفهم. تختبر هذه الدراسة العلاقة بين الذاكرة العاملة والقواعد النحوية من خلال مراجعة النماذج النظرية الرئيسية المتعلقة بالذاكرة العاملة ومعالجة الجمل. على خلاف الأبحاث السابقة التي اعتمدت بشكل أساسي على المهام المختبرية وركزت على المتحدثين الأصليين، تدرس هذه الدراسة 30 طالبا من جامعة طرابلس قسم اللغة الانجليزية الذين يدرسون اللغة الإنجليزية كلغة أجنبية. تم جمع البيانات باستخدام استبيان ومقابلات شبه منظمة. وتم مناقشة النتائج في ضوء النظريات القائمة والتركيز على كيفية تأثير القيود المعرفية على فهم الجمل، وحيث اتضح تأثر فهم الجمل يرتبط بقيود ادراكية كالذاكرة العاملة والانتباه وفهم المحتوى. وتنظر الدراسة أيضًا في الآثار المترتبة على هذه النتائج في مجال تدريس اللغة الإنجليزية كلغة أجنبية.

الكلمات المفتاحية :*معالجة الجمل، الذاكرة العاملة، القيود المعرفية، متعلمو اللغة الانجليزية كلغة اجنبية، فهم اللغة.*