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Research Article

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Contributions of cognitive load theory to understanding information overload: a literature review

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ABSTRACT

Introduction: Information overload (IO) has become a prominent phenomenon in the digital age, when an excess of information leads to cognitive overload. Objective: This study aimed to examine how Information Science research addresses IO in relation to Cognitive Load Theory (CLT). Methodology: A survey of scientific articles and conference papers was conducted using the Web of Science and Scopus databases. Twenty-six papers were selected. Using thematic analysis, three thematic categories were identified in the analyzed corpus: Effects of digital information and communication technologies; Impact on learning; and Misinformation and sharing during the COVID-19 period. Results: CLT has been used as a theoretical foundation for the development of conceptual models and hypothesis testing to explain how information systems, through their designs and search options, can induce IO. It was also employed in the design of learning resources to improve knowledge acquisition, and in understanding the misinformation caused by information excess during the COVID-19 pandemic. Conclusion: The study concluded that integrating CLT and IO provides a deeper understanding of the challenges faced by human cognitive capacity by identifying factors contributing to IO and implementing CLT-based strategies.

KEYWORD

Information overload. Cognitive Load Theory. Cognitive loads. Cognitive overload. Literature review.

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Contribuições da teoria da carga cognitiva para compreensão da sobrecarga informacional: uma revisão de literatura

RESUMO

Introdução: A sobrecarga informacional (SI) tem se tornado um fenômeno destacado na era digital, onde o excesso de informações provoca sobrecarga cognitiva. Objetivo: Este estudo objetivou verificar como os estudos da Ciência da Informação abordam a SI relacionada à Teoria da carga cognitiva (TCC). Metodologia: Para coleta de dados, foi realizado um levantamento de artigos científicos e trabalhos apresentados em eventos nas bases de dados Web of Science e Scopus. Vinte e seis trabalhos foram selecionados. Utilizando-se a análise

temática, foram identificadas três categorias temáticas no conjunto de trabalhos analisados: Efeitos das tecnologias digitais de informação e comunicação; Impacto no aprendizado; e Desinformação e compartilhamento durante o período de covid-19. Resultados: Verificou-se que a TCC foi empregada como fundamentação teórica para o desenvolvimento de modelos conceituais e testes de hipóteses para explicar como sistemas de informação, por meio de seus *designs* e opções de busca, podem provocar a SI. Também foi utilizada no *design* dos recursos de aprendizagem visando melhorar a aquisição do conhecimento, e ainda na compreensão da desinformação causada pelo excesso de informações durante a pandemia de covid-19. Conclusão: Concluiu-se que a integração entre TCC e SI proporciona uma compreensão mais profunda dos desafios enfrentados pela capacidade cognitiva humana, ao identificar os fatores que contribuem para a SI e a implementação de estratégias baseadas na TCC.

PALAVRAS-CHAVE
Sobrecarga informacional. Teoria da carga cognitiva. Cargas cognitivas. Sobrecarga cognitiva. Revisão de literatura.

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SDG: 4. Quality education

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1 INTRODUCTION

Information Overload (IO) is a phenomenon that has gained prominence in the digital age, with the evolution of the internet and Digital Information and Communication Technologies (ICTs), which have made society highly dependent on information and consistently caused an excess of information. According to Bawden and Robinson (2009, 2020), IO should be taken seriously within Information Science, posing one of the greatest challenges currently faced, and is cited across various fields as a highly problematic factor.

This is not a new theme for Information Science. In 1948, at the Royal Society Scientific Information Conference, IO was indirectly addressed with concerns about recommending information service standards to avoid overburdening scientists and professionals. In 1976, Brenda Dervin published a paper on strategies to handle human information needs, criticizing the prevailing assumptions in communication and information search studies. One such assumption was the notion that more information is better. Dervin argued that information is complex and voluminous, which can lead to information overload, harming the individual in the process of becoming informed. She argued that having information is not the same as being informed and advocated for the development of skills that would allow individuals to effectively handle search systems and better organize information, facilitating its processing. (Case; Given, 2016; Dervin, 1976).

According to Bawden and Robinson (2020), there is no consensus on the definition of IO, but in the Oxford Research Encyclopedia of Politics, the authors present a definition deemed the most widely accepted: a situation in which "there is so much relevant and potentially useful information available that it becomes a hindrance rather than a help." (p. 2), obstructing the efficient and effective use of information by the individual, causing a sense of losing control over the situation and feeling overwhelmed.

IO is termed by Cognitive Psychology as cognitive overload, which pertains to the brain's limit for processing information. Thus, the discussion on Cognitive Load Theory (CLT), developed in the field of Cognitive Psychology, and its relation to IO, is important as a means to understand how information overload influences human cognitive capacity in processing information and the way knowledge is acquired (Laato *et al.*, 2020). According to Savolainen (2007b), interdisciplinarity in studies of information behavior becomes very important to integrate findings from other fields and assist in resolving conceptual problems.

Consequently, cognitive manifestations linked to various Information Science research that investigates IO may find explanations in Cognitive Load Theory (Belabbes *et al.*, 2023; Eppler; Mengis, 2004; Guo et al., 2020; Laato *et al.*, 2020), considered one of the most utilized theories as a structural model in research on IO (Mcdowall, 2022).

Thus, this research aims to analyze studies that address IO related to CLT through a literature review, in order to answer the following research question: How do Information Science studies that deal with information overload approach Cognitive Load Theory?

2 INFORMATION OVERLOAD

Studies on information overload, from a cognitive perspective, describe this phenomenon as the human inability to process large volumes of information in sensory and working memory (Chandler; Sweller, 1991; Graf; Antoni, 2021; Miller, 1956; Miller, 1960; Sweller, 1988; Sweller; Ayres; Kalyuga, 2011).

Information overload has always been a challenge for humans. However, in the so-called "information age," it has transformed into a significant problem, considered one of the most challenging phenomena of the current era. IO affects not only individuals but also organizations, cities, and society at large. The burden of IO felt by individuals in the 21st century stems from the excess of information and the proliferation of dissemination channels such as social media, emails, internet publications, and technological advances. This phenomenon is akin to challenges faced in the modern era with the proliferation of publications through the development of mass printing (Bawden; Robinson, 2020).

It was psychologist George Miller (Miller, 1956) who first scientifically addressed information overload through interdisciplinary research applying Information Theory and systems theory to Psychology, characterizing cognitive overload as the limit of human capacity to process large amounts of information. Psychologist James Miller (Miller, 1960) applied Information Theory to human behavior, a proposal by George Miller, to explicitly explain the concept of information overload, testing the limit of information flow between neurons, individuals, social groups, and society, thus creating his "Theory of Living Systems," that is, he attempted to theoretically prove the information processing limit of living beings (Levine, 2017; Miller, 1960).

Information Science scholars suggest that when confronted with a large amount of information, individuals struggle with searching, selecting, organizing, and mentally processing the desired information (Bawden; Robinson, 2020; Case; Given, 2016; Graf; Antoni, 2023). Bawden and Robinson (2020) highlight several consequences of IO, including health-related issues, as IO can trigger a range of emotional manifestations such as anxiety, uncertainty, stress, demotivation, fear, and mental fatigue. As a result, individuals may perform below expectations, give up, or procrastinate on tasks, often settling for superficial and low-quality information. Moreover, factors such as information excess, the characteristics of the information, various technological and communicational distractions, external environmental stimuli, lack of time, and personal factors make information processing more complex, leading to information overload.

According to Graf and Antoni (2021), IO can be associated with both quantitative and qualitative characteristics of information. The quantity refers to its excess, while quality involves subjective aspects of information judgment, such as complexity, novelty, trustworthiness, relevance, accessibility, origin, and ambiguity, among others. The quality of information relates to how well it meets the information needs of the user (Arnold *et al*., 2023; Batini; Scannapieco, 2016; Becerra *et al*., 2021; Jackson; Farzaneh, 2012; Jiang *et al*., 2021; Paim *et al*., 2007; Stvilia *et al*., 2007). Moreover, IO significantly influences decision-making in individual and organizational actions. As the volume of information increases, identifying useful, accurate, reliable, and quality information becomes more challenging to retrieve and distinguish (Batini; Scannapieco, 2016; Bawden; Robinson, 2020; Graf; Antoni, 2023; Oleto, 2006; Stvilia *et al*., 2007).

There are various coping mechanisms for IO. According to Koltay (2021b), avoiding, forgetting, and losing information are common and strategic reactions adopted by people overwhelmed with information. Information filtering is identified in several studies as a way to mitigate the effects of IO, characterized by selective attention that varies from individual to individual and depends on each person's priorities to create criteria that will help eliminate or avoid excessive or irrelevant information, seeking information that supports their decisions. Moreover, developing digital and information literacy can help minimize the effects of information overload (Bawden; Robinson, 2020; Savolainen, 2007a).

A variety of terms are used in different knowledge areas to denote information overload, such as information superabundance, infobesity, information excess, data pollution, information pollution, information fatigue, social media fatigue, social media

overload, cognitive overload, cognitive load, communication overload, information anxiety, information violence, and information assault (Bawden; Robinson, 2020; Belabbes *et al*., 2023; Eppler; Mengis, 2004; Koltay, 2021b, 2021a).

3 COGNITIVE LOAD THEORY

Cognitive Load Theory (CLT) was developed in the 1980s by education psychologist and professor John Sweller (1976, 1988, 2011), from the University of New South Wales, Australia, based on studies of problem-solving in learning, which utilized the cognitive architecture and information processing framework by Miller (1956). CLT is founded on what is known about human cognitive architecture, focusing on the individual's capacity to process new information. CLT proposes adapting instructional procedures and reducing unnecessary cognitive load, to avoid overwhelming the student's working memory and to stimulate learning (Schnotz; Kürschner, 2007).

Human cognitive architecture refers to how human cognition is structured, encompassing short-term and long-term memory (Sweller *et al.,* 2011). Long-term memory is characterized by its capacity to store a vast amount of information and the complexities involved in handling it, as well as the organization through schemas and the retrieval of this information. Thus, one concern of CLT is to help individuals increase their knowledge and specific skills in long-term memory, suggesting ways to present information to facilitate the acquisition of schemas.

Schemas are structures that organize information and represent the concepts and procedures used in cognition (Kalyuga, 2015). Knowledge in long-term memory is organized in the form of countless schemas; learning requires a large number of these, which are the result of the interaction of knowledge stored in long-term memory in the form of schemas and when required, are transferred to working memory (Colvin *et al*., 2006).

Short-term memory is limited for new information, both in capacity and duration (Miller, 1956). It mediates between the external environment and long-term memory, but its processing capacity is lower than its storage capacity. According to Sweller (2022), up to seven items can be supported in working memory (Miller, 1956), processed three to four at a time, and new items are retained for up to 20 seconds. Moreover, working memory cannot handle multiple elements simultaneously. Therefore, information that cannot be processed is consequently not transferred to long-term memory, causing processing failures and thus impairing learning.

Information from the external environment is first processed by the sensory system, which then passes it to working memory, which consciously processes information contained in long-term memory. Thus, information retained in working memory for a period is sent to long-term memory as permanent (Sweller; Ayres; Kalyuga., 2011).

Another important approach considered in Cognitive Load Theory (CLT) is the cognitive load imposed on an individual in working memory by information, which is categorized into three types (Alves *et al*., 2017; Colvin *et al*., 2006; Sweller, 2011, 2022):

- Intrinsic Load: Imposed by intrinsic information and refers to the complex acquisition of knowledge acquired without mention of its acquisition; it is a fixed type of load that cannot be changed. Its fixation occurs between what the individual needs to learn and what they already know.Carga intrínseca: Imposta por informações intrínsecas e se refere a aquisição complexa do conhecimento adquirido sem ter uma menção de sua aquisição, é um tipo de carga fixa que não pode ser mudada. Sua fixação se dá entre o que o indivíduo precisa aprender e o que ele já possui de conhecimento.

- Extraneous Load: The way information is presented by instruction can provide many interactive elements irrelevant to processing. Thus, CLT aims to ensure that extraneous cognitive load does not overwhelm working memory, freeing up cognitive capacity to handle intrinsic information in learning.
- Germane Load: This is a cognitive load that is not imposed by learning materials. It can be considered part of the relevant and pertinent information used by working memory resources in learning. Therefore, the attention given to relevant resources in learning is characterized by germane load. And the greater it is, the better the performance in learning and schema formation.

As cargas cognitivas intrínseca e estranha são complementares, juntas elas somam a carga cognitiva total, já a "carga relevante é considerada um reflexo da carga cognitiva imposta pela quantidade de elementos interagindo intrinsecamente, assim não contribuindo para a carga total" (Sweller *et al.*, 2011, p. 83, tradução nossa).

4 METHODOLOGY

This study is a literature review to which a bibliographic survey was conducted in the Web of Science and Scopus databases, using the search terms "information overload," which is the term consensually used in the field of Information Science to refer to the concept of information overload, and "cognitive load theory." The searches were carried out in October 2023. Journal articles and conference papers were considered, and no time limitations were imposed, as investigations addressing both information overload and cognitive load theory are relatively recent. The search results are shown in Chart 1:

Chart 1. Research Strategies in the Web of Science and Scopus Databases

Database	Search Strategy	Retrieval Date	Total of Records
Scopus	(TITLE-ABS-KEY ("information overload") AND TITLE-ABS-KEY ("cognitive load theory"))	October, 2023	26
WoS	"information overload" (All Fields) AND "cognitive load theory" (All Fields)	October, 2023	26
Overall Total			52
Duplicates			19
Total			33

Source: Authors (2024)

The papers retrieved from both databases were imported into the reference management software Mendeley, and the following exclusion criteria were applied: unavailable access to the full text, articles not in English, Portuguese, or Spanish, and those not aligned with the research question. This resulted in a corpus of 26 papers for analysis, comprising 23 journal articles and 3 conference papers. Title, abstract, keywords, and the

main body of the text were reviewed for this purpose. After filtering and qualitative analysis, the metadata of the selected papers were organized in Chart 2, including author(s), title, and subjects to identify the themes of the studies and arranged in order of publication date. Subsequently, they were distributed according to thematic analysis.

5 RESULTADOS

Through the analysis of the corpus, the following papers were obtained, listed in Chart 2.

Chart 2. Metadata of the Selected Papers

Authors	Title	Tags
Karr-Wisniewski & Lu (2010)	When more is too much: operationalizing technology overload and exploring its impact on knowledge worker productivity	Technological Overload; Impact of ICTs; Professional Work Context
Chen, Pedersen & Murphy (2011)	Learners' perceived information overload in online learning via computer-mediated communication	Online Learning; Impact of ICTs; Perception of Information Overload
Chen, Pedersen & Murphy (2012)	The influence of perceived information overload on student participation and knowledge construction in computer-mediated communication	Online Learning; Impact of ICTs; Perception of Information Overload
Dang & Yan (2012)	Theory-informed design and evaluation of an advanced search and knowledge mapping system in nanotechnology	Information System
Liu *et al.* (2013)	Evaluating exploratory visualization systems: A user study on how clustering-based visualization systems support information seeking from large document collections	System Evaluation; Cognitive Loads
Galani *et al.* (2014)	Battling the challenges of training nurses to use information systems through theory-based training material design	Use of Health Information Systems; Instructional Design; Professional Context
Kaylor (2014)	Preventing information overload: Cognitive load theory as an instructional framework for teaching pharmacology	Learning; Instructional Design
Kao & Peng (2015)	A multi-source book review system for reducing information overload and accommodating individual styles	Information System; Measurement of Cognitive Loads
Sobotta *et al.* (2016)	How e-mail threads contribute to e-mail overload: Investigating intrinsic, extraneous, and germane cognitive load	Emails, Measurement of Cognitive Loads
Pacauskas & Rajala (2017)	Information system users' creativity A meta-analysis of the link between IT use and creative performance	Creativity; Cognitive Loads; Information Technology
Yin *et al.* (2018)	Coping with mobile technology overload in the workplace	Mobile Information Technologies; Workplace Context
Fry (2018)	Information reduction and studio project frameworks	Design, Undergraduate Students
Roetzel & Fehrenbacher (2019)	On the role of information overload in information systems (IS) success: Empirical evidence from decision support systems	Information Systems; Managerial Performance; Workplace Context

Laato *et al.* (2020)	What drives unverified information sharing and cyberchondria during the COVID-19 pandemic?	Social Media; Information Sharing; Misinformation; Cyberchondria
Apuke & Omar (2021)	Social media affordances and information abundance: Enabling fake news sharing during the COVID-19 health crisis	Sharing Fake News; Social Media
Hawkins *et al.* (2021)	Exploring why medical students still feel underprepared for clinical practice: a qualitative analysis of an authentic on-call simulation	Learning; Cognitive Loads; Students; Medical Education; Clinical Practice
Mai, Taillon & Haytko (2021)	The impacts of information factors and health beliefs on attitudes towards social distancing behaviour during COVID-19	Social Distancing; Information Sources
Al-Jallad & Radwan (2021)	Exploring social media fatigue among youth in the United Arab Emirates	Fatigue; Social Media; Youth
Farooq *et al.*(2021)	Understanding the impact of information sources on COVID-19 related preventive measures in Finland	Online Information Sources
Apuke *et al.* (2022)	Information overload and misinformation sharing behaviour of social media users: testing the moderating role of cognitive ability	COVID-19 Pandemic; Sharing of Fake News; Social Media
Qaisar *et al.* (2022)	Effects of social networking site overloads on discontinuous intentions of users: a moderated mediation analysis	Social Media
Mullins & Sabherwal (2022)	Just Enough Information? The Contingent Curvilinear Effect of Information Volume on Decision Performance in IS-Enabled Teams	Information System; Team; Decision Making
Mladenović, Todua & Pavlović-Höck (2023)	Understanding individual psychological and behavioral responses during COVID-19: Application of stimulus-organism-response model	COVID-19 Pandemic; Online Information Sources; Cyberchondria
Guo *et al.* (2023)	Modelling the Information Abundance Factors That Predict Fake News Sharing Behaviour of Social Media Users: Testing the Moderating Role of Resilience	COVID-19 Pandemic; Sharing of Fake News; Social Media; Resilience
Rathnayaka *et al.* (2023)	Preparative pre-laboratory online resources for effectively managing cognitive load of engineering students	Learning
Huang *et al.* (2023)	Enabling and Inhibiting Factors of the Continuous Use of Mobile Short Video APP: Satisfaction and Fatigue as Mediating Variables Respectively	Short-Video Social Network

Source: Authors (2024)

Subsequently, the papers were read in full for a more detailed analysis of the addressed themes, allowing them to be grouped by theme. This process identified three categories that addressed information overload and Cognitive Load Theory: a) Effects of digital information and communication technologies, b) Impact on learning, and c) Misinformation and sharing during the COVID-19 period. These categories are presented below.

5.1 Information Overload and the Effects of Digital Information and Communication Technologies

Some studies examined the use of ICTs in relation to IO, utilizing Cognitive Load Theory as the theoretical foundation for model development. Information overload

is primarily investigated in research concerning the use of systems, improvements in design, and search systems. Some studies addressed IO as part of technological overload and analyzed the types of cognitive loads that lead to overload.

Karr-Wisniewski and Lu (2010) investigated technological overload, considering it in three divisions: information overload, system resource overload, and communication overload, in order to explore the relationship between overload and worker productivity. Cognitive Load Theory was employed to explain the human limitations in using complex technology for specific tasks, influencing productivity in knowledge-based work. Accordingly, a qualitative study was conducted with 61 employees who work with knowledge (engineers, analysts, software developers, teachers, among others) in the industrial sector, such as in IT, health, education, among others. The findings showed that more than half of the respondents experienced information overload, especially when conducting information searches related to work and needing to filter out because they encountered irrelevant information or get distracted by links leading to non-relevant sites. Lack of time and interruptions from other forms of communication (email, phone, fax, etc.) are factors linked to information overload. Thus, it was possible to develop a psychometric instrument with responses from 104 participants, which was grounded on theories, including Cognitive Load Theory, confirming that high dependency on technology generates technological overload and reduces productivity. The study emphasized that each individual experiences information overload in their own way, even when immersed in the same environment, as it is closely related to personal characteristics. The study also noted that information overload merges with communication overload, as one is highly dependent on the other. Although the study stated being based on Cognitive Load Theory, the authors failed to clarify how the study utilized the theory.

Liu *et al*. (2013) conducted a study to evaluate exploratory visualization systems from the user's cognitive standpoint during interaction and information seeking, as well as the induction by algorithms using clustering to group related news topics. The study surveyed 36 university students to assess cognitive load, employing Cognitive Load Theory (CLT) as the theoretical foundation for the research design and analysis. The students were grouped based on prior knowledge to measure and distinguish extraneous and germane cognitive loads based on feedback during system use. Systems that employed clustering were more encouraging in the search process and improved information retrieval, which motivated learning from new information and increased confidence in the task. The general visualization of topics and information organization were crucial for understanding the content, and the process of advancing the search for more information about content after an initial summarized contact evolved during the learning process.

Galani *et al*. (2014) reviewed the use of new health information systems by nurses and their impact on cognitive loads, employing CLT to guide instruction and information system design to avoid overwhelming working memory, as it was found that these professionals struggled with information overload when acquiring skills to use these systems, which hindered learning. Dang *et al*. (2012) also used CLT among the theories for design development to mitigate users' information overload by developing an information system in the field of Nanotechnology, integrating various information sources to aid in the search, analysis, and visualization of scientific information. The system was tested by users and proved effective in employing cognitive theories in design to reduce cognitive load, as they reported greater ease in searching, using, and visually interpreting analyses in an intuitive and comprehensible manner.

Kao and Peng (2015) developed a centralized online system to assist in searching for book reviews from various sources to minimize or avoid information overload. CLT is mentioned to justify the need for developing instructional material that avoids information overload and enables more efficient learning with better-structured information. The system was applied to participating students, who were divided into groups and

trained on the system and Google, tasked with locating summaries of specific books and differentiating both systems. The research showed that the developed system, compared to Google, generated less information overload, provided higher quality information, and in less time. Moreover, reviews presented in video format were more engaging than those in text format. Thus, the authors concluded that presenting ordered and coherent review information reduces information overload and allows users to focus more on reading.

Sobotta *et al*. (2016) conducted a study to determine how email threads contribute to information overload, aiming at measuring the different cognitive loads (intrinsic, extraneous, and germane) imposed by this type of email. CLT was thoroughly examined and employed to guide the investigation, as conventional emails were compared with thread emails but with a difference in presentation format. The goal of the study was to develop a scale for experimental measurement of the three loads, attributing intrinsic cognitive load to the content, extraneous cognitive load to the structuring and format of the email, and germane cognitive load to learning from the email.

Pacauskas and Rajala (2017) conducted a meta-analysis to determine whether information systems contribute to users' creative processes. The term information overload was used only in the keywords and was implied along with mentions of the cognitive loads outlined by Cognitive Load Theory (CLT). CLT was discussed throughout the study to underpin human cognitive processing and how cognitive loads affect the use of information systems, through users' prior knowledge and ease of use of the system. The study proposed that the imposition of cognitive load can hinder creativity, requiring more cognitive effort to use systems, complicating learning, and inhibiting individual creativity, particularly when tasks are perceived as complex or require substantial information. The study confirms that a user unfamiliar with a system's features faces an intrinsic load that can focus on the task and hinder information acquisition. Thus, the study suggested that systems should be easy to use and include advanced options for more experienced users.

Yin *et al*. (2018) analyzed the influence of mobile information and communication technologies (ICTs) in the workplace to determine whether they cause usage overload among workers. Similarly to the study by Karr-Wisniewski and Lu (2010), information overload is considered one of the technological overloads, which also includes interruption overload, albeit from a subjective perspective. Mobile ICTs impose a large amount of information through access to multiple information channels, increasing users' perception of overload. Although CLT was mentioned in the abstract and as a significant theory for the study's foundation, it was not discussed in the text, only conceptual aspects related to information processing concerning information overload and cognitive load. The research employed questionnaires to workers and identified that they experience IO, influencing job satisfaction. The use of mobile ICTs, both in personal life and at work, has become a dependency due to the multiple channels of information available for interaction. However, the study identified that, despite the high cognitive load induced by these technologies, they do not significantly affect job satisfaction, as individuals form a relationship with their devices that enables them to cope with this overload. They also identified that the large amount of information at work is the main stressor and cause of IO, while mobile ICTs help individuals handle complex tasks and multitasking.

Roetzel and Fehrenbacher (2019) examined whether the use of decision-support information systems was associated with IO in managers. The research utilized a mixed-method data collection approach, grounded in IO from the perspective of CLT. The goal was to examine the relationship between cognitive load and the quality and in-depth use of systems in managers' performance. The results showed that IO has negative effects on managerial performance. Even high-quality systems can provoke involuntary IO due to ease of use, increasing demand and generating an excess of information. However, deeper use of the systems reduces cognitive load as the user gains more experience.

In a similar line of study, Mullins and Sabherwal (2022) investigated how work teams deal with information excess using information systems for organizational decision-making. CLT was used as one of the theories to explain how team composition can affect the team's cognitive load and decision-making. A theoretical model was developed that related information volume and decision performance with three attributes influencing cognitive load (computational self-efficacy, computer anxiety, and orientation towards learning objectives) when interacting with information systems. The system was tested through a two-stage simulation, the first with undergraduate students and a second with professional graduate students, both in an introductory course on enterprise resource planning systems; however, the second group used a more advanced version of the system, resulting in the understanding that cognitive load impacts both individually and as part of a team. Thus, teams with higher computational self-efficacy exhibited greater cognitive load linked to a larger volume of information. Experience aided in problem-solving, teams that spent more time planning and preparing for the simulation performed better, while other teams with experience prepared less.

Further findings from the study concluded that although an increase in information aids in team decision-making, it can result in cognitive overload that impairs decision-making. Additionally, higher computational self-efficacy and lower computer anxiety lead to reduced cognitive expenditure in system usage, motivating focus on necessary information. Some level of anxiety may be important for driving motivation, making it beneficial to include individuals with both low and high anxiety within the same team. Thus, the article attempted to contribute to Cognitive Load Theory (CLT) by evaluating team-level impacts beyond the individual level, developing measures of information volume related to the use of information systems in decision-making data collection.

Qaisar *et al*. (2022) conducted a study to analyze user discontinuation on social networks, aiming to uncover the relationship between information overload, communication overload, and discontinuation intentions. The study utilized CLT to propose a conceptual model. The findings, obtained through a questionnaire administered to university students, showed that both information and communication overload have positive relationships with social network dependency; when self-efficacy is high, information overload and dependency on social networks are also high; information overload and communication overload cause fatigue, which can motivate the discontinuous use of social networks.

Another study that explored social networks, emphasizing the influence of fatigue on their use, was conducted by Al-Jallad and Radwan (2021), who addressed information overload as one of the causes of fatigue in young adults in the United Arab Emirates. The results indicated that women suffer more from information overload, thus experiencing more fatigue; extensive use of social networks can create high cognitive load that interferes with daily activities, and information overload is positively related to social network fatigue. CLT is briefly mentioned to describe cognitive overload and as a theory that could explain the technological and psychosocial factors leading to social network fatigue, though it was little explored and utilized in this study.

Huang *et al*. (2023) conducted research to investigate the continuous usage intentions of short video apps, employing CLT to understand the inhibiting factors of use and to construct a sub-model of these factors, which forms part of an integrated model. A questionnaire was administered to users of TikTok, a short video app. The research identified that satisfaction and enjoyment are the main motivators for use, as they promote habits that do not require cognitive effort and lead to an automatic process. On the other hand, fatigue was identified as an emotion that inhibits use, since information and communication overload contribute to its emergence.

5.2 Information Overload and Its Impact on Learning

Another theme closely related to Cognitive Load Theory (CLT) is learning, as the theory provides theoretical grounding and techniques for constructing schemas to assist in learning through the optimization of cognitive loads. Thus, the studies have reported using the theory to measure and propose the management of students' cognitive loads to minimize information overload.

Chen, Pedersen, and Murphy (2011) proposed a study to assess online learning in students and the factors leading to information overload in computer-mediated teaching. They noted a strong emphasis on CLT and its conceptualization as, for the authors, it provides a basis for understanding information overload. They distinguished between information overload, which pertains to attention and information loss in the environment due to the limited capacity of sensory and working memory, and cognitive overload, which relates to the long-term memory's inability to store, retrieve, and relate new information with prior knowledge. According to the researchers, information overload precedes cognitive overload, and both overlap in terms of the limited capacity of working memory. The authors emphasized that information overload includes sensory memory, initially not addressed by CLT, representing a type of noise that hinders individual learning, while cognitive overload would be the load imposed by content during learning. They associate information overload significantly with the term 'extraneous cognitive load.' Questionnaires and interviews were conducted at different times with 12 graduate students from two online courses, who attempted to identify the information overload perceived by students related to online learning, with questions based on CLT and information overload. They identified that information overload increases for several reasons: lack of time for developing papers, high demands of continuous discussions and readings, difficulties in text reading and organizing learning, lack of skills to handle the system and its interface, difficulty in accessing scientific databases for reading mandatory materials. Furthermore, they observed that the quantity and quality of information influenced information overload.

The authors confirmed that high levels of prior knowledge, as advocated by CLT, aid in interpreting new information in working memory with existing schemas, helping students organize their learning. Another perception was the divided attention students suffer when participating in discussion lists in which information becomes fragmented, an explanation supported by CLT. Finally, the authors suggest ways of presenting and designing the course system for better online learning, so students can manage the information overload perceived individually.

In a similar research line based on CLT guidelines, Chen, Pedersen, and Murphy (2012) sought to verify the interference of IO in knowledge construction, analyzing cognitive and metacognitive processes in online discussions conducted by 12 graduate students in two online courses. Research methods included questionnaires, interviews, and observation of group meetings, in which prior knowledge of reading and writing, English language, and system and technology use were identified to discern perceptions of information overload. Subsequently, students' perceptions of the learning difficulties caused by IO were collected. The mentioned difficulties were related to the quantity of information: connection problems, navigation difficulties, discomfort with online communication; to the interface: excessive demands of continuous discussions and readings, difficulty in organizing learning; and to the quality of information: problems understanding texts. Most participants reported feeling IO. Students who felt greater IO tended to participate less in online discussions, were more likely to have difficulties understanding messages, keeping up with the volume of information, or found the information repetitive or trivial. According to the studies, mental effort and the development of metacognitive skills helped some students cope with IO and develop deep learning. Thus, the amount of

mental effort significantly depended on the motivation, attitudes, and beliefs regarding a learning domain, in addition to the available time.

Kaylor (2014) used Cognitive Load Theory as an instructional framework for teaching pharmacology, tailoring course content to the needs of nursing students and discussing how educators can support student-centered learning by implementing CLT principles to reduce information overload. This was achieved by optimizing cognitive resources through: reducing extraneous load by avoiding redundancy, unnecessary information, simplifying and segmenting information in instructional materials; encouraging prior knowledge and automatization of long-term memory for addressed contents; prioritizing and focusing on key concepts; developing critical thinking to enhance clinical judgments; promoting active and collaborative learning strategies to improve retention and comprehension of course material.

In the study presented by Fry (2018), CLT was applied to undergraduate students in industrial design to reduce IO in their design projects, proposing the use of segmentation and fragmentation to reduce cognitive load, emphasizing that the latter is more effective in a design development process by helping them separate relevant from irrelevant information. Segmentation involves dividing information into smaller, manageable groups so that it can be stored and retrieved, while fragmentation reduces information sets to smaller, meaningful parts, grouping them into coherent categories to aid short-term memory retention. It was possible to understand problems and resolution, organize ideas, and stimulate students' creativity.

Another study that applied CLT in an educational context was conducted by Hawkins *et al*. (2021) with undergraduate medical students, aiming to identify how the training of these future physicians prepares them to handle clinical practice. Thirty students participated in a hospital shift simulation, in which documentation, observation, and discussions about the decisions made occurred, and various themes emerged from the research and were discussed under the view of CLT for data conceptualization. The results showed the high IO faced by the subjects when dealing with multiple patients and simultaneous information, as well as the difficulty in prioritizing it, with the guidance of experienced doctors being important for analyzing, assisting, and resolving medical cases. High levels of uncertainty, insufficient knowledge, and clinical skills were observed in the subjects' behavior, in addition to difficulty applying previously learned knowledge, due to the high level of pressure and interactivity of elements. Negative emotions such as anxiety, stress, fear, and frustration hindered concentration and performance, generating extraneous cognitive load. However, it was noted that as the shift progressed, students were able to apply learning resulting from their decisions and actions. Thus, CLT was important in this study to optimize cognitive load in this context, to enhance learning in the undergraduate curriculum that supports the improvement of clinical practice, improving the automaticity and availability of cognitive schemas in long-term memory and reducing intrinsic cognitive load.

Rathnayaka *et al.* (2023) investigated how online pre-laboratories resources could reduce the cognitive load of engineering students during laboratory classes. Based on CLT, resources were developed with knowledge of theories, concepts, and laboratory protocols that allowed students to prepare with prior information to laboratory classes and dedicate time and focus on acquiring new information, aiming to reduce IO for better performance in the laboratory. A longitudinal study was developed to ascertain how students were prepared and confident after using these pre-laboratory resources and how these affect students' cognitive load. The research identified that the materials were effective for understanding concepts and content, despite a need for greater clarity, but they contribute to the management of students' cognitive load regarding extraneous and germane load, in addition to forming schemas in long-term memory, overburdening short-term memory less. It was also observed that there was an increase in students' confidence,

the class had less teacher-centered time, with greater student participation, leading to greater self-reflection, learning, reduction of stress and pressure. What also contributed was the sufficient time that students had to understand the pre-laboratory resources.

5.3 Information Overload, Misinformation, and Sharing During the COVID-19 Period

Studies conducted during the COVID-19 pandemic, caused by the SARS-CoV-2 virus which impacted global public health, investigated IO. The studies highlighted below examine the effects of excessive information input and the dissemination of new information about the virus, the resulting information overload, as well as misinformation and behavioral responses to an unfamiliar situation. Cognitive Load Theory (CLT) was utilized to theoretically underpin the inability to process the excess of new information amidst fake news, which influenced individuals' information behavior.

Farooq *et al*. (2021) aimed to investigate the information sources that caused IO during the COVID-19 pandemic. CLT was employed to substantiate and explain the information behavior of individuals when confronted with new, abundant, and low-quality COVID-related information, contributing to IO. A questionnaire was administered to 225 members of a university community, identifying that online sources resulting in IO predominantly stemmed from social media and other internet sources such as news websites, search engines, and miscellaneous sites, whereas official sources did not contribute to this increase, inferring that people consulted these IO-inducing sources more frequently, encountering large amounts of low-quality information, while official information was more structured. According to the authors, these findings were significant in demonstrating how information overload influences people's behavior in new situations such as the COVID-19 pandemic, and they could point out, based on CLT, the limited human capacity to process information in new and unexpected situations.

Mai, Yaillon, and Haytko (2021) also attempted to investigate individuals' trust in COVID-related information sources concerning social distancing, adopting CLT among other theories to construct a conceptual model. In the context of the pandemic, IO represented a significant barrier to processing new and contradictory information, along with difficulties in filtering and comprehension. The findings from a survey showed that IO negatively impacted social distancing, harming it due to exposure to excessive information input, which includes unreliable information.

Laato *et al*. (2020) used the perception of cognitive load and health to empirically understand individual misinformation sharing and cyberchondria during the pandemic, utilizing CLT as one of the theories for theoretical grounding on the impact of technology on information sharing, including on social media. Questionnaires were sent to teachers, students, and alumni of a university, revealing that information overload on social media contributes to misinformation sharing and cyberchondria. Additionally, the study identified that older individuals contributed less to the sharing of unverified information. Thus, CLT was instrumental in helping to understand human behavior in the face of new information and the spread of misinformation.

In a similar line of research, Apuke and Omar (2021) also used CLT among the theories to explain the sharing of fake news during the pandemic, applying a questionnaire to social media users in Nigeria. The results indicate that IO leads to the sharing of fake news, as the excessive information leads to fatigue, which motivates the lack of verification. Apuke *et al*. (2022) identified, in order of relevance, that IO, fatigue, and information tension lead to misinformation sharing. IO is the most significant for this behavior, as in the face of an immense amount of information, individuals are less likely to verify sources. Fatigue, caused by information overload, reduces individuals' cognitive capacity to analyze information. And tension, in the face of excessive information, reduces the

motivation and effort to make sense of new information and process it. Even a high cognitive capacity, in the face of fatigue and excessive information, is not sufficient to prevent the sharing of fake news. However, those researched who had higher cognitive capacity were less likely to disseminate misinformation, as they employ more effective filtering and more efficient information processing.

Guo *et al*. (2023) also used CLT as a basis to investigate why people shared fake news during the pandemic in Nigeria and resilience in the face of information overload. A questionnaire was also applied to social media users in Nigeria, reaching conclusions similar to Apuke and Omar's (2021), that IO and tension contribute to the sharing of fake news, as there is less effort for verification, and irrelevant information also contributes, as its excess leads to fatigue and lack of focus. Communication overload is another factor contributing to IO, as users who constantly communicate on social networks may suffer from fatigue and stress, causing less comprehension of new information and tendency to share fake news. The study also pointed out that more resilient people are less likely to share fake news and better handle moments of tension, fatigue, and stress in the face of a large volume of information, as they can exhibit a greater capacity to filter information.

Mladenović, Todua, and Pavlović-Höck (2023) studied individuals' exposure and interaction with online information sources during the pandemic period, using CLT among the theories to investigate the psychological and behavioral responses of individuals. A questionnaire was based on Laato *et al*. (2020) approach to online information sources, enabling the measurement of a proposed theoretical model that explains the relationships between information sources, information overload, cyberchondria, and information behavior, reaching the following conclusions: exposure to online sources about COVID-19 influences the psychological and behavioral state of people, leading to IO, which further induces cyberchondria, which, in turn, drives the search and provision of information.

6 CONCLUSION

The analysis of the literature found in the Scopus and Web of Science databases demonstrated that Cognitive Load Theory (CLT) provides a robust framework for understanding and guiding research on information overload, allowing exploration of the limits of human cognitive capacity in information processing.

Three themes were identified around which the analyzed studies were grouped. The first theme addressed the effects of ICTs, considering information overload as a component of technological overload, analyzing the use of systems and how improvements in design and search mechanisms can mitigate information overload. Another theme focused on the aspect of learning, highlighting the use of CLT in mitigating information overload to promote more efficient and effective learning, facilitating the creation of schemas and the management of cognitive loads. The last theme examined research that relates the excess of new information, difficulty in criteria for selection and understanding of information with the triggering of information overload and, consequently, with the spread of misinformation during the COVID-19 pandemic.

CLT was applied in the studies in various ways, whether to explain IO through theoretical grounding, in the development of conceptual models, or in hypothesis testing. Many studies also identified the relationship of stress, fatigue, prior knowledge, anxiety, lack of time, tension, distractions, information quality, motivation, personal beliefs, personal characteristics, and trust with the inhibition or facilitation of IO and cognitive loads.

Thus, the presented literature review highlighted the importance of CLT as an essential theory for understanding and managing IO in various contexts, from education to the use of Information and Communication Technologies. Therefore, the integration

between CLT and information overload provides a deeper understanding of the challenges faced by human cognitive capacity, identifying factors that contribute to IO, bringing significant contributions to the field of Information Science, in seeking to understand and minimize the effects of information overload, which affects people of all ages and in various contexts and roles.

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