Research Article

Impact of Different Types of Cognitive Load in Foreign Language Learning

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ABSTRACT

Cognitive load plays a critical role in foreign language learning, impacting the effect of learners' language acquisition. Various aspects of learners and instruction can influence different types of cognitive load. However, existing research on cognitive load in foreign language learning lacks a comprehensive review that categorizes and examines these different types of cognitive load. This literature review examined the factors contributing to intrinsic, extraneous, and germane cognitive load and the impacts of these three types of cognitive load in foreign language learning. Research revealed that the elements, such as the complexity of language materials, instructional design flaws, and motivational factors, significantly impacted cognitive load in foreign language learning contexts. A thorough understanding of these types of cognitive load and their impacts may inform effective instructional design, reduce unnecessary cognitive strain, and enhance foreign language acquisition. This review concluded by identifying gaps in current research and proposing suggestions to optimize cognitive load for further studies in foreign language education.
Keywords: Cognitive Load Theory; Foreign Language Learning; Intrinsic Cognitive Load; Germane Cognitive Load; Extraneous Cognitive Load

1. Introduction

Cognitive load theory (CLT) is a foundational framework in educational psychology, particularly significant in understanding and enhancing foreign language learning [1]. Developed by John Sweller in the 1980s, CLT emphasizes the limitations of working memory and examines how instructional design can optimize mental resources for effective learning [2]. In foreign language acquisition, learners may be confronted with complex grammar, unfamiliar vocabulary, and various syntactic structures, all of which place substantial cognitive demands on them [3]. As a result, managing cognitive load becomes essential for facilitating comprehension, retention, and overall language proficiency.

Previous literature reviews have investigated cognitive load in the context of foreign language learning. However, these reviews have generally treated cognitive load as a unified concept without distinguishing

different types of cognitive load [4,5]. This generalized approach overlooks the unique effects that each type of cognitive load has on the language learning process [6]. Understanding the specific impacts of each type is crucial, as intrinsic load relates to the complexity of language material, extraneous load arises from suboptimal instructional design, and germane load contributes positively by promoting schema construction [7]. Without categorizing cognitive load, prior reviews have not fully addressed how each load type uniquely affects foreign language acquisition.

This review aims to bridge this gap by examining existing research from Google Scholar and categorizing cognitive load into intrinsic, extraneous, and germane types to provide a thorough understanding of their specific impacts on foreign language learning. By reviewing studies that focused on each type of cognitive load individually, this review aims to inform instructional design strategies that effectively manage these loads, thereby enhancing language learning outcomes.

2. Conceptual Framework: Cognitive load in foreign language learning

Cognitive Load Theory (CLT) has become increasingly relevant in the domain of foreign language education, where learners are frequently challenged by complex linguistic structures and unfamiliar vocabulary. Understanding how different types of cognitive load interact with the processes of language learning is essential for designing effective instruction [8]. To provide a comprehensive foundation, this part first outlines the theoretical principles of CLT and the distinct functions of intrinsic, extraneous, and germane cognitive loads. It then explores how these principles have been applied in foreign language contexts through instructional practices and empirical studies.

2.1. Theoretical foundations and cognitive load types

Cognitive Load Theory is grounded in the limitations of human working memory, which has a finite capacity for processing new information [3,9]. According to the theory, instructional design and learning tasks must be structured to manage cognitive load effectively, enabling learners to maximize their cognitive resources and support long-term retention [10]. As such, instructional design and learning tasks must be well-structured to manage cognitive load effectively, allowing learners to maximize their cognitive resources and enhance long-term retention [10]. According to Sweller[2,6], effective learning requires transferring information from the limited-capacity working memory to long-term memory through the construction of organized schemas. Learning begins with sensory input via visual or auditory channels, which must be processed through attention to enter working memory. Given the severe limitations in both capacity and duration of working memory [9], instructional design must carefully manage cognitive resources. Intrinsic load originates from the inherent complexity of the learning material and the learner's prior knowledge. Extraneous load stems from suboptimal instructional presentation, such as redundant information or disorganized layouts, which can hinder learning. Germane load, in contrast, refers to the beneficial cognitive effort invested in constructing and automating schemas [3,7,10]. Therefore, effective instructional strategies should aim to reduce extraneous load, regulate intrinsic load, and promote germane load to facilitate schema construction in long-term memory. Once schemas are automated, they significantly improve learning efficiency and task performance. Cognitive Load Theory classifies cognitive load into three primary types: intrinsic, extraneous, and germane. Each type plays a distinct role in the learning process and requires different instructional strategies to optimize learning outcomes. Understanding these types of load is crucial for effectively applying the theory in language learning contexts. The nature and source of each type of load define the cognitive demands faced by learners and reveal how instructional design can either hinder or support learning.

CLT's relevance extends to foreign language learning, where learners may face complex syntactic structures, unfamiliar vocabulary, and varied linguistic rules, managing cognitive load becomes especially crucial [1,11]. For example, extraneous load from poorly designed materials can hinder learning, whereas germane load fostered through interactive tasks enhances retention [7]. The following sections detail the three types of cognitive load and their implications for language education.

2.2. Applications of cognitive load theory in language education

In foreign language learning, intrinsic load often arises from language-specific components such as grammar rules, vocabulary, pronunciation, and syntax [11]. For example, sentence structures in a foreign language may require learners to comprehend multiple grammatical elements simultaneously [11]. While intrinsic load is considered a fixed attribute in CLT, it can be managed through appropriate instructional design strategies, such as segmenting complex content and introducing linguistic elements progressively. These strategies make the material more comprehensible and help learners gradually build a foundation for more advanced language skills [1].

Extraneous load is caused by external factors unrelated to the core learning material and often results from poor instructional design. This type of load leads to unnecessary cognitive effort due to ineffective information presentation, thereby distracting learners from the primary task [12]. For instance, complex multimedia content, redundant explanations, or tasks requiring learners to process text and images located separately may contribute to high extraneous load [13]. In language learning, such issues may manifest as disorganized interfaces or poorly designed visual aids that impede learners' focus on linguistic content. Reducing extraneous load is essential for efficient allocation of cognitive resources. Simplifying instructional content, integrating text with visuals, and eliminating irrelevant information can help learners focus more effectively on core language skills [14].

Germane load refers to the cognitive effort devoted to constructing and automating schemas—mental structures that aid in organizing and interpreting information [10]. In the context of language learning, germane load is often associated with deep processing and meaningful learning activities, such as interactive discussions, problem-solving tasks, and collaborative projects [15]. Unlike intrinsic and extraneous loads, which should be managed to avoid cognitive overload, germane load is beneficial and should be encouraged to enhance comprehension and retention [15]. Engaging learners in tasks that require critical thinking or the integration of language concepts helps support schema construction and thus promotes long-term language acquisition [16]. For example, asking students to write sentences using newly learned vocabulary helps them incorporate the words into their existing language schemas, thereby stimulating germane cognitive load.

Building upon the theoretical foundations of Cognitive Load Theory, it is essential to examine how these cognitive load types have been empirically investigated in the context of foreign language learning. The following section reviews key studies that demonstrate how intrinsic, extraneous, and germane cognitive load influence language acquisition processes and learning outcomes in real instructional settings.

3. Synthesis of key findings on cognitive load in foreign language learning

The study of cognitive load in foreign language learning is of great importance, as viewing foreign language learning from the perspective of cognitive load provides valuable insights into how learners allocate mental resources and navigate cognitive challenges during language acquisition [6,10]. Understanding and managing cognitive load can help teachers and learners optimize the learning process and improve the learning effect [12,14]. Following common narrative review practices [17], literature for this review was retrieved from Google Scholar using keywords such as "cognitive load," "foreign language learning,"

"intrinsic cognitive load," "extraneous cognitive load," and "germane cognitive load." Only empirical studies published in English between 2014 and 2023 were included. Studies had to focus on at least one type of cognitive load in the context of foreign language learning. The following table lists various factors causing or influencing cognitive load in foreign language learning from 2014-2023.

Table 1. Causing/ influence factor of cognitive load in foreign language learning

Intrinsic Cognitive Load (IL)	Extraneous Cognitive Load (EL)	Germane Cognitive Load (GL)
The complexity of the learning activity in language learning, such as grammatical structures [11].	Material interactivity, text complexity, and time requirements were major contributors to extraneous cognitive load [18].	In conditions of isolation, individuals tended to rely more frequently on L1 translation, using L1 thinking as a compensatory strategy to mediate the germane cognitive load impacted by external factors [18].
Unfamiliar vocabulary in academic listening materials may lead to higher intrinsic cognitive load when learners are not allowed to look up the meanings of words [19]	Extraneous illustrations enhanced attentional competition, hindering reading comprehension caused extraneous cognitive load [20].	The interactive participation of multiple players is beneficial to the germane cognitive load in a web-based simulation game for learning foreign language vocabulary [15].
Translation tasks with highly interactive subcomponents cause intrinsic cognitive load[21].	Defects in task design may result in a shift of attention resources from instructional objectives, such as overly challenging materials and inefficient presentation of formats, which may cause more extraneous cognitive load[22].	Generation of germane cognitive load was found through metaphorical interfaces [16].
Segmenting/sequencing of instructional materials is needed to reduce the intrinsic load [23].	Conditions of both dictionaries can increase extraneous cognitive load in reading comprehension [24].	Meta-cognitive learning strategies can affect germane cognitive load [25].
Provide meaning for unfamiliar L2 words through annotations, subtitles, dictionaries, and online translation tools to reduce intrinsic cognitive load [26].	Guidance strategies were utilized in game-based scenarios to diminish extraneous cognitive load [27].	
Matching the complexity of tasks with the students' proficiency to reduce intrinsic cognitive load [28].	Visual cues used to direct the students' attention in support of writing text to diminish extraneous cognitive load [16].	
Dual computer displays can deconstruct complex concepts into simpler elements to decrease intrinsic cognitive load caused by complex concepts [29].	Visualization cues used in supporting written text can diminish extraneous cognitive load [30].	
	Dual screens can be used with explicit connections to lessen processes in searching to diminish extraneous cognitive load [31].	
	Crucial information close to online dictionaries is integrated to prevent split-attention, aiming to minimize extraneous cognitive load [32].	

From table 1, the factors causing intrinsic cognitive load can be summarized from two perspectives: learners and learning tasks [33]. From the learner perspective, learners' language proficiency level, as prior knowledge, can influence individual intrinsic cognitive load. Mayer[1]. highlighted that students with weak vocabulary might struggle to comprehend certain materials automatically during listening tasks. Prior knowledge thus directly impacts intrinsic cognitive load; for the same learning task, lower-level learners may find the material more challenging and experience higher intrinsic cognitive load. In contrast, advanced learners may experience lower intrinsic cognitive load when processing complex grammar, idiomatic

expressions, or advanced vocabulary. From the perspective of foreign language instruction, intrinsic cognitive load refers to the inherent complexity of the learning task, including vocabulary, grammatical structures, and other elements [11]. Learning a language with complex grammatical structures, limited vocabulary, or unfamiliar phonetic sounds increases intrinsic cognitive load. Chen et al.[34] also further emphasized that intrinsic cognitive load is solely determined by the complexity of the materials and is not influenced by the teaching methods employed. Their study found a consistent positive correlation between intrinsic cognitive load and foreign language learning, indicating that the complexity of learning materials played a significant and stable role in foreign language acquisition, regardless of instructional techniques such as cooperative learning or gamification [34].

In terms of extraneous cognitive load, the factors causing extraneous cognitive load in foreign language learning were due to task design flaws, which refer to improperly designed instructional materials or instructional activities [12,13]. The reviewed studies revealed several factors contributing to extraneous cognitive load (EL) in foreign language learning, including material interactivity, text complexity, and time constraints, all of which demand significant cognitive effort from learners [18]. Extraneous illustrations were found to cause attentional competition, diverting students' gaze from text and reducing reading comprehension [20]. Poor task design, such as overly challenging materials or unclear presentation formats, was found to misdirect attention, increasing EL as learners expend additional cognitive resources managing the structural complexities of the material [22]. Additionally, both digital and traditional dictionaries can elevate EL by increasing element interactivity, which taxes working memory during reading tasks [24]. To mitigate EL, various strategies were proposed, such as using guidance mechanisms in game-based learning environment to efficiently direct learners' focus [27]. and applying visual cues in writing and reading to support text processing[16,30]. Dual screens with linked information sources and integrating key information near online dictionaries were shown to streamline information search and processing, further reducing EL [31,32]. These findings emphasize the importance of well-structured instructional materials and support strategies to enhance learning efficiency in foreign language education.

Research on germane cognitive load, as shown in the table, is very limited. As the latest addition to cognitive load theory, it remains the least comprehended aspect [12]. The literature revealed several factors influencing germane cognitive load in foreign language learning. Research indicates that in isolated learning conditions, individuals, especially those with lower language proficiency, often rely on L1 (first language) translation as a compensatory strategy to manage GL affected by external factors [18]. Furthermore, interactive learning activities have also been shown to have a positive effect on germane cognitive load. A reviewed study showed that interactive participation in a web-based simulation game enhances GL by engaging multiple players in foreign language vocabulary learning, providing beneficial collaborative support [15]. Additionally, metaphorical interfaces have been shown to foster GL by facilitating deeper cognitive engagement with the material [16]. Finally, metacognitive learning strategies have been identified as a factor that positively influences GL, by helping learners organize and process information effectively [25].

4. Discussion

This section draws on existing research to examine the applicability and practical implications of Cognitive Load Theory in foreign language learning. The discussion focuses on theoretical validation, learner characteristics and instructional design, as well as directions for future research.

4.1. Theoretical validation of cognitive load theory

The reviewed empirical studies provide important validation and extension of the theoretical claims proposed by Cognitive Load Theory. Specifically, the core concepts of intrinsic, extraneous, and germane cognitive load are not only conceptually distinct but are also supported by practical research findings. For example, the work by Mayer et al. [19] and Chen et al.[34] supports the idea that the complexity of learning materials (intrinsic load) correlates positively with learners' perceived difficulty, particularly among lower-proficiency learners. This supports Sweller[2]'s proposition that intrinsic load is content-dependent and must be regulated through appropriate instructional sequencing. Similarly, several studies[20,24] illustrate how poorly structured materials or digital tools increase extraneous load, aligning with CLT's assertion that such load detracts from working memory resources. These findings reinforce the importance of optimizing instructional design to reduce cognitive load, especially in technology-enhanced environments [12]. Although germane cognitive load has been less frequently examined, it has been shown to increase through interactive activities, metaphorical interfaces, and learner motivation [5,15,25], reflecting Paas et al.[10]'s theoretical model of schema construction [12,13].

4.2. Instructional strategies for managing cognitive load in foreign language learning

Regarding intrinsic cognitive load, students' prior knowledge significantly influences their intrinsic cognitive load levels [33,35]. Therefore, only instructional content design that matches their prior knowledge levels can effectively reduce their intrinsic cognitive load[19,33,34]. Consequently, in foreign language teaching, learners' language proficiency should be a key consideration in instructional design. In practical teaching, instructors can reduce intrinsic cognitive load for lower-level learners by providing tasks and materials that align with varying levels of language proficiency. For instance, breaking down complex grammatical structures into simpler components can facilitate students' understanding and processing of the language. Providing clear annotations and definitions [26] or employing visual aids, such as diagrams and flowcharts, further enhances the comprehension of challenging concepts. In addition, the incremental introduction of new grammatical structures, starting with the simplest forms and gradually progressing to more complex structures, allows learners to learn without feeling overloaded. This strategy of scaffolding may help reduce intrinsic cognitive load, allowing learners to focus on understanding the core content rather than struggling with unfamiliar language elements [11]. In addition, graded materials designed to cater to learners at different proficiency levels, may help ensure that all students are engaged in learning that is appropriately challenging but not beyond their cognitive load. This could involve offering more support and guidance for lower-level learners, such as annotations for grammatical structures and translations of advanced vocabulary to ensure that learners are not exposed to content that is either overly simplified or excessively complex helps optimize the learning experience, and enhance the retention and development of language skills [26]. By matching task difficulty with learners' cognitive capabilities, instructors can improve learning outcomes, enabling students to acquire and retain new language knowledge more effectively without experiencing cognitive overload.

Extraneous cognitive load in foreign language learning is often caused by suboptimal instructional design, including the use of overly complex texts, cumbersome learning tools (e.g., electronic dictionaries or online platforms), excessive interactivity, and tight time constraints [18]. It can also arise from features that are misaligned with instructional goals, such as poorly organized materials or ineffective classroom tasks. For instance, when instructional content lacks sufficient contextual scaffolding—such as relatable examples, multimedia supports, or essential background information—learners may struggle to connect new input with prior knowledge, which increases mental effort. Likewise, non-essential elements like decorative graphics or cluttered visual layouts can pull learners' attention away from key content and negatively impact comprehension [20]. When combined, these issues may overwhelm cognitive processing capacity, making it

harder for learners to absorb and integrate new language input effectively. As a result, learners may focus on peripheral details rather than core language concepts, hindering both understanding and long-term retention. To manage this challenge, instructional design must actively minimize extraneous cognitive load, allowing learners to dedicate more mental resources to meaningful language learning. Research highlights several strategies that can support this goal in the context of foreign language education. These include simplifying materials by eliminating non-essential information—such as overly ornate visuals or confusing layouts—and ensuring that explanations are clear, succinct, and suited to learners' language levels [13]. Supplementing content with supportive tools like glossaries, annotations, or visual aids can help learners grasp complex material more easily [30]. Tasks should be sequenced from simple to complex, broken into manageable stages, and presented with explicit instructions to ease learners into cognitively demanding activities [22]. Technological tools, if well-designed, can further facilitate learning by integrating interactive and multimodal resources that support, rather than distract from, comprehension [27,31]. Additionally, highlighting key terms or organizing information through structured layouts can reduce learners' search efforts and enhance clarity[16]. By applying these instructional techniques, educators can effectively reduce extraneous cognitive load and foster a more focused and productive learning environment. Still, it is essential to avoid overcomplicated formats or poorly implemented technology, as these may inadvertently increase learners' cognitive burden and negatively influence learning outcomes[12].

Germane cognitive load can be enhanced through effective instructional design and well-structured learning activities [10], which promote deeper thought processes and more active learning [1]. Besides, germane cognitive load is also associated with learners' motivation and self-regulation as well as their prior knowledge [12]. There were few studies on cognitive load in the field of foreign languages, thus more research is necessary to bridge the gaps. In foreign language teaching, various methods can be employed to increase germane cognitive load and support more effective learning processes. For instance, the following strategies can be implemented: incorporating task-based learning games to engage learners actively through authentic scenarios and problem-solving tasks [15]; Utilizing multimedia and multimodal presentations to enhance information delivery through the synergy of visual, auditory, and tactile channels [36]; Fostering interaction through cooperative learning [15], etc. Using these methods, educators may effectively increase germane cognitive load and improve the learning effect.

4.3. Research gaps and future directions

The cognitive load in instructional design combining different technologies needs to be studied in further research [37], such as research combining with software, learning systems or online environments. More and more researchers tend to consider cognitive load as a key factor when instructions for technology-assisted language learning are designed and implemented [4]. Many studies have indicated that online environments or the use of software tools can increase germane cognitive load [38] while simultaneously raising extraneous cognitive load, which may cause cognitive overload easily [3]. For instance, in online learning environment, factors such as instant feedback and interactive learning settings can enhance learners' learning attitudes and motivation, potentially increasing germane cognitive load [38]. However, the environment may also elevate extraneous cognitive load due to the complexity of the system or its operation [39]. Monitoring cognitive load during the use of these technologies can provide insights into whether the instructional design supports learning effectively. Assessing cognitive load helps educators and researchers determine whether these tools enhance language learning by increasing germane cognitive load or hinder it by causing cognitive overload through excessive extraneous load. It is recommended that future studies include more diverse learning environments, such as AI-assisted foreign language learning and online interactive learning settings [5].

Suggestions for methodological improvements in the study of cognitive load in foreign language learning could focus on increasing sample sizes and utilizing a wider variety of measurement methods to capture the experience of cognitive load more comprehensively. Increasing the sample size would help to improve the external validity of the research by making the results more generalizable. A larger and more representative sample would ensure that the findings apply to a broader range of learners, covering various linguistic backgrounds and proficiency levels [10]. Additionally, a larger sample size can help detect smaller effects, improving the power of statistical tests and leading to more reliable conclusions [7].

Another suggestion for further research is to adopt a wider range of measurement methods to more accurately assess cognitive load. Traditional self-report tools, such as questionnaires and scales, often provide valuable insights into learners' subjective experiences, but these tools can be limited by social desirability bias or inaccurate self-assessment [11]. To address this, researchers could use multidimensional scales to assess different types of cognitive load, such as intrinsic load, extraneous load, and germane load, which would allow for a more nuanced understanding of how each type of load impacts the learning process [5,11]. Additionally, incorporating objective measurement tools, such as eye-tracking, can provide real-time data on how learners interact with learning materials, helping to identify areas of high cognitive load that may not be captured by self-reports [39]. Other physiological measures, such as EEG (electroencephalogram) and EDA (electro-dermal activity), can offer valuable data on the physiological responses associated with cognitive load, helping to uncover the neural and physiological processes involved in language learning [3]. These objective measures can complement traditional self-reports, providing a more comprehensive view of cognitive load and allowing researchers to monitor fluctuations in cognitive load throughout the learning process and link these changes to learning outcomes [12].

5. Conclusion

This review underscores the critical role of understanding and managing intrinsic, extraneous, and germane cognitive loads in foreign language learning. Intrinsic load management, through segmentation and simplification of materials, is essential for minimizing the cognitive strain associated with complex linguistic elements. Empirical findings by Mayer and Moreno[3] and Leppink et al.[11] support this approach, showing that segmented and progressive content can significantly lower learners' intrinsic cognitive load. Extraneous load, often a byproduct of flawed instructional design, can be minimized by using contextual support, carefully structured materials, and effective visual aids to reduce distractions [12,13]. This is reinforced by studies such as Eng et al.[20] and Dilenschneider[24], which demonstrate how cluttered visuals and redundant information increase extraneous cognitive load and hinder comprehension. Although research on germane cognitive load is limited, its role in fostering deeper comprehension and long-term retention is evident. Engaging tasks, such as interactive learning and metaphorical interfaces, encourage the formation of mental schemas essential for language retention and application [10,16]. Lin[15] further showed that web-based simulation games involving multiple participants can effectively stimulate germane load, enhancing vocabulary acquisition and learner engagement. Well-balanced instructional approaches that manage these cognitive loads improve learning experiences by reducing unnecessary cognitive strain, enhancing focus on core language skills, and promoting meaningful engagement [40].

This review identifies gaps in the existing literature, particularly the limited research on different types of cognitive load compared to studies on overall cognitive load. Particularly, germane cognitive load is less frequently studied, despite its importance in enhancing learning outcomes [11]. In addition, the cognitive load in instructional design combining different technologies needs to be studied in further research, such as research combining with software, learning systems or online environments. In addition, the cognitive load

in instructional design combining different technologies needs to be studied in further research, such as research combining with software, learning systems, or online environments, because, as Zhang[38] and Bahari et al.[4] suggested, although digital learning tools can enhance motivation and interactivity, they also risk increasing extraneous load due to complex interface designs, requiring careful instructional planning. Furthermore, future studies should prioritize utilizing a wider variety of measurement methods. These might include multidimensional scales to assess different types of cognitive load [5], as well as objective measures such as eye-tracking[41], EEG (electroencephalogram) [42], or EDA (electro-dermal activity) [43] to monitor fluctuation in cognitive load during the learning process.

Viewing foreign language learning from the perspective of cognitive load provides valuable insights into how learners allocate mental resources and navigate cognitive challenges during language acquisition [4]. Integrating the principles of cognitive load theory into foreign language education allows instructors to design more effective teaching methods that alleviate unnecessary cognitive strain while actively promoting meaningful learning[1,2,10,12]. These are crucial for enhancing learners' proficiency and sustaining their motivation [19], particularly in increasingly complex and technologically driven language learning environments [4]. Paas et al.[10] and Koudsia & Kirchner[40] proposed that effective instructional design must simultaneously reduce extraneous load, regulate intrinsic load, and foster germane load to optimize schema construction and knowledge retention. Overall, the study of cognitive load in foreign language learning is pivotal for optimizing the learning process and improving learning outcomes, as a thorough understanding and effective management of cognitive load can significantly enhance learners' performance and language acquisition [10].

Conflict of interest

The authors declare no conflict of interest

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